AALTO UNIVERSITY
SCHOOL OF BUSINESS

ABSTRACT OF THE
BACHELOR'S THESIS

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Title: The Effectiveness of Forest Assets as Inflation Hedges

Date: 24.4.2023 Language: English Number of pages: 4+26

Degree programme: Economics

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This literary review aims to examine the effectiveness of forest assets as inflation hedges, both in portfolio terms and as an asset class on their own. Initially, I review models and theoretical frameworks utilized by Washburn and Binkley in “Do Forest Assets Hedge Inflation”, where some forest areas are considered to hedge against “higher than expected inflation” and others are not, and “Can Timber Hedge against Inflation? An Analysis of Timber Prices in the US South” by Zhang et al., where it is concluded that forest investments do not offer uniform protection against inflation. Macroeconomic implications are discussed, further empirical evidence is reviewed, and potential shortcomings that affect my conclusion are mentioned. The results by previous works are mixed, as the manner in which researchers measure, or define what “forest assets” are, is dependent on the context of the study, albeit proxies are often used. Additionally, there are but a few existing empirical studies that directly measure the relationship between the return on forest investments and inflation.

Keywords: Inflation / Hedging / Forest Assets

Contents

Abbreviations and Symbols

Abbreviations

CAPM	Capital Asset Pricing Model
SML	Security Market Line
OLS	Ordinary Least Squares

Symbols

γ	measure of inflation hedging
β	CAPM beta, signifying responsiveness to market changes
α	Jensen's alpha, average return above/below CAPM predictions
ω, ϵ	error terms

1 Introduction

Forests play a significant role in global manufacturing and the global economy (SE 2021). Not only do forests provide inherent value in terms of timber, but also through ecological conservation and biodiversity factors. With forests covering nearly one third of land globally (FAO 2020) there are bound to be potential sources of value that can be translated into optimal investment opportunities and asset classes, not to mention economic growth and other macroeconomic benefits. In recent years, investors have increasingly gravitated toward the forestry sector as a potential hedge against rising prices, especially in the face of current global economic uncertainty and volatility. Forest investment can be considered as quite a wide range of investments, but usually forest investments cover maintenance and planting of forests, timberland and woodland (Chudy, Cubbage 2020). Forests play a unique role in the context of assets, as they generate commodity products such as timber and fuelwood, but are also public goods and ecological assets that provide ecosystem services (Chudy, Cubbage 2020).

However, such investment decisions certainly do not just impact investors' portfolios or firms' bottom lines. According to the IMF (ADB et al. 2016), public investment "increases output in the short and long term" , "crowds in private investment, and reduces unemployment". As such, the development of forestry as an asset class influences all aspects of the economy at large, whether global or local. Due to the multiple types of forest ownership, forest investment also contributes to economic growth. While economists do not track financial investment as a component in their definition of aggregate demand (ADB et al. 2016), increased market value and cash flows of specific firms or asset classes provides the forest industry itself with growth opportunities, and as forestry is so closely linked to manufacturing, transportation and many other industry sectors, it is sure to spur economic growth in general as well.

In the past decades, investors have become more and more interested in investing in forestry as it provides unique ways to diversify to a more carbon-neutral portfolio, but perhaps most importantly because of the potential inflation-hedging characteristics of forest and timber asset classes. Inflation hedging has not been deemed overly significant for large parts of the 21st century, as inflation and interest rate levels have generally remained low (Chudy, Cubbage 2020), but recent economic turmoil and looming recession may signify the onset of increasing relevance of inflation hedging for investors and policymakers.

In this thesis, I will examine the effectiveness of forest assets as a hedge against inflation, drawing on a range of academic literature and empirical evidence on the topic, various methods of estimation, and application of various theories. The goal is to come to a conclusion on not only the past success of forestry as an investment in general, but to apply past hypotheses to current times to examine whether the modern day indeed calls for more emphasis by institutional and individual investors to be put on forests as a means of hedging. Additionally, other aspects and characteristics of forest assets will be brought up, in addition to maceoeconomic implications, to determine whether there is a future with forestry in a more prevalent role than before in asset portfolios or larger scales, with or without inflation.

2 Inflation and its negative effects on investments

This section will provide clarity on the definition and relevance of inflation on the topic of investments. It is important for the purposes of this thesis that inflation is clearly defined, as it essentially is the catalyst for the problems investors are attempting to avoid by way of 'hedging' and additionally has effects in a macroeconomic way as well.

Inflation as a term signifies a rise in average costs of goods and services for a specified span of time. When it comes to the implication on investments, they are multiple. For investors, tracking inflation is important as increased inflation can reduce the real return on investments. Some researchers believe that the impact of inflation on stock returns is generally minimal or even with a somewhat positive relationship between the two, as a company's revenues, earnings and thus cash flows should increase at simultaneously with inflation, at least to some extent. Nonetheless, an increase in inflation can lead to an increase in the riskiness of an asset, causing investors to demand higher rates of return as a means of protection (Ammer 1994).

