Long-Horizon Losses in Stocks, Bonds, and Bills: Evidence from a Broad Sample of Developed Markets

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JEL classifications: C15, D31, G10, G11, G12, G15, G17, N20

Key words: Long-horizon returns, loss probability, survivor bias, easy data bias

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1 Introduction

Long-term losses from diversified investments in major asset classes have stark consequences for long-horizon investors. A 30-year loss in the domestic stock market, for example, is particularly concerning to retirement savers, as much of their viable savings period is consumed without generating wealth. Pensions and endowments rely on long-run returns from their equity and fixed income investments to maintain asset balances while supporting payouts to claimants. Long-horizon losses are even more damaging if multiple asset classes simultaneously lose, and investor welfare especially suffers when losses occur in conjunction with poor economic outcomes. Investors heeding the conventional wisdom, which is largely based on the historical record of US asset classes, may view a long investment horizon as sufficient to achieve gains in stocks and bonds with virtual certainty.[1] The historical record of US asset class performance is short, however, such that it may provide an incomplete characterization of long-term outcomes. The global history of developed markets can provide investors with a broader view of the probability and potential severity of long-term losses as well as the financial market and economic conditions accompanying these losses.

We provide systematic evidence on periods with long-horizon losses from investments in domestic stocks, international stocks, government bonds, and government bills. We use a new, comprehensive dataset that spans nearly 2,500 years across 38 developed countries with an overall study sample period of 1890 to 2019. We are cognizant of the potential for survivor bias [Brown, Goetzmann, and Ross (1995)] and easy data bias [Dimson, Marsh, and Staunton (2002)], which arise from conditioning on eventual market outcomes or easy availability of data while forming a sample. Our sample formation techniques are designed to mitigate these biases. We identify developed countries using ex ante available information, and we take significant steps to ensure that our data contain no unintentional gaps in the middle or at the end of our sample for any of the four asset classes.

We use a bootstrap simulation approach to study the joint distribution of real returns on domestic stocks, international stocks, bonds, and bills in developed markets with investment horizons ranging from one month to 30 years. We focus on estimating the probability and potential

[1] See, for example, "these short-term swings in the [stock] market, which so preoccupy investors and the financial press, are insignificant compared with the broad upward movement in stock returns," [Siegel (2014)] and "US government bonds are considered to be the world's safe store of value," [He, Krishnamurthy, and Milbradt (2016)].

severity of long-horizon real losses in these asset classes. Long-horizon losses are not rare. Our estimates of real loss probabilities for 30-year, buy-and-hold investments are 13% for domestic stocks, 27% for bonds, and 37% for bills. We characterize the periods with long-horizon losses by examining (i) financial market conditions and the potential for simultaneous losses across multiple asset classes, (ii) return components to better understand the causes of poor performance, and (iii) macroeconomic outcomes in loss periods.

We identify developed countries following Anarkulova, Cederburg, and O'Doherty (2022). Before 1948, countries are classified as developed when their agricultural labor shares drop below 50%, drawing from evidence in the economics literature about labor patterns and economic development [e.g., Kuznets (1973)]. Beginning in 1948, developed country classifications are based on membership in the Organisation for Economic Co-operation and Development (OECD) and its predecessor, the Organisation for European Economic Co-operation (OEEC). During the developed period of each country, we calculate real monthly returns on domestic stocks, bonds, and bills. We also calculate returns on a value-weighted portfolio of all foreign stock markets (excluding the domestic stock market), and we measure international stock portfolio performance using real returns denominated in the domestic currency of the country under consideration.[2] Our dataset spans 91% of the potential sample of developed country asset returns.

We estimate distributions and loss probabilities using a block bootstrap procedure. The procedure extends the methods used in recent studies characterizing the distribution of stock market returns [e.g., Fama and French (2018) and Anarkulova, Cederburg, and O'Doherty (2022)]. Our bootstrap approach draws blocks of multiple consecutive months from a given developed country period and draws simultaneously the set of returns on domestic stocks, international stocks, bonds, and bills for each month in the block. The block structure preserves time-series dependencies in the data, and drawing all four asset returns preserves cross-sectional dependencies.

Our empirical analysis begins with an examination of the marginal distributions of the four asset classes. We focus on bootstrap marginal distributions of 30-year cumulative real wealth from a $1.00 investment. We note that all payoffs are denominated in the home country currency to reflect the

[2] For the fixed income assets classes (i.e., bonds and bills), we consider only domestic market performance. About two-thirds of total public debt is held by domestic investors [Reinhart and Rogoff (2011)].

investment experience of a developed country investor, and we denote wealth in dollars only for the convenience of specifying a currency when we discuss wealth levels. Domestic and international stocks have favorable payoff distributions relative to bonds and bills with a 30-year horizon. Stocks have high average payoffs at $7.45 for domestic stocks and $7.80 for international stocks compared with only $2.34 for bonds and $1.32 for bills. The broad asset class distributions also have non-trivial mass in the region of real losses. The loss probability for domestic stocks is 12.6%. This estimate is consistent with the results of Anarkulova, Cederburg, and O'Doherty (2022), who emphasize that the estimated loss probability for domestic stocks in developed countries is quite high relative to the conventional wisdom that stocks are safe over long horizons [e.g., Siegel (2014)]. Relative to domestic stocks, the international stock portfolio produces a lower loss probability of 4.2%. International stock investments benefit from diversification across markets, and mean reversion in real exchange rates helps to hedge domestic inflation outcomes consistent with the literature on purchasing power parity (PPP). Bonds and bills often fail to outperform relative to inflation with real loss probabilities of 26.8% and 36.9%, respectively, and these asset classes occasionally realize catastrophic real outcomes in inflationary periods. These high loss probabilities dispel any notion that fixed income investments are safe, at least when considering real buying power.

We next study the joint performance of multiple asset classes with a focus on the potential for joint losses across markets over a 30-year horizon. The results show a considerable tendency for multiple asset classes to experience simultaneous losses. Whereas the unconditional loss probability for domestic stocks is 12.6%, for example, loss probabilities are substantially higher conditional on a loss in international stocks (39.1%), bonds (28.8%), or bills (20.7%). Bonds and bills are more likely than not to lose for all cases in which another asset class experiences a loss.

We proceed to characterize the long investment periods with losses in domestic stocks, international stocks, bonds, or bills. We find that poor domestic stock market outcomes are typically driven by large, negative real dividend growth realizations, with drops in valuation levels providing a secondary effect. Losses from international stock investments tend to occur from a combination of poor real foreign stock market performance and unfavorable shifts in real exchange rates. Inflation plays the dominant role for bonds and bills, as it is rare for fixed income assets to achieve gains in inflationary periods.

Finally, we investigate economic conditions during the periods with long-horizon losses. Losses in each asset class tend to occur in periods with worse economic outcomes. The average log per capita real gross domestic product (GDP) growth rate, for example, is 1.0% per year in periods with 30-year losses in domestic stocks versus 1.9% in periods with gains. The poor cumulative economic growth outcomes in loss periods are concentrated within the handful of worst return years for stocks, as these periods tend to contain a large, negative economic shock along the lines of the rare disasters studied by Barro (2006) and Barro and Ursúa (2008), among others. We also observe contrasts between patterns in real dividend growth and real GDP growth in loss periods. Unlike the concentrated losses in GDP, dividend growth tends to be negative or stagnant during the majority of a 30-year loss period. Because of this pattern and the large magnitude of losses in dividends compared with GDP, loss periods tend to display a large shift in the ratio of aggregate dividends to GDP, which can be interpreted as a proxy for the profit share of total output in the economy [see, e.g., Kuvshinov and Zimmermann (2022)]. Our results thus provide circumstantial evidence in support of the importance of shifts in labor share and capital share [see, e.g., Barkai (2020)] for long-term stock market outcomes [see, e.g., Greenwald, Lettau, and Ludvigson (2022)].

We contribute to a large literature studying interrelations between domestic stocks, international stocks, bonds, and bills. For example, Longin and Solnik (2001); Forbes and Rigobon (2002); Goetzmann, Li, and Rouwenhorst (2005); Connolly, Stivers, and Sun (2007); Bekaert, Hodrick, and Zhang (2009); Christoffersen, Errunza, Jacobs, and Langlois (2012); and Bekaert, Harvey, Kiguel, and Wang (2016) consider comovement in equity markets across countries. Shiller and Beltratti (1992); Campbell and Ammer (1993); Connolly, Stivers, and Sun (2005, 2007); Yang, Zhou, and Wang (2009); Baele, Bekaert, and Inghelbrecht (2010); Duffee (2022); and McQuarrie (2021), among others, study the relations between the returns on stocks and bonds.

Our study also contributes to a literature that uses international data and long samples to address issues for which the relatively short US sample may fail to provide definitive evidence. These studies often examine tail probabilities and peso problems [Rietz (1988)] or economic issues for which statistical tests have low power. For example, Barro (2006); Barro and Ursúa (2008, 2012, 2017); Barro and Jin (2011); and Nakamura, Steinsson, Barro, and Ursúa (2013) study rare macroeconomic events using broad samples of countries and long periods, and Muir (2017) and Kroencke (2022) investigate asset prices in recessions and financial crises. Goetzmann and Jorion (1995), Lundblad (2007), Golez and Koudijs (2018), and Anarkulova (2022) consider stock market return predictability and overcome power issues by extending their samples with longer historical periods. Several studies also estimate equity premiums across a broad set of countries [e.g., Jorion and Goetzmann (1999); Jorion (2003); Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019); and Dimson, Marsh, and Staunton (2002, 2021)]. Homer and Sylla (2005) and Schmelzing (2020) use long samples of developed countries to study trends in real interest rates.

Our paper is most closely related to Anarkulova, Cederburg, and O'Doherty (2022) and Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019). Anarkulova, Cederburg, and O'Doherty (2022) use sample formation procedures and simulation methods similar to ours to estimate the long-horizon distribution of real domestic stock returns in developed economies. We make a significant extension to this dataset by adding returns for international stocks, bonds, and bills, and this extension allows us to study both marginal and conditional distributions of long-horizon returns for four major asset classes. We also characterize loss periods in terms of joint asset market performance, underlying drivers of performance, and contemporaneous macroeconomic outcomes. Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019) construct a dataset of annual returns for stocks, bonds, bills, and housing across 16 countries over the period from 1870 to 2015. Their empirical analyses focus primarily on first moments of asset class performance: average real returns for risky and safe assets, average risk premiums of risky assets over safe assets, and average returns to wealth relative to economic growth. Our focus, in contrast, is on the full marginal and joint payoff distributions for major asset classes over long horizons. We place specific emphasis on the uncertainty about long-horizon outcomes, the probabilities of experiencing a real loss for each asset class, and the real macroeconomic outcomes in loss periods.

The remainder of the paper is organized as follows. Section 2 describes our dataset construction, details return calculations, and provides summary statistics. Section 3 outlines our primary bootstrap approach for estimating payoff distributions. Section 4 presents our empirical findings for the payoff distributions and characterizes the periods with a long-horizon loss in a major asset class. Section 5 concludes.

2 Data

We construct a dataset of real returns on domestic stocks, international stocks, bonds, and bills for developed countries. When we form the return series for a given country, all returns are measured in the local currency and the local country's inflation rate determines the adjustment from nominal to real returns. The returns for each country thus reflect the experience of an investor living in that country. The overall sample period for our study is 1890 to 2019, but sample start dates for individual countries differ based on economic development and data availability. Our dataset contains monthly return observations, and we have a balanced panel of data for each country in the sense that no asset has a missing return for any of the country-months included in the sample.

Our primary data source is the GFDatabase by Global Financial Data (GFD). This database contains long time series of returns, prices, and dividend-price ratios for stocks; yields for bonds and bills; inflation; exchange rates; total stock market capitalization; GDP; and population for a broad set of countries. For some countries, we supplement these data with observations that we hand collect from original source documents (e.g., statistical yearbooks) or gather from alternative sources [e.g., the St. Louis Federal Reserve or Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019)] to extend samples, fill gaps, or replace apparent errors in the data. As we detail further below, the resulting dataset has no unintended gaps in the middle or at the end of the sample, which is important for mitigating the effects of survivor and easy data biases. Anarkulova, Cederburg, and O'Doherty (2022) show that these biases can have a large quantitative effect on the estimated distribution of long-horizon domestic stock market returns.

The remainder of this section is organized as follows. Section 2.1 provides information about real return calculations. Section 2.2 outlines the classification of developed countries and details country-specific sample periods. Section 2.3 discusses special data issues. Section 2.4 presents summary statistics.

2.1 Return calculations

2.1.1 Domestic stocks

Our domestic stock market return calculations mirror those in Anarkulova, Cederburg, and O'Doherty (2022) with minor exceptions. The GFDatabase contains data for total return indexes, price indexes, and dividend-price ratios. It includes stock market indexes that are created and calculated by stock exchanges (e.g., the Tokyo Stock Price Index from the Tokyo Stock Exchange), by well-known index providers (e.g., the S&P 500 Index), or by GFD directly from original source documents. Multiple stock indexes are available in the database for some countries and periods. We select a single index in these cases by considering the breadth of market coverage and the length of historical coverage. We use a total return index whenever one is available, and we otherwise use a price index and a dividend-price ratio to calculate returns. Our index choices for each country are available in the Internet Appendix.

For sample months in which a total return index is available, we calculate the monthly nominal return,

$$R_{i,t}^{Nominal\ stocks} = \frac{I_{i,t}^{Total}}{I_{i,t-1}^{Total}}, \tag{1}$$

where $I_{i,t}^{Total}$ is the total return index for country i at the end of month t and $R_{i,t}^{Nominal\ stocks}$ is the gross nominal return for country i in month t. If no total return index is available, we use price index and dividend-price ratio data to calculate returns. Following Anarkulova, Cederburg, and O'Doherty (2022), we assume that the annual dividend reflected by the reported dividend-price ratio is paid equally across months in the year. If $I_{i,t}^{Price}$ is the price index and $\hat{D}_{i,t}$ is the estimated dividend (appropriately scaled to the level of the price index) for country i in month t, then we calculate the monthly nominal return,

$$R_{i,t}^{Nominal\ stocks} = \frac{I_{i,t}^{Price} + \hat{D}_{i,t}}{I_{i,t-1}^{Price}}. \tag{2}$$

Additional details on return construction are available in the Internet Appendix and in Anarkulova, Cederburg, and O'Doherty (2022).

We use consumer price index (CPI) data to convert nominal returns into real returns. We first calculate gross inflation,

$$\Pi_{i,t} = \frac{I_{i,t}^{CPI}}{I_{i,t-1}^{CPI}}, \tag{3}$$

where $I_{i,t}^{CPI}$ is the CPI for country i at the end of month t. We then calculate the gross real return on domestic stocks given the gross nominal return and gross inflation,

$$R_{i,t}^{Stocks} = \frac{R_{i,t}^{Nominal\ stocks}}{\Pi_{i,t}}. \tag{4}$$

This return calculation produces real returns that are denominated in the local currency of country i.

2.1.2 International stocks

We calculate real returns on a portfolio of international stocks from the perspective of an investor in a developed country. For each country, the international stock portfolio is a weighted investment across all developed stock markets excluding the local stock market. The international stock portfolio is value weighted by total market capitalization, and the returns are expressed in the domestic currency such that they reflect the exchange rate risk incurred by investing in assets denominated in foreign currencies.

The return calculation for international stocks uses the gross nominal stock market returns calculated in the previous section. We first convert the nominal return for each country $j \neq i$ into a real return that is denominated in the domestic currency of country i,

$$R_{j,t}^{Real\ domestic\ currency} = \frac{R_{j,t}^{Nominal\ stocks}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right), \tag{5}$$

where $E_t^{i,j}$ is the exchange rate at the end of month t expressed in country i currency per country j currency. We then calculate the gross real return on international stocks for country i in month t,

$$R_{i,t}^{International\ stocks} = \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Real\ domestic\ currency}, \tag{6}$$

where $w_{j,t-1}$ is country j's weight in the international stock portfolio in month t,

$$w_{j,t-1} = \frac{M_{j,t-1}}{\sum_{j \neq i} M_{j,t-1}}, \tag{7}$$

and $M_{j,t-1}$ is the total market capitalization for the stock market in country j at the end of month $t-1$ expressed in US dollars.

2.1.3 Bonds

We calculate bond returns using monthly data on bond yields. For comparability across countries and periods, we focus on ten-year government bonds. The GFDatabase has variables for ten-year bond yields for most countries and periods in our sample, and we supplement these data to achieve full data coverage. We provide details on these instances in the Internet Appendix.