Additionally, since inflation can harm corporate profits, which in turn reduces dividends, this can also lead to a negative effect on unexpected asset returns. Economists Fama and Schwert (1977), when researching the connection between inflation and US stock returns, found a negative relation between US stock returns and inflation between 1953 and 1971, suggesting that inflation indeed has a negative impact on the stock market and thus on investors in general. Further, economists and researchers widely accept that supply shocks, reducing output and raising prices, also cause lower marginal productivity of capital, leading to reductions in real future earnings of capital and consequently diminishing the value of the firm and the capital assets (Tatom 2011). Several researchers suggest that the notion of a negative correlation between inflation and stock prices has developed to be one of the more solidified and accepted empirical 'truths' in economics and financial studies (Bakshi 1996).

Investors generally have many factors and risks to consider when making their investment choices. The rational investor's aim is to maximize returns and reduce risk as much as possible. Most private citizens may only invest short-term in safe ETFs (Exchange-Traded Funds), or in stable indices, blue chip stocks, treasury bills, etc. that have stability and credibility to their name. However, it is usually significant for the institutional investors, those who have a longer investment horizon, to hedge a portfolio against inflation. Alas, stocks do not consistently serve as good hedges, with another asset class potentially being the superior inflation-hedge. Perhaps in especially inflationary times, even the irregular and more spontaneous investor is starting to consider whether or not to put more focus into protecting their assets against inflation, something that the world is currently dealing with to potentially detrimental effects.

3 Background of Forest Assets

This section will provide some background specifically concerning the definition of forest assets and includes context-building history of said asset class.

For this paper, 'forest assets' will be the term used in the context of investment in the asset class. Additionally, while the term 'forest asset' can be confusingly broad, it will be narrowed for the purposes of this literature review to define investment in natural capital that specifically includes timber products, and/or purchase of forest land directly.

In reality, researchers use various methods of arriving at a rate of return for forest assets and for categorising them to begin with. Lausti (2004) measures forest asset return in part as a sum of the stumpage price change, while Zhang et al. (2011) instead study the price history of five specific timber products, and Washburn and Binkley (1993) instead only use historical stumpage prices, which is timber that gets sold for harvest.

While the history of forestry as an asset class may be long, much of the forest and timber asset classes that are of interest today have developed "over the last three to four decades" (Chudy, Cubbage 2020). This development has been catalyzed by a shift from ecosystems that provide public goods and services to commercially viable value creators that can be effectively monetized by governments and private owners alike. Adam Smith's economic theory about land rents and forest returns provided a solid foundational point (Chudy, Cubbage 2020), leading to Martin Faustmann's forest rotations hypotheses and terms for soil expectation value (SEV) land expectation value (LEV) and/or bare land value (BLV). This led to forests being treated more as investments and less as pure services, shifting the focus of owners toward maintaining these assets by more scrutinized trimming, harvesting, and other forms of maintenance (Chudy, Cubbage 2020). Today, about 73 percent of the world's forests is under public ownership (FAO 2020), however several sub-regions contain majority private owned forests, such as the Americas and several western European regions (Chudy, Cubbage 2020). As these previously non-market entities began to be monetized, forest investors and governments started making investments to capture profits from those goods and services.

3.1 The Characteristics of Timberland/Forestry as an Asset

One could make the case that investors have every reason in the world to think of forestry and timberland assets as risky, for instance due to exposure to potential hazards such as wildfire, insects, and disease. After all, forests are in no way insular and encompass large swaths of land and area that are exposed to exogenous factors and systemic shocks just like other land ownership assets. However, some claim that losses occurring from these kinds of natural events are relatively low (Chudy et al. 2020) and when applied to a portfolio for diversification purposes, may actually lower the overall risk, depending on the other assets in said portfolio (Wan et al. 2015). Further, due to the biological growth component, forest investments are thought to have less volatility than many common investment instruments. According to Newell and Eves (2009), the investment risk of forests is significantly lower than those of stocks, albeit higher than in the rest of the real estate sector. As an investment with a long-term time horizon, timberland investments offer portfolio diversification, attractive return relative to risk, a potential steady cash flow, and a potential inflation hedge.

When it comes to the value of forestry and why it would be an attractive investment target to begin with, one should look no further than the inherent quality that comes from what forests contain and contribute to the world at large. Sweden's Stora Enso, one of the largest private forest owners in the world, describes its value sources as returns from wood sales, forest asset growth, returns through land development, cost efficiency of the wood supply, etc. (SE 2021) Additionally, biological growth and timber prices (Chudy et al. 2020) are unique characteristics of forestry that contribute to its identity as a distinguishable asset. However, the ever-emerging characteristic that may prove to be the most important is the potential inflation-hedging capability of forest assets.

3.2 Forest as an Inflation Hedge

Forest investments are generally thought to be a good hedge against inflation (Healey et al. 2005) due to the generally held belief that whenever prices of final goods and services inflate, they at some point feed back into timber prices. However, these claims are difficult to prove and substantiate, and many of such are still not widely and unconditionally accepted as being empirically proven (Washburn, Binkley 1993). For one, different analysts and researchers have used different criteria and formulae to describe the ability of forest investments to hedge against inflation. Additionally, there are only but a few empirical studies that specifically measure the relationship between the return on forest investments and inflation, so one can assume that there is still a research gap in this particular field. However, because of forest assets' perceived, and in some instances substantiated, low market correlation and systemic risk, they are deemed good candidates for portfolio diversification (Wenjing et al 2016). In the United States, several investors on a more institutional level, such as pension funds or foundations, have increasingly opted for timberland assets for long-term sustainable returns, and have during the past couple of decades become "unprecedentedly active buyers" of forest assets (Mei 2019).

Inflation hedging as a term is considered to signify ‘protection’ from the effects of decreased purchase power and rising prices that accompany a period of inflation locally or globally. Hedging can be applied to asset pricing theory and investment portfolios, most commonly with inflation hedging assets being thought to maintain or increase their value over a specified period of time. In other words, investors hedge to insure against unexpected outcomes (Washburn, Binkley 1993). Therefore, assets found to have been fit for hedging against inflation are invested into to provide a protection against unexpected inflation.

There may not necessarily, however, be one type of inflation-hedging asset type, rather, some assets may hedge against higher than expected inflation, and some against lower than expected inflation. The various applications of inflation in the estimation of asset returns will be explored at a later section in this paper.

When it comes to the question of how or why forest assets are considered inflation hedging by some, the main component is considered by many to be the biological growth aspect. Biological growth can always be assumed to exist independently from any other potential disturbances, as no matter what is going on with the global economy, trees will grow and forests will expand. This constant growth is a source of consistent and fundamental value for the asset. Secondly, forest assets are comparatively stable through the long term as producers are largely unable to increase timber supply quickly due to most structural timber being grown in plantations over a 30-year cycle. Therefore, available timber being harvested in the present day is driven by planting decisions made decades ago. As such, and by many measures, there is a fixed number of acres available for harvest at any given time. Further, biological growth is often identified as the dominant return driver in terms of the percentage of contribution (Caulfield 1998). Due to this distinguishing feature, the volatility of timberland returns has been dampened during economic recessions (Caulfield 1998). Timberlands are illiquid assets with investment horizons of around 10-15 years (Clutter et al. 2005).

Some researchers suggest that the diversification benefits of timberland are overstated, arguing that most previous conclusions are based on "short-run indicators" (Heikkinen, Kanto 2000) and indeed, harvesting processes and forest maintenance are long-term projects that bind manufacturers to decisions made decades ago. With that in mind, some doubt that timberland assets really do have substantially high returns with lower levels of risk long term. Assets such as timberland that regularly generate higher return with lower risk cannot exist, as short run abnormal returns would be "absorbed to achieve a long-run equilibrium under the zero-profit condition" (Liao et al 2009).

The lack of direct, focused empirical research on the topic in addition to the wide range of conclusions could be attributed to different measures in timber investment returns, multiple geographic locations, product mixes, and distinct criteria to measure the" effectiveness" of inflation hedging, as it is not necessarily a concrete term for a specific benchmark.

4 Theoretical Models and their Empirical Tests

This section will focus on the relevant theoretical frameworks utilized by researchers to measure the inflation-hedging capability of assets. There will be a review of Washburn and Binkley's 1993 paper Do Forest Assets Hedge Inflation? where a two-factor model containing a CAPM beta and unexpected inflation is used, followed by theories explaining different methods of quantifying the relationship between asset prices and inflation, and a comparison to Zhang et al. (2011) a study of Timber Prices in the US South, where a two-factor CAPM is used, yielding some differences in the results. While both papers utilize two-factor CAPM betas in their estimation, the following analyses differ in the application. First the theory is presented, empirical studies and their choices of models are presented, and finally criticisms of the empirical works are discussed.

In the world of asset pricing, inflation hedging is often conducted on a fundamental level by examining the correlation between the returns of the asset and inflation. Simply put, if the correlation is positive, it suggests that the asset is a good inflation hedge, as its returns tend to increase with inflation. If the correlation is negative, it suggests that the asset is a poor inflation hedge, as its returns tend to decrease with inflation. If the correlation is close to zero, it suggests that the asset is neutral to inflation, as its returns are not significantly influenced by changes in inflation. However, there is additional complexity to be considered when researching the relation between asset prices and inflation.