We first estimate ten-year bond prices given bond yields. We assume the bond has exactly ten years to maturity, semiannual coupons, and a coupon rate equal to the greater of the bond yield and zero at the end of month $t-1$. For nearly all observations in the sample, this calculation implies the bond is trading at par at the end of month $t-1$; the calculation implies the bond price is above par in the few cases with negative bond yields. We then reprice this bond at the end of month t given the month-t yield and the one month shorter maturity. We calculate the gross nominal return,

$$R_{i,t}^{Nominal\ bonds} = \frac{P_{i,t}}{P_{i,t-1}}, \tag{8}$$

where $P_{i,t}$ is the calculated dirty bond price (i.e., inclusive of accrued interest) for country i at the end of month t. Finally, we calculate the gross real bond return,

$$R_{i,t}^{Bonds} = \frac{R_{i,t}^{Nominal\ bonds}}{\Pi_{i,t}}. \tag{9}$$

This return calculation requires assumptions about the maturity and the coupon rate of the underlying bond. We validate this calculation in the Internet Appendix by comparing our calculated returns with returns from Datastream over the period of overlap between the two data samples.

Our return calculations are very highly correlated with and have similar moments to those from Datastream.

2.1.4 Bills

We estimate returns on bills using short-term yields and rates. For most countries and periods, the GFDatabase has coverage with yield data on short-term (typically three-month) government bills. When these data are missing, we next use central bank rates when available and then interbank rates from the GFDatabase. We supplement these data with hand-collected, short-term rates from original source documents to achieve full coverage. We provide additional information about variables and sources for short-term rates in the Internet Appendix. We convert annual nominal rates on bills into monthly nominal returns denoted by $R_{i,t}^{Nominal\ bills}$ and then calculate real returns,

$$R_{i,t}^{Bills} = \frac{R_{i,t}^{Nominal\ bills}}{\Pi_{i,t}}. \tag{10}$$

2.2 Development classification

We follow Anarkulova, Cederburg, and O'Doherty (2022) to classify countries as developed. We classify a given country as developed early in the sample period if its agricultural labor share is less than 50% based on evidence about labor patterns from the economics literature [e.g., Kuznets (1973)]. Beginning with the formation of the OEEC in 1948, we use membership in the OEEC and the OECD to identify development dates.

Table I displays the development date and the reason for classification for each country. As in Anarkulova, Cederburg, and O'Doherty (2022), our sample contains three instances in which a previously developed country is reclassified as developing. These instances occur in Argentina, Chile, and Czechoslovakia, and each reclassification results from substantial changes in governments and markets in these countries. Chile is reclassified as developed in 2010 with its membership in the OECD, and the Czech Republic and Slovakia are reclassified on the same basis in 1995 and 2000, respectively. We include the early periods in these countries to avoid survivor bias.

In order to form a balanced panel, a developed country can not enter into our sample until its government issues ten-year bonds. Several countries achieved economic development, but did not immediately issue long-term government bonds. As such, sample eligibility for these countries postdates their development years. Estonia is the sole developed country that did not have outstanding long-term bonds during its developed period, so this country is excluded from our dataset.

Table I shows the sample eligibility date and the data coverage for each country. The sample eligibility date is the latest of 1890 (i.e., the sample period start date for our study), the country development year, and the year in which the country first issued long-term bonds. The sample coverage dates denote the periods for which we have monthly data on domestic stocks, international stocks, bonds, and bills. No country has data gaps in the middle or at the end of its series.

For some countries, we have missing data at the beginning of the eligible period. Domestic stock market returns are the binding constraint in each of these instances, as we lack data for diversified indexes of stocks over these time frames. There are some periods for which we are missing both stock and bond data, but the bond data always become available before or at the same time as the stock data. Table I shows the sample coverage for each country by calculating the number of months in our sample as a percentage of the number of months between the sample eligibility date and the end of the sample period.

Figure 1 provides a visual representation of our sample coverage. The development dates and classification reasons are denoted by diamonds (agricultural labor share) and stars (OEEC/OECD membership), and years that predate the 1890 sample period start are shaded gray. The blue lines indicate developed periods in which we have continuous monthly data for domestic stocks, international stocks, bonds, and bills. The black dashed lines show periods in which the country is eligible to be in our sample but we have missing data. As the figure indicates, our dataset achieves broad coverage of the eligible sample periods. Our data span 29,919 months (about 2,493 years) of the 33,007 possible months (about 2,751 years), such that we cover 90.6% of the potential sample.

2.3 Special data considerations

A systematic issue with data availability arises from stock market closures. Anarkulova, Cederburg, and O'Doherty (2022) discuss 35 instances in which stock exchanges closed for extended periods, typically as the result of a major war, political revolution, or banking crisis. Investors tend to earn negative real returns in these periods, such that omitting countries or periods because of these stock return data gaps induces an easy data bias. Anarkulova, Cederburg, and O'Doherty (2022) treat each stock market closure period as a single multi-month observation in their bootstrap procedure. We also consider international stocks, bonds, and bills in this study, and a consistent monthly data frequency facilitates a cleaner analysis of the joint distribution of asset returns. As such, we produce a series of monthly returns on domestic stocks for each of the multi-month periods.

For some of the stock exchange closure periods, the GFDatabase provides monthly returns from black markets that operated during the period over which the regular exchange was closed. A prominent example of this type of market is the "New Street" market that formed within days of the closure of the New York Stock Exchange in July 1914 with the onset of World War I [Silber (2005)]. We use the data provided by GFD in these cases. For most other multi-month periods, we allocate the full-period real return to the first month of the period. An investor who held stocks when the stock market closed and was not able to trade in a black market would have eventually realized this full-period return, and the negative returns that occurred in many of these periods would have been foreshadowed to some degree by the negative nature of the event that caused the market closure. We also note that the block bootstrap design described in Section 3 often draws the entire set of returns that accompany an exchange closure, such that the buy-and-hold cumulative payoff reflects the full return realization that occurred during the exchange closure. Additional information about these periods is provided in the Internet Appendix.

We measure returns that are denominated in the primary home currency with one exception. Our real returns for Germany are denominated in gold marks (rather than paper marks) for the 1917 to 1923 period. Extraordinary hyperinflation during this period complicates the calculation of real returns based on nominal returns in paper marks, and the GFDatabase reports a series of stock market returns denominated in gold marks. We also calculate gold mark returns for international stocks, bonds, and bills.

The German bond market during this period of hyperinflation provides an interesting example of contrasting nominal and real outcomes. From the beginning of 1922 until Germany issued a new

Reichsmark currency in January 1924, German bonds realized a paper mark capital gain of over 1,200,000,000,000%. The bonds were trading at an extremely large multiple of their par value, as investors anticipated that the German government may issue new bonds to holders of the original bonds as compensation for the enormous real losses from inflation. The ultimate compensation to investors was small, and the cumulative real bond return denominated in gold marks was −99% despite the nominal return of nearly 800,000,000,000% over the inflationary period from 1917 to 1923.

The bond return calculation in Section 2.1.3 must be adjusted in the event of a default or bond exchange that produces a change in par value. Explicit defaults on domestic sovereign bonds are rare relative to external defaults, particularly for developed countries [Reinhart and Rogoff (2011)]. Rather, inflation is a more commonly used tool for eroding the real value of domestic debt.

A notable event that produced a change in par value is the Greek default in 2012. Greece undertook a debt exchange in March 2012 in which creditors exchanged their existing bonds for a package of new government securities with a lower face value. Zettelmeyer, Trebesch, and Gulati (2013) provide an issue-by-issue estimate of the haircut for existing bondholders. We use the 53.8% haircut estimate for the bond with maturity closest to ten years. The ten-year bond yield declined substantially from 36.6% to 21.0% in March 2012, such that our calculation based on bond yields produces a nominal net return of 67.1%. Our calculation of the nominal gross return that incorporates the haircut is $1.671 \times (1 - 0.538) = 0.772$ to produce a nominal net return of −22.8% for ten-year bonds in March 2012.

We also account for a bond conversion in Argentina in 1960 [Duggan (1963)] and the consequences of Germany's exchange in 1948 of Reichsmarks for Deutschemarks at a rate of 10:1 for sovereign bondholders [Schnabl (2019)]. Additional details are available in the Internet Appendix.

2.4 Summary statistics

Table II shows summary statistics for the monthly real net returns in our sample.[3] The table reports the number of monthly observations, the arithmetic and geometric means, the standard

[3] We provide summary statistics for nominal returns in the Internet Appendix.

deviation, the skewness and kurtosis, and the minimum and maximum returns for each asset and country. We also report statistics for the pooled sample of observations. The statistics in Panel A are for domestic stocks, those in Panel B are for international stocks, those in Panel C are for bonds, and those in Panel D are for bills. We note that (i) cross-country comparisons are somewhat difficult in this setting because of sample period differences and (ii) the recently developed countries have short samples that are likely not representative of long-term expectations.

Panel A of Table II reports summary statistics for domestic stocks. Several countries earned extreme real returns during the sample. Particularly notable losses occurred in Germany (−91.10%) and Czechoslovakia (−88.59%) in the aftermath of World War II and Portugal (−89.24%) during the Carnation Revolution in the 1970s. Relative to the US sample, the pooled sample from developed countries has lower means (0.53% versus 0.64% for arithmetic mean and 0.37% versus 0.52% for geometric mean), a higher standard deviation (5.59% versus 4.99%), and a higher kurtosis (39.91 versus 12.86).

Panel B of Table II shows results for real international stock returns. Investing in a portfolio of foreign markets produces a diversification benefit, but an investor's positions in assets denominated in foreign currency are subject to exchange rate risk. Given that the portfolio of international stocks is relatively similar across countries (i.e., the portfolio of international stocks is always a value-weighted investment in markets from all countries other than the one under consideration), much of the variation in international stock returns across countries is attributable to fluctuations in exchange rates. The most extreme examples of real returns that show this effect occur in countries that experienced large exchange rate shifts around currency reforms: Austria (299.72%), Germany (301.53%), Italy (372.03%), and Japan (373.06%). The pooled standard deviation of international stock returns in Panel B is higher than that of domestic stock returns in Panel A, but this difference is largely driven by the countries with volatile exchange rates. The international stock portfolio from the perspective of a US investor, for example, has a monthly standard deviation of only 3.78% compared with the pooled standard deviation of 6.74%.

A comparison of Panel C of Table II with Panels A and B reveals that bond investments earn lower real returns on average compared with stock investments, consistent with the historical US experience. The monthly arithmetic (geometric) mean return for bonds is 0.21% (0.10%) compared with 0.53% (0.37%) for domestic stocks and 0.58% (0.43%) for international stocks. Bonds have a higher pooled standard deviation compared with stocks, but this effect is attributable to the small set of extreme bond returns realized in the hyperinflation period in Germany discussed in Section 2.3. Bond returns have a lower standard deviation than do domestic stock returns for each country other than Germany.

Finally, Panel D displays results for bills. In our large sample of developed countries, bills earn, on average, just enough interest to offset inflation. The arithmetic (geometric) mean return of 0.01% (0.00%) indicates that the average real rate earned by investors in short-term, high-credit-quality debt is near zero.

3 Bootstrap design

We estimate the joint distributions of real returns on domestic stocks, international stocks, bonds, and bills over various horizons using a bootstrap simulation procedure. Our bootstrap approach randomly draws returns from the 29,919 monthly observations with replacement, and we calculate cumulative buy-and-hold returns for each asset at an H-month horizon to produce a bootstrap joint distribution. To capture the effects of time-series properties of returns, including time-varying volatility and mean reversion, we adopt a block bootstrap approach. A block bootstrap draws blocks of consecutive months of data from a country's sample, such that any time-series dependencies within these blocks are preserved. We draw random block sizes from a geometric distribution, and we set the block size parameter to produce an average block length of 120 months. Anarkulova, Cederburg, and O'Doherty (2022) demonstrate that this long average block length allows for the effects of relatively longer-term dependencies like mean reversion in returns to be reflected in the bootstrap distributions. We show robustness to this block length choice in the Internet Appendix.

As we draw a block of returns from a particular country, we maintain cross-sectional dependencies across assets by drawing the set of four asset returns for each month in the block. For example, the monthly bill return in a bootstrap draw is the return realization from the same country and month as the domestic stock return. Drawing the full set of four asset returns together allows us to estimate the joint distribution of returns while maintaining cross-asset relations.

We estimate bootstrap joint distributions at horizons up to 30 years, such that the longest horizon H is 360 months. Our approach is motivated by the stationary bootstrap of Politis and Romano (1994). This bootstrap method is designed to avoid undersampling from any portion of the sample. That is, to avoid undersampling returns at the beginning of each country's sample period, the stationary bootstrap specifies that a block that begins in a particular country's sample and is unfilled by the remaining data from that country wraps back to the beginning of a sample from a randomly chosen country to fill the block. The bootstrap procedure in iteration m is as follows:

1. We draw a random block size b from a geometric distribution with a probability parameter equal to the inverse of the desired average block length.

2. We randomly select a starting observation return vector for the block from the 29,919 months in the pooled sample. We denote this observation as

$$R_{i,t} = \begin{bmatrix} R_{i,t}^{Stocks} & R_{i,t}^{International\ stocks} & R_{i,t}^{Bonds} & R_{i,t}^{Bills} \end{bmatrix}, \tag{11}$$

   where i indexes the country and t indexes the month. If country i's sample contains return observations $R_{i,t}$ through $R_{i,t+b-1}$, the return block draw is $B_b = \{R_{i,t}, R_{i,t+1}, \ldots, R_{i,t+b-1}\}$. If not, then $\{R_{i,t}, R_{i,t+1}, \ldots, R_{i,T}\}$, where $R_{i,T}$ is the last observation in country i's sample, is insufficient to fill block B_b. In this case, we draw a random country j from the 39 developed periods discussed in Section 2.2. If country j has enough observations to fill the remainder of the block, the block is $B_b = \{R_{i,t}, R_{i,t+1}, \ldots, R_{i,T}, R_{j,1}, R_{j,2}, \ldots, R_{j,b-(T-t+1)}\}$. If not, the country j observations are added to the block, and we repeat the process and draw another random country until the block is filled.

3. We add B_b to the bootstrap return matrix draw $R^{(m)}$. We return to step one and repeat the process until the return matrix has 360 months of data for the four assets. The final bootstrap draw in iteration m is $R^{(m)} = \{R_1^{(m)}, R_2^{(m)}, \ldots, R_{360}^{(m)}\}$.

For a \$1.00 buy-and-hold investment, the draw of wealth for an H-month horizon is

$$W_H^{(m)} = \prod_{t=1}^{H} R_t^{(m)}. \tag{12}$$

We repeat this procedure for iterations $m = 1, 2, \ldots, 10{,}000{,}000$ to produce a bootstrap joint distribution of cumulative wealth in the assets at an H-month horizon. We choose the large number of draws because we consider conditional distributions in Section 4, and beginning with 10,000,000 draws from the joint distribution allows us to retain a large number of bootstrap draws even when we condition on relatively low probability events.

For two analyses, the return decompositions in Sections 4.2.2 and 4.3.1 and the macroeconomic outcomes in Section 4.3.2, we make two minor adjustments to the bootstrap procedure described above. First, we draw return components and macroeconomic variables from the selected periods in addition to drawing returns, maintaining cross-sectional dependencies across all variables. Second, we bootstrap over annual observations (rather than monthly observations) because we can more accurately measure GDP growth and the return decomposition components at an annual frequency. We maintain a block bootstrap approach with an average block size of ten years to capture time-series dependencies in the data.

4 Results

Section 4.1 provides information about asset class payoffs, including the estimated marginal payoff distributions (Section 4.1.1), the estimated joint payoff distributions (Section 4.1.2), and comparisons with estimates from US data (Section 4.1.3). Section 4.2 examines the underlying drivers of asset class performance by considering the effects of inflation on real outcomes (Section 4.2.1) and return decompositions and variance ratios that reveal sources of asset payoff uncertainty (Section 4.2.2). Section 4.3 characterizes the periods with long-horizon losses in a given asset class relative to the periods with gains. These comparisons focus on the sources of returns (Section 4.3.1) and macroeconomic outcomes (Section 4.3.2) across periods of loss and gain for each asset class.

4.1 Asset class payoffs

4.1.1 Marginal payoff distributions

We begin our analysis by considering distributions of payoffs for each asset class. Table III reports statistics for bootstrap distributions of real payoffs from buy-and-hold investments in domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D).[4] Each panel shows results for horizons ranging from one month to 30 years. For the marginal distribution at each horizon, we report the mean and standard deviation of the payoffs, percentiles of the distribution, and the probability of a loss in real terms. Figure 2 plots the distributions at horizons of one, ten, and 30 years. The distributions for domestic and international stocks are shown in the left panels (Panels A, C, and E), and the distributions for bonds and bills are shown in the right panels (Panels B, D, and F). The dashed line in each panel indicates the \$1.00 initial investment, such that the line separates the regions of real loss and gain.