The theoretical bedrock of multiple works researching relationships between asset prices and inflation is the Fisher's Hypothesis, which was utilized as a foundational theoretical framework in Washburn and Binkley's research. Initially, however, Fama and Schwert (1977) made use of this hypothesis to develop the classical view of studying asset prices in relation to inflation. Fama and Schwert showed the possibility of inference of the hypothesis, which suggests that nominal returns should move linearly with inflation, for all asset classes, conveying that the asset provides a complete hedge against inflation risks in the short run (Arnold and Auer, 2015). Hence, the dynamic of hedging against inflation requires that the investment return should be at the very least equal to the inflation rate (Fang et al., 2008). Both works that will be examined utilize estimates that signify the inflation hedging of an asset, which will be analyzed later on.

4.1 Fisher's Hypothesis

Fisher's hypothesis is the theoretical framework that is often used in studying inflation hedging by assets, and represents the first attempt to formally establish a concrete relationship between inflation and asset returns. The hypothesis states that nominal interest rates (interest rates not adjusted for inflation) are made up of two components: the real interest rate and the inflation premium. The real interest rate represents the return that investors demand for investing their money, while the inflation premium represents compensation for the loss of the purchasing power of money due to inflation. Fama and Schwert (1977), utilizing this theory, suggest that the notion that expected nominal return contains market assessment of expected inflation rates is a principle that can be applied to all asset types (Salisu et al. 2020).

The key distinction to make in terms of expected inflation (instead of inflation as a general term) in an asset price context is that capital markets generally incorporate expected inflation in asset demand, supply and pricing of assets, while unexpected inflation is not accounted for in the same fashion, as it cannot be foreseen (Tatom 2011). With the measurement of inflation, we distinguish between expected and unexpected inflation (as well as stock returns) for this reason, as the two differ in terms of their impact on investors' returns. Some researchers suggest that it makes more sense to, based on forecasts (ex-ante), hedge against expected inflation than to hedge based on results (ex-post) against actual inflation, as human expectations play a large role in our present valuations and logical reasoning of future developments. The expected return demanded can be defined as the real rate of return in addition to a premium for the rate of expected inflation over the lifespan of the asset, as compensation to investors for their lost purchasing power (Lausti 2004). Since investors cannot know what "actual" inflation will be in the future, investors looking to earn a return will thus hedge against expected inflation. Expected inflation can usually be taken into account in the prices of investment properties, and is not considered a risk. Unexpected inflation, on the other hand, describes the reaction of the market and causes price fluctuations, affecting the investor's wealth and is thus considered to be a risk (Wan et al. 2013).

4.1.1 Application of Fisher's Hypothesis

While both studies build on Fisher's hypothesis (1930) as well as Fama and Schwert (1977) utilization of that framework, the applications are different and take into account different factors. Washburn and Binkley (1993) use stumpage price series as a proxy for individual tree species returns, construct a three-stage instrumental variables regression and evaluate the relationship between the stumpage prices and inflation levels, while also using a two-factor CAPM beta. Zhang et al. (2011) similarly use a CAPM model to estimate the relationship between long-run asset prices and inflation, incorporating both expected and unexpected inflation, which will be explored more in detail later on.

Fama and Schwert in 1977 started examining the Fisher Hypothesis, the work of American economist Irving Fisher, who in 1930 suggested that in a model measuring expected inflation, the nominal interest rate (i_{t-1}) should equal the sum of the expected real rate of return ($E_{t-1}(r_t)$) and the anticipated inflation level ($E_{t-1}(\pi)$).

$$i_{t-1} = E_{t-1}(r_t) + E_{t-1}(\pi) \tag{1}$$

Where the market makes use of available information at time t–1 in order to "assess the expected rate of inflation" and thus determines the expectation level of the real return on assets with an accurate risk premium (Lausti 2004).

A classical method in examining the historical relationship between asset returns and inflation can be employed by utilizing Fama and Schwertz's aforementioned approach and Fisher's hypothesis. Continuous return rates are calculated through the natural logarithm of the relative values of the asset at the final (e.g. Dec 31st) and initial (e.g. Jan 1st) parts of the period (Washburn, Binkley 1993).

However, some problems arise when taking this a step further to regressions due to the unobservable nature of E(r) and E(π). Some analysts have overcome this hurdle by constructing instruments that serve as proxies, serving as sources of exogenous variation for real return and inflation expectations. Thus, to continue this method of analysis, one can construct an instrumental variables technique.