The distributions for domestic stocks in Panel A of Table III closely match the main results of Anarkulova, Cederburg, and O'Doherty (2022). Stocks carry the potential for large real payoffs over long horizons, with mean real wealth reaching \$7.45 at a 30-year horizon for a \$1.00 initial investment. The distribution of long-term payoffs is highly skewed, as can be seen in Panel E of Figure 2, such that the mean of \$7.45 is high compared with the median of \$4.06. The uncertainty about long-term payoffs is particularly striking. The 10th and 90th percentiles of the 30-year distribution, for example, are \$0.82 and \$15.76, which represent extraordinarily different outcomes. Anarkulova, Cederburg, and O'Doherty (2022) emphasize the large real loss probabilities that persist even with long horizons and the potential for catastrophic investment outcomes. For our bootstrap distribution, Panel A shows a real loss probability of 12.6% at a 30-year horizon. Further, the 5th percentile of the 30-year cumulative wealth distribution is only \$0.46, indicating that outcomes in which half or more of the investor's buying power is lost are not exceedingly rare.

Panel B of Table III shows statistics for the distributions of international stocks. The means and standard deviations of the international stock distributions are similar to those for domestic stocks. The most striking differences between the distributions for domestic and international

[4] We provide a version of Table III based on nominal returns in the Internet Appendix.

stocks come from a comparison of loss probabilities. Whereas the two asset classes have similar loss probabilities on a monthly basis (42.8% for domestic stocks versus 41.7% for international stocks), the loss probability for international stocks declines more sharply with horizon. With a 30-year horizon, the loss probability for international stocks of 4.2% is small relative to the loss probability for domestic stocks of 12.6%. This difference can be seen in Panel E of Figure 2, as the international stock distribution has considerably less mass at low payoffs.

The distributions for bonds and bills are summarized in Panels C and D of Table III. Relative to equities, average payoffs for fixed income assets are low. At a 30-year horizon, the mean payoffs of \$2.34 and \$1.32 for bonds and bills, respectively, are dwarfed by the averages of \$7.45 for domestic stocks and \$7.80 for international stocks. These lower averages for bonds and bills are accompanied by lower risk as measured by standard deviation. Assessing risk with the probability of loss yields a different conclusion. Whereas loss probabilities for domestic and international stocks decline substantially as the holding period grows, those for bonds and bills are more stable across horizons. The 31.0% loss probability for bonds at a five-year horizon, for example, is similar in magnitude to the 26.8% probability of loss at a 30-year horizon. The odds of a real loss in bills have a small range from 36.9% to 40.5% across the six horizons we consider. The fixed income asset classes also carry non-trivial chances of overwhelmingly large losses, as the 5th percentiles of the 30-year distributions for bonds and bills are only \$0.12 and \$0.16, respectively.

The stark contrasts across assets in the patterns of loss probabilities for different horizons are apparent in Figure 3, which plots the loss probabilities for domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D) at horizons from one to 360 months. Whereas the loss probabilities for domestic and international stocks steadily decline as the horizon grows, the loss probabilities for bonds and especially bills are relatively flat as a function of horizon. Long investment horizons are necessary for equity investors to ensure a high probability of real gains in wealth from domestic and international stocks. Fixed income investors, even those with very long horizons, face substantial risk of losses in buying power from buy-and-hold investments in bonds and bills.

In the Internet Appendix, we show that we obtain qualitatively similar findings about distributional properties and loss probabilities with several alternative specifications. We demonstrate robustness to an alternative international stock portfolio with a 25% cap on each foreign country's weight, sample screens that remove countries with small populations, sample screens that remove countries with small stock markets, the removal of US data from the sample (including the exclusion of the US from international stock portfolios of other countries), and alternative samples based on the post-World War II period or the post-Bretton Woods period.

4.1.2 Joint payoff distributions

Our bootstrap design produces joint distributions of domestic stocks, international stocks, bonds, and bills for the developed country sample. Of particular interest is the potential for joint left-tail risk across assets over long horizons, as the degree to which assets tend to experience poor outcomes simultaneously is important for investors who hold multiple asset classes. The joint distributions of asset returns also help to characterize financial market conditions in periods with long-horizon losses in a given asset class.

Figure 4 shows the joint distribution of 30-year real payoffs for each asset class pair. Each panel shows a scatter plot of the first 100,000 draws from the bootstrap distribution (for ease of presentation), and each dot represents a joint outcome of the payoffs for the two assets. The dots in higher density areas are shaded yellow and the dots in lower density areas are shaded blue, so the dot colors produce a heat map for the joint distribution. Each axis has a log scale. Finally, the dashed lines mark the \$1.00 initial investment for each asset. Dots in the lower left quadrant of a panel, for example, are bootstrap draws with real losses in both asset classes.

Panel A considers domestic and international stocks. The payoffs show a clear positive relation, and the correlation between log payoffs is 0.35. Despite the positive relation, many of the poor outcomes in domestic stocks are accompanied by gains in international stocks, such that gains in foreign markets can often help investors offset local losses. A key to this protection provided by international stocks is a hedge against domestic inflationary periods, as described in Section 4.2.1 below.

Panels B and C show the relations of domestic stocks with bonds and bills, respectively. Domestic stock payoffs are positively related to the payoffs of both bonds and bills. The correlations of log domestic stock payoffs with log payoffs on bonds and bills are 0.46 and 0.36, respectively, indicating economically meaningful connections between the long-term realized performance across these asset classes.

International stock performance has little relation to bond and bill performance. Panels D and E of Figure 4 show the joint distributions, and there are no obvious patterns in the figure. Consistent with the visual appearance, the correlations of international stock payoffs with payoffs on bonds and bills are only 0.06 and 0.05, respectively. These results provide further evidence of the potential diversification benefits for investors who add international stock exposure to their portfolios.

Finally, Panel F of Figure 4 displays the joint distribution of bond and bill payoffs. A pronounced positive relation exists in the figure, consistent with intuition. As detailed in Section 4.2 below, realized inflation is the dominant determinant of the long-term performance of bonds and bills, and the nominal performance of both assets is tied to the level of interest rates. Despite the additional tendency for bonds to perform poorly on occasion due to increasing interest rates or domestic default, the estimated correlation is 0.81, such that the two fixed income asset classes are closely related.

An alternative approach to studying the joint behavior of asset classes is to examine distributions that condition on an outcome in another asset class. We begin by conditioning on domestic stock outcomes, and Table IV shows statistics for 30-year payoff distributions of international stocks (Panel A), bonds (Panel B), and bills (Panel C). Each panel summarizes the unconditional distribution (repeated from Table III for convenience) as well as conditional distributions for the sets of bootstrap draws for which the real payoff of domestic stocks at a 30-year horizon is greater than or less than \$1.00 (i.e., gain or loss periods, respectively).

The conditional distributions for international stocks in Panel A of Table IV show that investments in international stocks fare better in periods with gains in domestic stocks relative to periods with losses. The average (median) real payoff on international stocks is \$8.09 (\$4.99) in gain periods for domestic stocks versus only \$5.85 (\$2.72) in loss periods. The loss probability is also elevated when domestic stocks lose, with a 12.9% chance of real loss on international stocks accompanying a loss in domestic stocks compared with only a 2.9% chance of loss accompanying a gain in domestic stocks. As such, investors face a heightened risk of joint losses in the two equity asset classes.

Panels B and C of Table IV indicate that the long-horizon performances of bonds and bills are even more sensitive to domestic stock losses. The average (median) real bond payoff conditional on a loss in domestic stocks is only $1.07 ($0.70) compared with $2.52 ($1.95) conditional on a gain. Bills similarly suffer poor average performance when stocks lose with a conditional mean (median) payoff of $0.93 ($0.80) versus the mean (median) of $1.38 ($1.26) with a gain. Conditional loss probabilities are high at 61.0% and 60.4% for bonds and bills, respectively, when domestic stocks lose compared with 21.9% and 33.5% when stocks gain. These findings imply that investors who focus exclusively on domestic asset markets are subject to the potential for joint losses in each asset class. In untabulated results, we estimate the probability that domestic stocks, bonds, and bills all realize real losses over a 30-year horizon to be 6.4%, and these cases occur in over half of the bootstrap draws with losses in domestic stocks.

Table V expands our analysis of conditional 30-year loss probabilities by reporting results for all asset pairs. The table first shows the unconditional loss probabilities $[\mathbb{P}(W_{H,A}^{(m)} < 1)]$, which are repeated from Table III for convenience. The first column of conditional loss probabilities $[\mathbb{P}(W_{H,A}^{(m)} < 1 | W_{H,B}^{(m)} \geq 1)]$ corresponds to the results in Table IV for international stocks, bonds, and bills conditional on a gain in domestic stocks. The next three columns show loss probabilities for each asset conditional on a gain in international stocks, bonds, or bills. The final four columns show loss probabilities conditional on a loss in the reference asset class $[\mathbb{P}(W_{H,A}^{(m)} < 1 | W_{H,B}^{(m)} < 1)]$.[5]

The conditional loss probabilities for domestic stocks in Table V indicate substantial risk of loss in the event of a loss in another asset class. At a 30-year horizon, the conditional loss probabilities are 39.1% with a loss in international stocks, 28.8% with a loss in bonds, and 20.7% with a loss in bills. These conditional loss probabilities, which are all high compared with the unconditional probability of 12.6% and the corresponding loss probabilities conditional on gains in other asset classes, indicate an elevated risk of joint tail outcomes.

[5]In the Internet Appendix, we present a plot for each asset class of the unconditional loss probability and loss probabilities conditional on a loss in another asset class as a function of horizon.

The remaining asset classes in Table V also show indications of correlated losses. Consistent with the visual appearance of the joint distributions in Figure 4, the conditional loss probabilities for international stocks are most closely related to outcomes in domestic stocks. The loss probabilities for bonds and bills are high conditional on a loss in any other asset class. Bonds have an unconditional 26.8% chance of loss at a horizon of 30 years, and the conditional loss probabilities are 61.0% (loss in domestic stocks), 52.6% (international stocks), and 61.0% (bills). Similarly, the 36.9% unconditional loss probability for bills increases to 60.4%, 64.0%, or 83.9% when we condition on a loss in domestic stocks, international stocks, or bonds, respectively.

4.1.3 Comparison with US results

Before proceeding, we compare the distributions estimated using our full sample of developed countries with distributions estimated using only US data. Table VI reports statistics for the US distributions for each of the four assets. Anarkulova, Cederburg, and O'Doherty (2022) emphasize that the loss probability in domestic stocks estimated from US data is small compared with the value from the full developed sample. We similarly find in Panel A of Table VI that the 30-year loss probability estimated using US data is only 1.2% compared with the 12.6% probability in Table III.

From the perspective of an investor who learns only from historical US data, international stocks appear less attractive relative to domestic stocks. This finding contrasts with that in Table III for the full developed country sample. The results for international stocks in Panel B of Table VI show lower mean and median payoffs relative to domestic stocks in Panel A. Loss probabilities are also higher for international stocks compared with domestic stocks using the US data. At a 30-year horizon, for example, the international stock portfolio shows a 7.6% chance of loss relative to 1.2% for domestic stocks. This result reflects that the international stock portfolio excludes the US when we take the perspective of a US investor, whereas the US has a large weight in the international stock portfolios of other countries. The higher loss probability estimate for international stocks using US data is the flip side of the same coin that produces the lower probability estimate for domestic stocks.[6]

[6] We caution against making sharp predictions about whether domestic stocks or international stocks are likely to outperform for investors domiciled in a particular country, such as the US, based on the relatively short history of a

Panels C and D of Table VI show that bonds and bills have low average payoffs compared with stocks, similar to the evidence from developed countries in Table III. The loss probabilities over long horizons are somewhat lower for the US analysis compared with the developed country analysis, but the chances of loss remain relatively high at 18.5% for bonds and 25.0% for bills over a 30-year horizon. A comparison of Tables III and VI also reveals that the developed country sample produces much higher probabilities of catastrophic real losses in bonds and bills compared with the US sample, which reflects the relative lack of inflationary periods in the historical US record compared with all developed countries.

A natural question is whether investors domiciled in the US should consider historical information from other developed countries or learn solely from the US experience. Our perspective is that the developed country sample is informative to US investors. Our US sample spans just 130 years, which is a relatively short history when considering potential outcomes over long horizons such as 30 years. Further, there is evidence that the average realized US stock return exceeded the ex ante expectation over this period because the equity risk premium unexpectedly declined [Fama and French (2002); Avdis and Wachter (2017); and Binsbergen, Hua, and Wachter (2022)]. The full developed country sample is much broader with nearly 2,500 years of information about asset returns, and the set of developed countries reflects a much larger variety of circumstances during our sample period compared with a US-centric view. In sum, we believe that US investors would be wise to consider the historical record of developed countries in addition to learning from their home-country experience.

4.2 Drivers of asset class performance

4.2.1 Effects of inflation

As a starting point for characterizing the drivers of asset class performance, we study the relation between realized inflation and real performance for each asset class. Figure 5 shows joint

single country. As a cautionary tale, Eun and Resnick (1994) conclude based on a sample ending in 1989 that US investors could benefit from international diversification whereas Japanese investors could not. With the benefit of hindsight, we observe that, over the 30-year period from 1990 to 2019, a $1.00 investment by a US investor would have produced $8.48 of real buying power with domestic stocks versus $2.07 with international stocks. For Japanese investors, in contrast, a ¥1.00 investment would have produced just ¥0.79 with domestic stocks versus ¥8.09 with international stocks.

distributions for inflation and each of domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D) at a horizon of 30 years. The plots adopt a format similar to the one used in Figure 4 to examine joint asset class performance. Each dot represents the joint outcome of cumulative inflation and the payoff for one of the asset classes. Each axis has a log scale, and the dashed lines mark 0% for log inflation (annualized) and a \$1.00 initial investment in the relevant asset class.

The joint distribution of 30-year outcomes for domestic stocks and inflation is shown in Panel A of Figure 5. The figure shows a slight negative relation between inflation and the performance of domestic stocks. In untabulated results, we estimate a correlation of -0.30 between log inflation and log real payoffs on domestic stocks. There are, however, many bootstrap draws in which inflation is high but domestic stocks still produce a large real gain, and we estimate a correlation of 0.47 between log nominal domestic stock returns and log cumulative inflation. As such, we find evidence that growth in the nominal value of stocks partially offsets inflation. This finding initially seems to contrast with Fama and Schwert (1977), who test the Fisher (1930) hypothesis for stocks and find a negative relation between nominal stock returns and inflation at horizons less than one year, such that stocks appear to be a poor inflation hedge. Fama (1981) and Gallagher and Taylor (2002) contend that this negative relation is a proxy for a positive relation between stock performance and real activity due to the tendency for high inflation to correspond to worse economic outcomes. This proxy effect weakens as the horizon grows, and the correlation in 30-year payoffs is consistent with studies [e.g., Boudoukh and Richardson (1993)] that find positive relations between nominal stock returns and realized inflation over longer horizons.

The joint distribution of international stocks and inflation in Panel B shows little relation between the two. The correlation between log inflation and the log real payoff is just -0.03. This weak correlation provides initial evidence regarding purchasing power parity. Specifically, if PPP holds month-by-month, then real exchange rates are constant,

$$\frac{\Pi_{j,t}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right) = 1. \tag{13}$$

From equations (5) and (6), real international stock returns are given by

$$R_{i,t}^{International\ stocks} = \sum_{j \neq i} w_{j,t-1} \frac{R_{j,t}^{Nominal\ stocks}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right), \tag{14}$$

such that, under the PPP condition in equation (13), the real international stock return is equal to the weighted average of real foreign stock market returns,

$$R_{i,t}^{International\ stocks} = \sum_{j \neq i} w_{j,t-1} \frac{R_{j,t}^{Nominal\ stocks}}{\Pi_{j,t}} \frac{\Pi_{j,t}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right) \tag{15}$$

$$= \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Stocks}. \tag{16}$$

Equation (16) shows that the real international stock return does not directly depend on local inflation under PPP. The same argument applies to H-month cumulative returns if PPP holds over this horizon,

$$\prod_{t=1}^{H} \frac{\Pi_{j,t}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right) = 1, \tag{17}$$

so the -0.03 correlation between real returns and inflation may be unsurprising. Moreover, log nominal payoffs on international stocks have a correlation of 0.72 with log domestic inflation at a 30-year horizon, providing further evidence that international stocks provide an effective long-term inflation hedge for investors.

The distributions for bonds and bills in Panels C and D of Figure 5 show a stark relation between fixed income performance and inflation. High inflation erodes the real value of bonds and bills, and we see few exceptions of good performance for debt securities when inflation is high. The correlations between log inflation and the log payoffs of bonds and bills are -0.74 and -0.83, respectively. Panel C also shows a considerable set of bootstrap draws with poor bond performance even without high realized inflation. Increases in interest rates and domestic defaults on long-term government bonds occasionally produce poor bond market outcomes in the absence of high inflation, but inflation is the primary driver of long-term performance.

4.2.2 Return decompositions and variance ratios

The payoff distributions in Section 4.1.1 reveal substantial uncertainty about real asset class outcomes. In this section, we develop return decompositions that allow us to study the underlying sources of this uncertainty. Our analyses for domestic stocks and bonds decompose returns into components that reflect aspects of asset valuations and cash flows. These decompositions extend the loglinearization approximation approach of Campbell (1991).[7] For international stocks, we decompose returns into components that reflect the real performance of foreign stock markets and the effects of real exchange rate fluctuations. We present decompositions of H-period, buy-and-hold returns, and full details for the derivations are given in the Internet Appendix.