4.1.2 Instrumental Variables Technique using Fisher's Hypothesis

To construct an instrument for expected inflation, Washburn and Binkley (1993), studying the forest hedging capability of forest in Louisiana and Maine, subtract estimates of real risk free rates (r_f) of investment from yields on US treasury bills (Y):

$$instrE(\pi) = Y - r_{ft} \tag{2}$$

Consequently, OLS can be used to estimate a model for the return on a real asset:

$$r_{i,t} = \gamma_{0i} + \gamma_{1i} r_{m,t} + \gamma_{2i}(I - instrE(\pi)) + \omega_i \tag{3}$$

Where the quantity I_t - instrE(π), is a measure of unexpected inflation. The estimate of this regression serves as an instrument for the expected real return for asset i, where the coefficient 1i provides the first measure of the relation between inflation and asset returns, that being the "responsiveness" of real rates of return for asset i to unanticipated inflation levels (Washburn, Binkley 1993).

This parameter can be used as an appropriate measure of the inflation-hedging capability of an asset. With a value above 0, the asset hedges against higher than expected inflation, and vice versa for a value below 0, with exactly 0 signifying immunity to inflationary pressures.

With a measure for hedging capability acquired, one could assume that a diversifying investor would want asset classes with a wide range in γ values, so that some assets hedge against higher inflation, and some against lower inflation.

Finally, Washburn and Binkley acquire the Fisher-effect measure with the final equation for the instrumental variables technique:

$$R_{i,t} = \beta_{0i} - \beta_{1i} instrE(r_{i,t}) + \beta_{2i} instrE(\pi_t) + \epsilon_i \tag{4}$$

Where β_{2i} represents the degree to which inflation expectations are incorporated into expected nominal asset returns (Fisher effect). As such, the β_{2i} measure is historically treated more as a measure of market efficiency rather than inflation hedging (Washburn, Binkley 1993).

Utilizing fisher relationship estimates, Washburn and Binkley conclude that the hedging capabilities of forest assets had been area-dependent, saying that forests in the West and South were “effective hedges” against higher-than-expected inflation, while northeastern forests were “less effective” hedges (Washburn, Binkley 1993) additionally suggesting that these differences are down to different levels of expectation incorporation into the asset prices, causing West/South forests to be overvalued during period of higher inflation – while northern forests, incorporating expected inflation more efficiently, had less inflation hedging success. Additionally, Washburn and Binkley argue that the relation between real return rates for the asset and unanticipated inflation is the most fitting measure of an asset's ability to hedge inflation (Washburn, Binkley 1993), concluding that insurance against departures from inflation expectations is what constitutes effective hedging.

When it comes to utilizing the different techniques of studying inflation hedging abilities of stocks, researchers have had some difficulties with application to forest assets. Historical returns for actual forest assets are not always available for study, as sources such as NCREIF (National Council of Real Estate Investment Fiduciaries) only provides data to institutional investors (NCREIF). Additionally, Redmond and Cubbage (1988) have for decades suggested that inflationary expectations play a large role in stumpage prices and therefore forest assets and, further, that the negative Capital Asset Pricing Model (CAPM) beta-values for the stumpage price - series could suggest that forest assets are kept as a "store of value" for times of high inflation rates. However, due to a lack of return series availability for forest ownership, this hypothesis has not been conclusively tested (Lausti 2004).

4.2 Regression Technique

Some research works, such as Lausti (2004), analyze the relationship between inflation and return on forest assets by utilizing a regression based on the Fisher hypothesis:

$$R_t = \alpha_0 + \alpha_1 P_t + \beta_1 r_{mt} + \epsilon_t \tag{5}$$

R_t = nominal return, P_t = inflation rate, r_{mt} = Helsinki stock exchange rate

With this regression, positive estimates for α_1 indicate "some effectiveness" in inflation hedging. One can test the fisher hypothesis (expressed in the first equation) by writing the following equation:

$$R_t = \alpha_0 + \alpha_1 E(P_t) + \alpha_2 [P_t - E(Pt] + \epsilon_t \tag{6}$$

Utilizing this technique, Lausti finds that forest ownership did not provide a hedge against actual inflation between the years 1973 and 2003, however suggesting that forest assets were, comparatively speaking, a better hedge than stocks.

4.3 CAPM

Redmond and Cubbage (1988) suggest that inflation expectations play a major role in deducing stumpage prices and, therefore, the price of forest assets in general. Further, it is suggested that the value of the betas estimated by a real CAPM model may be the key component in indicating whether forest assets are held as a store of value in times of inflation. In this sense, a negative beta, suggesting movement against the market, would signify significant hedging capability. The Capital Asset Pricing Model, which builds on Portfolio Theory (Laubscher 2002), provides a simple and succinct description of the connection between risk and return in efficient markets. The CAPM, with the principle that the relationship between systematic risk (β)and expected returns is linear, models the equilibrium risk/return relationship (Laubscher 2002).

Zhang et al. (2011) use the CAPM model to study the relationship between inflation and timber returns. First, a nominal CAPM model is estimated, empirically and theoretically based on Markowitz's (1952) work of mean-variance efficient portfolio, with Sharpe (1964) and Lintner (1965) developing the macroeconomic implications (Zhang et al. 2011). Nominal CAPM states that the expected return of an asset/portfolio $E[R_i]$ equals a risk-free rate R_f in addition to a premium that is dependent on the beta of the asset and the expected market premium $E[R_m]R_f$.

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f] \tag{7}$$

However, since the empirical analysis is often done with realized returns, Zhang et al. replace ex ante expected returns $E[R_i]$ and $E[R_m]$ with ex post realized returns R_i and R_m and therefore the nominal CAPM can be estimated in the excess return form:

$$R_i - R_f = \alpha_i + \beta_i[R_m - R_f] + \mu_i \tag{8}$$

Where intercept α, known as Jensen's alpha, measures the abnormal performance, and slope beta i , also known as the systematic risk, measures how returns on an asset change with the market overall (Zhang et al. 2011).

Applying Fisher's hypothesis once more, nominal rate of return for asset i (R_i) can be expressed as:

$$1 + R_i = (1 + r_i)(1 + \pi)^{\gamma_i} \tag{9}$$

Where r_i is the nominal return of the asset, π is the inflation rate and, just like in Washburn and Binkley's model, we have arrived at a γ-value measuring the responsiveness of an asset to inflation, and thus its inflation hedging capability.

Zhang et al. (2011) argue that a two-factor model, i.e., the CAPM in real terms, which accounts for market risk, is the most appropriate model for examining the marginal ability of inflation hedging, as while the nominal CAPM can measure hedging ability, investors additionally care about diversifying their residual risk (Zhang et al. 2011). Therefore, the above equation is linearized using the Taylor expansion, and the equation is decomposed into expected inflation π_e and unexpected inflation π_u, which finally leads to:

$$R_i - r_f = \alpha_i + b_i(R_m - r_f) + c_{i,e}\pi_e + c_{i,u}\pi_u + \epsilon_i \tag{10}$$

Where c signifies how the return generating process relies on inflation and is composed of the difference between hedging capability of the market and the asset (i - m * b). With the model showing a positive linear relationship between the hedging capability and both forms of inflation, we can see that higher returns for an asset should be accompanied by increases in either inflation or increased market returns.

Using rolling regressions, i.e regressions with a data set that is allowed to change values over time, Zhang et al. find low β estimates, signifying low sensitivity to market changes and thus a good diversifying asset, which is consistent with previous empirical work. Additionally, when converting to the CAPM in real terms, the Jensen estimate generally disappeared, suggesting a reduction in abnormal returns found when accounting for inflation. Finally, Zhang et al. (2011) argue that forest assets alone, outside of a portfolio context, should not be considered as consistent or persistent hedges against inflation unless held long term.

4.4 Criticisms of the Theoretical Framework and Models

Several researchers doubt the applicable relevancy of the Fisher hypothesis, especially in the context of measuring hedging ability against expected inflation. The empirical support and validation for the Fisher Hypothesis has historically been mixed and inconclusive (Salisu et al. 2020), with several researchers from multiple parts of the world studying different circumstances finding evidence to support it while others have found evidence in favor or rejection.

Wahlroos and Berglund (1986), when studying the 1970 - 1982 period, found that the suggestion that nominal stock returns "vary one-to-one with real returns can be rejected". Solnik (1983) rejects the soundness of the Fisherian assumption that real stock returns are independent, of and separate from, inflationary expectations altogether (Lausti 2004). Some more econometrics-centric perspectives have also been prevalent in this area. Generally, two time series should only be regressed on each other if they are both stationary, thus not varying unreliably, or if they both would require the same amount of differencing, a transformation technique, to become stationary (same order of integration). Bekdache et al. (2000), with such an econometric perspective, points out that tests using the Fisher equation assume that nominal interest rates and inflation are of the same order of integration, and find that the regressions constructed from Fisher's hypothesis are "spurious" (meaningless correlation with no real causality) and that, because the two variables (inflation and interest rates) indeed do not share the same order of integration, the Fisher models, especially when applied to long-term research, are flawed and unreliable.

Additionally, the stationarity of the real interest rate implied by Fisher has been questioned since the work of Rose (1988). According to multiple studies such as Rapach and Wohar (2004), the real interest rate has a unit root, which implies nonstationarity, and therefore the long-run Fisher effect does not hold. Another method of questioning the stationarity of the real interest rate involves whether or not a cointegration relation can be found. Atkins and Serletis (2003) find no evidence of cointegration between inflation and nominal interest rates, while Evans and Lewis (1995) find evidence in favor of cointegration. It can be concluded that there is no general consensus among economists or statisticians within the field of finance or economics on whether or not the real interest rate can be considered stationary.