Domestic stocks

Single-period log real domestic stock returns can be decomposed as follows:

$$r_{t+1}^{Stocks} \approx \rho_s((p_{t+1} - d_{t+1}) - (p_t - d_t)) + \rho_s(\Delta d_{t+1} - \pi_{t+1}) + (1 - \rho_s)(d_{t+1} - p_t - \pi_{t+1}) + q_s, \quad (18)$$

where p_t, d_t, and π_t are the logs of price, dividend, and inflation, respectively, $\Delta d_{t+1} = d_{t+1} - d_t$ is log dividend growth, and ρ_s and q_s are loglinearization constants. Equation (18) demonstrates that single-period real returns are affected by valuation changes, real dividend growth, and real dividend income. These effects can be cumulated across periods to decompose cumulative, buy-and-hold stock market performance. Denoting the real wealth from investing in stocks with a horizon of H months as W_H^{Stocks}, ending log real wealth is determined by

$$\begin{aligned} w_H^{Stocks} &= \sum_{t=1}^{H} r_t^{Stocks} \\ &\approx \rho_s[(p_H - d_H) - (p_0 - d_0)] + \rho_s \sum_{t=1}^{H} (\Delta d_t - \pi_t) + (1 - \rho_s) \sum_{t=1}^{H} (d_t - p_{t-1} - \pi_t) + H q_s. \end{aligned} \quad (19)$$

The three terms represent the cumulative effects of valuation changes, real dividend growth, and

[7] Campbell and Ammer (1993) take a different approach to decomposing the variance of long-horizon stock and bond returns, relying on the dynamics implied by a vector autoregression. In contrast, we directly estimate the variances and covariances of the H-horizon returns and components produced by our bootstrap procedure.

real dividend income on real stock market outcomes.[8] The Hq_s term most naturally acts to adjust the level of the dividend income term, so we sum these terms for our analyses.

We study sources of uncertainty about domestic stock payoffs using a variance decomposition. Given the form of equation (19), the H-period variance of stocks can be approximately decomposed as

$$\mathrm{Var}(w_H^{Stocks}) \approx \mathrm{Cov}(w_H^{Stocks}, \rho_s[(p_H - d_H) - (p_0 - d_0)]) + \mathrm{Cov}\left(w_H^{Stocks}, \rho_s \sum_{t=1}^{H} (\Delta d_t - \pi_t)\right) + \mathrm{Cov}\left(w_H^{Stocks}, (1-\rho_s) \sum_{t=1}^{H} (d_t - p_{t-1} - \pi_t) + Hq_s\right). \quad (20)$$

For expositional purposes, we focus on variance ratios [Poterba and Summers (1988)], which scale the variance of H-month log wealth by $H/12$ times the variance of one-year log wealth [i.e., $VR_H^{Stocks} = \mathrm{Var}(w_H^{Stocks})/(\frac{H}{12}\mathrm{Var}(w_{12}^{Stocks}))$], and we also scale the three covariance terms by $H/12$ times the variance of one-year log wealth to calculate contributions to the H-period variance ratio. Returns that are independent and identically distributed would produce a variance ratio equal to one at all horizons, such that deviations from one are informative about the time-series properties of returns.

Panel A of Figure 6 plots variance ratios and components for stock returns at horizons from one to 30 years. The variance ratios for returns are decreasing with horizon (beyond two years), consistent with the well-known empirical pattern in Poterba and Summers (1988). This pattern arises from the mean reversion property of stock market returns. The plot also shows the approximate contributions of variation in valuation, dividend growth, and dividend income at each horizon. At short horizons, valuation effects contribute about half of return variance, but this mechanism shrinks in importance (on a per-year basis) with longer horizons and contributes less than one-fifth of the variance at a 30-year horizon. Dividend growth, in contrast, is important at both short and long horizons and drives most of the variance of long-horizon returns. The effect of real dividend income on return variance is small at all horizons. Overall, other than for very short-horizon

[8] This decomposition is equivalent to a decomposition of long-horizon stock returns by Avramov, Cederburg, and Lučivjanská (2018) with a different arrangement of terms.

returns, variation in dividend growth is the primary source of uncertainty in returns.

International stocks

Our decomposition of real international stock returns uses the form of equation (15). The cumulative real wealth from investing in international stocks is closely approximated by

$$W_H^{International\ stocks} = \prod_{t=1}^{H} R_{i,t}^{International\ stocks}$$
$$\approx \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Stocks} \right) \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} \frac{\Pi_{j,t}}{\Pi_{i,t}} \frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right), \tag{21}$$

such that H-horizon log real wealth is given by

$$w_H^{International\ stocks} \approx \log \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Stocks} \right) + \log \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} \frac{\Pi_{j,t}}{\Pi_{i,t}} \frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right). \tag{22}$$

That is, the cumulative real performance of international stocks is dependent on two terms: (i) the value-weighted average of foreign stock market real returns and (ii) changes in real exchange rates.

The first term in equation (22) reflects the potential for international diversification, as investors can gain exposure to the real stock market outcomes across a broad set of foreign countries. Asness, Israelov, and Liew (2011) emphasize that international diversification improves with longer investment periods, such that we may expect the per-period variance from this term to decline with horizon. The second term arises from the currency exchanges required to invest internationally. Given findings in the international economics literature, there is reason to expect horizon effects in the importance of real exchange rates in determining investor outcomes. Purchasing power parity predicts that real exchange rates are constant, such that exchange rate changes offset differences between foreign and domestic inflation. Rogoff (1996) notes that monthly real exchange rates display substantial volatility, such that PPP does not hold over short horizons. Several researchers have shown, however, that shocks to real exchange rates tend to revert over intermediate horizons such that there is empirical support for PPP over longer horizons [see, e.g., Rogoff (1996) and Taylor and Taylor (2004)]. Finally, Lothian and Taylor (2008) and Chong, Jordà, and Taylor

(2012) show the importance of accounting for the Harrod-Balassa-Samuelson effect in studying real exchange rates and PPP, as long-run equilibrium real exchange rates may change over time. In particular, productivity differences across countries may be more pronounced for traded goods compared with nontraded goods and services, which can cause persistently higher consumer prices in more productive countries. The resulting changes in equilibrium real exchange rates could affect international stock returns over the long 30-year horizons we consider.

Panel B of Figure 6 shows variance ratios and components for international stocks. The contributions of the components in equation (22) are computed analogously to those for domestic stocks in equation (20). Similar to domestic stocks, variance ratios for international stocks decline with horizon. Both terms in equation (22) are important to determining investor outcomes. At a one-month horizon (untabulated), real international stock market performance and real exchange rate fluctuations each contribute about half of the volatility (49% from the first term and 51% from the second term) of log international stock returns. Panel B shows that, even by a one-year horizon, the relative importance of real exchange rates is lower for buy-and-hold investments, consistent with short-run reversion in real exchange rates. The contributions to variance from both components shrink with horizon, and the relative contributions stay roughly constant with about two-thirds of variance from real foreign stock performance and one-third from exchange rate fluctuations. The continued importance of real exchange rates at long horizons is indicative of the Harrod-Balassa-Samuelson effect.[9]

The reversion in real exchange rates also has implications for the effects of currency hedging on international investments. A number of studies [e.g., Eun and Resnick (1988) and Glen and Jorion (1993)] demonstrate improvements in nominal outcomes over short horizons from hedging currency risk. In the Internet Appendix, we demonstrate that potential currency hedging benefits crucially depend on whether performance is measured in nominal or real terms and on the investment horizon, consistent with Campbell, Viceria, and White (2003). In particular, currency-hedged international

[9] In the Internet Appendix, we compute variance ratios and components for international stocks in the post-Bretton Woods period to remove potential effects from pegged exchange rates. Over this subperiod, the variance ratio experiences a somewhat larger decline with horizon compared with the base result. The real exchange rate component contributes between 27% (one-year horizon) and 18% (30-year horizon) to the variance of international returns, such that real exchange rates seem relatively more stable during this era.

stock investments are riskier than unhedged investments in real terms for all horizons of four years or longer.