However, the Fisher hypothesis is still held as an accepted and evidenced baseline for empirical research in economics, and has, while being widely tested in many different scenarios worldwide, been proven by many to hold. Ozcan and Ari (2013) tested whether the nominal interest rate fully responds to changing inflation in G7 countries, and found that the results indicated that a long-run relationship between inflation rate and nominal interest rate is present, thus signifying that the Fisher equation holds. Further, the basis of the Fisher hypothesis builds on economic theory that has long been proven true. Inflation erodes the purchasing power of money over time, and lenders require higher levels of nominal interest rates in order to compensate. Mishkin (1981) found that inflation and nominal interest rates were positively correlated in the United States between 1960 and 1979, supporting the

Fisher Hypothesis, additionally claiming that Fama's 1974 finding that the constancy of the real rate could not be rejected is "the exception and not the rule" (Mishkin 1981).

Although there exists evidence of the Fisher effect globally, different countries have different inflation rates, monetary policies, and economic structures that affect the relationship between, and the causality of, inflation and nominal interest rates. Countries where the monetary policy decision-making power is centralized may be able to swiftly alter rates in order for the economy to end up in a long-run situation where the Fisher estimate was correct. Similarly, different time periods may have different economic conditions that affect the relationship between inflation and nominal interest rates, which the Fisher hypothesis may not be able to predict.

Similarly, the CAPM has been subject to considerable theoretical investigation and years of empirical research. One of the core assumptions of CAPM is that all investors have the same set of information and hold identical portfolios, which is of course an unrealistic assumption to make. Further, the assumption of no taxes is wholly unrealistic, as is the assumption of homogeneity, as investors generally have differing expectations, apply various investment periods, and have differences in rationale and motivations for each decision made (Laubscher 2002). The non-existence of a true market portfolio (Laubscher 2002) also dilutes the CAPM validity as the market portfolio is used as the main comparison for individual assets. The notion that investors purely care about the mean and the variance of returns is also an assumption deemed flawed, as portfolio returns are generally distributed asymmetrically and investors tend to view risk as more than means and variances of returns, causing the beta measure to be perceived as an incomplete estimate for risk (Laubscher 2002). Some researchers argue that a one-period asset pricing model such as the CAPM may not fully explain the managerial flexibility when it comes to assets such as the class of forestry (Zhang et al. 2011), and that the model in general fails to capture the complexity of financial markets.

With application to forest assets in mind, past results may be subject to doubt as there are several other considerations for evaluating timber assets. First, timber is a long duration asset. A typical southern pine plantation has a "25-30 year rotation" (Zhang et al. 2011) With the previously mentioned assumptions regarding CAPM, with differences in investor's time horizons not accounted for, there may be too vast generalizations made which could weaken the validity of the overall conclusion.

5 Discussion

Few studies in the field of forest assets have assessed the performance of forestry-related investment in conjunction with a CAPM application by directly using investment return from timberland (Liao et al. 2009). Alas, the strikingly different approaches to evaluating the hedging ability of forest assets may be the main culprit in a lack of consensus among researchers.

With the two research papers reviewed, one could consider the possibility that the measures of inflation expectations could be biased on a systematic level. Perhaps comparing inflation-hedging characteristics against actual inflation is a step in confirming an absence of bias in these studies, which could alter the results somewhat. Lausti (2004) finds a correlation coefficient of 0.28 (p-value 0.12) over the whole period from 1972 to 2003 between forest ownership and inflation in Finland. With a p-value above 10 percent, it is deemed insignificant and the notion of a possible correlation between inflation and forest assets is rejected (Lausti 2004).

Additionally, the variation in time periods researched means that while forest assets may be considered as inflation hedging for a certain period, perhaps it can be the opposite in certain cases with a shorter time horizon. Forest asset prices are especially cyclical. If a forest property owner is considering harvesting now or at some future point, he or she is naturally interested more so in the short-run than the long-run, which would also apply to some investors. Perhaps modeling short-run, such as yearly, decision making by using dynamically different time series models or something of the like could account for these discrepancies.

There are clear macroeconomic implications and opportunities when it comes to the impacts of potentially increased investments into forest assets. Whether investment in forest assets is done through direct ownership or purchase of timber products, such investments provide societal benefits and a road ahead in terms of a direction for future investors and thus macroeconomic implications. Increased investment from the public sector can help to increase biodiversity protection efforts by keeping trees and other wildlife in place not only for conservation reasons but as they are inherently value generators themselves due to forests' new found 'asset' status. However, this would not necessarily be restricted purely to the public sector as such developments and potentially furthered focus on bio-development or sustainability in general can help prop up forest asset value even more, satisfying both shareholders and stakeholders in a wider sense of the word.

As mentioned earlier in the text, 73 percent of the world's forests is under public ownership. This suggests a clear pathway for governments to be more involved in ’propping up’ their forest sectors financially and utilizing it perhaps for more multi-faceted reasons than e.g. exports. Public, direct investment itself could serve as a way for governments to protect their own purchasing power, as forests are a revenue stream that is not directly tied to traditional financial markets, leading them to be able to provide more government aid with less of a burden. Additionally, more prevalence in the forest sectors could create increased employment opportunities, thus generate revenue, and promote economic development in otherwise more rural or indigenous communities. Hence, inflation protection can be provided in other fashions than simply additions to portfolios for investors, instead also through diverse revenue or income sources for the labor market and governments on a macroeconomic scale.

Some researchers have considered alternate methods of modeling, but these are largely unsubstantiated. Heikkinen and Kanto (2000) suggest that the Finnish stumpage prices are co-integrated with stock prices, which would affect diversification decisions by investors. While forest assets are generally not considered correlated with other stocks in the short run in the larger view, studying long-run correlation could shed light on ties to the rest of the stock market that could make application of conventional models to forest stocks easier. Accounting for the long-run correlation may also improve predictions of asset returns. Since current and past researchers already use proxies for forest asset returns, establishing what kind of relationship forest assets have to other, more prominent inflation hedging mainstays like gold, could help measure hedging easier as gold does not share many of the unique characteristics of forests.

The methods of research may also have to vary more depending on the purpose of the study. For institutional investors looking to diversify their portfolios, perhaps using mean-variance optimization (Heikkinen 2002) is more fitting. The expected mean, variance, and correlation (or covariance) matrix of asset returns are crucial input data for portfolio optimization, the inclusion of which would narrow down the research and make it more focused, possibly leading to more significant and relevant results.

6 Conclusion

Forest assets have long been viewed to be effective hedges against inflation. Inflation hedging is an important component of an asset for an investor to consider when either diversifying their portfolio against risk or purely when protecting them from what is expected to be an incoming or current inflationary period. While some assets may hedge against higher than expected inflation, some may instead protect from lower than expected.

Research has shown that forest assets have, quite recently in relative terms to other asset classes, risen as a suitable contender as a stable, long-sighted investment target due to the unique components and characteristics of biological growth, long-term commitments by producers, steady cash flows, etc. However, the sparse, significantly diverging and inconclusive research has yet to cement the notion of forest assets as a safe-bet hedge against inflation as an empirical truth. After all, inflation can occur due to a wide variety of circumstances, and investment contexts can differ. Washburn and Binkley (1993) as well as Zhang et al. (2011) attempt to tackle this issue, leading to differing results and conclusions. The former use Fama and Schwert's work and the Fisher hypothesis to examine stumpage prices' relation to inflation in the US, while the latter suggest that a two factor model, i.e the CAPM in real terms which accounts for market risk, is more appropriate for examining the marginal ability of inflation hedging. Perhaps the theoretical framework(s) employed are weak, or the different approaches concerning an all-too wide categorisation of forest assets is to blame.

Therefore, although past empirical work has helped influence investors' decision making and strategy regarding investment decisions during periods of inflation and recession, additional work in the future is all but necessary in order to establish any form of consensus on the issue, especially with recent surges in price levels globally due to a wide variety of causes. Allowing institutional and private investors to protect themselves against eroding purchasing power is significant for preserving economic strength and demand, which makes any information gained a valuable asset in and of itself for investors and forest owners alike. Forest assets also represent a future in terms of sustainability and stability, symbolizing a steady, trustworthy source of cash flow in addition to protection of natural environments.

Future researchers may want to explore employing other applications of the Fisher hypothesis, as further research would go a long way to recognising more affirmed tools for measuring inflation hedging. While Fisher's hypothesis is sound and holds in various contexts, the application could be tweaked to include fewer unrealistic assumptions about homogeneity in investor conditions and expectations, variations in time periods, and so on. A potential improvement when it comes to the methodology could be the use of risk assessment tools such as the Monte Carlo method, which could be made impossible when applied to forest assets hedging inflation if inflation itself is incorporated as a risk, and not just treated as a rise in the price level. Chudy et al. (2020) already made use of a Monte Carlo model when examining risk sources in timberland, so one would assume that further application, especially in this field, is possible.

Despite empirical challenges and more work to be done, it is clear that several traits of forestry contribute to its attractiveness for investors, as it has long stood as a helpful asset class for various objectives such as sustainability, stability, and potentially, protection from damage done by inflation. With empirical work using several different methodologies and coming up with vastly different results, one cannot conclude, based on existing work, that forest assets unconditionally successfully hedge against inflation, although several examples of successful investments in such assets exist.

With macroeconomic implications in mind, it is apparent that forest assets can represent a future for sustainable investment and a safe, welcoming direction for such investments that also provides ground for macroeconomic support by way of subsidization and other financial aid approaches. People visit parks, forests, other nature reserve areas almost if not every day, and the uniqueness of such an asset that lends itself not only as an attractive investment but also a public good, makes it important to consider from a societal perspective.

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