Bonds

Monthly log bond returns are approximated as follows:

$$r_{t+1}^{Bonds} \approx \rho_b(\tilde{p}_{t+1} - p_t - \pi_{t+1}) + \rho_b \log(1 - L_{t+1}) + (1 - \rho_b)(c_{t+1} - p_t - \pi_{t+1}) + q_b, \qquad (23)$$

where p_t is the price of a new ten-year bond, $\tilde{p}_{t+1}$ is the clean price of a one-month-old ten-year bond, L_{t+1} is the percentage loss in face value from a default event, c_{t+1} is a monthly coupon payment (assumed to be one-twelfth of the annual coupon), and ρ_b and q_b are loglinearization constants. If cumulative wealth from investing in bonds is denoted W_H^{Bonds}, then log cumulative wealth is

$$\begin{aligned} w_H^{Bonds} &= \sum_{t=1}^{H} r_t^{Bonds} \\ &\approx \rho_b \sum_{t=1}^{H}(\tilde{p}_t - p_{t-1} - \pi_t) + \rho_b \sum_{t=1}^{H} \log(1 - L_t) + (1 - \rho_b) \sum_{t=1}^{H}(c_t - p_{t-1} - \pi_t) + Hq_b. \qquad (24) \end{aligned}$$

This decomposition produces a real valuation term, a default loss term, and a real coupon income term (which includes Hq_b).[10]

Panel C of Figure 6 analyzes the variance ratios of bonds. In contrast to stocks, the variance ratios of bond returns substantially increase with horizon. The per-year variance of 30-year log bond returns is nearly two-and-a-half times the one-year variance. The increasing variance ratios imply positive autocorrelation in real bond returns, which is driven by persistent trends in inflation. The valuation component of bond returns is dominant, and the default and coupon income components produce little variation in investment outcomes. Equation (24) indicates that the valuation component includes the lion's share of the effect of inflation on real returns (i.e., ρ_b is close to one), and the valuation component reflects the cumulative effect of month-by-month losses in real value of the bond's principal. As such, this result is consistent with our finding in Section 4.2.1 that real

[10]The decomposition in equation (24) is valid for months in which the coupon yield is positive. We present an alternative decomposition for zero-coupon bond returns in the Internet Appendix.

bond returns are heavily reliant on inflation realizations.[11]

Bills

Long-horizon returns on bills simply cumulate the real one-month returns, such that no return decomposition is necessary. Panel D of Figure 6 shows variance ratios for bills. Similar to bonds, variance ratios increase sharply with horizon. The variance ratio at a 30-year horizon is 3.84, demonstrating a substantial increase in the per-period risk of investing in bills with a long investment horizon.

4.3 Long-horizon loss periods

A striking feature of the payoff distributions in Section 4.1.1 is the high real loss probabilities for domestic stocks, bonds, and bills even with a horizon as long as 30 years. We proceed to study the underlying drivers of realized long-horizon losses and the economic conditions in gain versus loss periods.

4.3.1 Return components

We first relate the average values of the components from the return decompositions in equations (19), (22), and (24) to the average log returns across gain and loss periods to study the sources of performance. Table VII reports results for domestic stocks (Panel A), international stocks (Panel B), and bonds (Panel C). In each panel, we report the mean of each component from the asset-specific decomposition across all periods, gain periods (i.e., the real payoff of the asset at a 30-year horizon is greater than \$1.00), and loss periods (i.e., the real payoff is less than \$1.00) for the asset under consideration. We also report the average of the log return by outcome in the last column. The horizon is 30 years. In our discussion below, we often express the cumulative log variables in annualized percentages by dividing them by 30 (reflecting the 30-year horizon) and multiplying them by 100%.

[11] The valuation component of bond returns can be decomposed into a nominal valuation term (i.e., the valuation component plus ρ_b times the sum of inflation) and an inflation term (ρ_b times the sum of inflation). We compute the covariance of the valuation component with each of these two terms and find that the inflation term drives 71% of the variance of the valuation component with the remaining 29% of the variance coming from valuation changes attributable to changes in interest rates.

Panel A of Table VII shows that most of the average real domestic stock return across all bootstrap draws is generated by real dividend income. That is, of the 4.4% average annual log return, 3.5% is attributable to income. Valuation effects are near zero on average, and real dividend growth contributes about 0.5% per year to average performance unconditional on the eventual outcome.

Conditioning on a gain or loss in domestic stocks allows us to draw inferences about which components may be most important in determining outcomes. In untabulated results, we find that the valuation component is particularly important at short horizons, consistent with the analysis in Panel A of Figure 6. Across gain periods over a one-year horizon, for example, a positive average valuation change of 8.2% accounts for nearly half of the average log return of 17.8%, and across loss periods a large negative valuation effect of −14.2% is the dominant driver of the −18.8% average log return. At a 30-year horizon, in contrast, valuation changes have a more muted effect. Valuation changes account for only 0.1% of the 5.5% average annual log return in gain periods and −0.8% of the −2.7% average in loss periods. The dividend income component is also relatively unimportant in explaining differences in real outcomes across gain and loss periods.

Real dividend growth is the primary driver of real stock market outcomes over long horizons. In gain periods, the dividend growth component contributes 1.4% of the 5.5% average return. In loss periods, this component is strikingly large in magnitude with a contribution of −5.4% to the average log return of −2.7%. The difference in annual log dividend growth of 6.8% [= (0.413 − (−1.626))(100%)/30] across gain and loss periods accounts for most of the annual log return difference of 8.2% [= (1.644 − (−0.816))(100%)/30].

Figure 7 provides additional evidence on the components of domestic stock performance. For each 30-year draw from the bootstrap procedure, we first sort the 30 annual observations based on the real return rank for domestic stocks. We then compute the cumulative sum of each annual log variable. Finally, we plot the average across bootstrap draws of these cumulative sums. Given this plot design, the leftmost point in each panel shows the average contribution of the worst return year to the cumulative log variables, the next point shows the combined contribution of the worst two years, and so on, and the rightmost point represents the log of the total 30-year cumulative variable. Each panel plots an unconditional case as well as cases that condition on a gain or loss in domestic stocks. Panel A shows cumulative sums for domestic stock returns. Panels B, C, and D plot the corresponding sums for the valuation, dividend growth, and dividend income components. The years in Panels B, C, and D continue to be sorted by the domestic stock return, such that the sorting of years is the same across all panels. This figure thus shows how the worst (or best) years for returns in a given 30-year period are associated with the return components in those years.

Panel A of Figure 7 plots cumulative sums for log domestic stock returns sorted on return rank. This figure is informative about the concentration of losses and gains within the 30-year periods conditional on the outcome for domestic stocks. Notably, the figure shows that loss periods in domestic stocks are characterized by very poor returns in their worst few years compared with gain periods. The difference between gain and loss periods of 2.460 in the 30-year log returns shown in Table VII is not, however, fully attributable to the worst year or two. Only about 29% of this difference occurs in the worst year, and the worst five years account for only 54% of the difference. Loss periods have losses on average in nearly half (14) of the 30 years, such that these periods are characterized by persistent, sustained runs of negative real returns.

Figure 7 shows that the stock return patterns are driven almost entirely by the dividend growth component in Panel C, whereas the patterns in the valuation and dividend income components in Panels B and D, respectively, are nearly identical across gain and loss periods. The periods with losses in stocks are characterized by large negative real dividend growth, and these poor realizations are heavily impacted by extremely poor dividend growth outcomes in the years with the worst stock returns. A realization of log real dividend growth equal to the mean of -0.956 in the worst year for stocks within a loss period, for example, would imply a 62% decrease in real dividends, representing a catastrophic outcome for stock investors. Loss periods also tend to include several years of negative growth as well as several years of stagnation. Overall, Figure 7 provides strong additional evidence that domestic stock market performance is dominated by real cash flow outcomes.

Panel B of Table VII and Figure 8 present results for international stock components across gain and loss periods. Consistent with our findings in Section 4.2.2, the real outcome of foreign stock markets is the more important component, but real exchange rate fluctuations still play an important role. For gain periods, real foreign investment outcomes almost entirely account for the gains with little role on average for real exchange rates. Loss periods tend to be accompanied by poor foreign stock performance of 0.6% per year (relative to 5.4% per year for gain periods) along with a poor realization for the effect of real exchange rates of −1.7% (relative to 0.3% for gain periods) to produce an average annual log return of −1.1% (relative to 5.5% for gain periods). Figure 8 shows that, unlike for domestic stocks, loss periods in international stocks do not show large one-year crashes relative to gain periods. Losses in international stocks, when they do occur, tend to be driven by sustained periods of relatively poor outcomes for the two components.

Finally, Panel C of Table VII and Figure 9 show analogous analyses for bonds. Consistent with Panel C of Figure 6, default and real coupon income explain relatively little of the average difference in bond performance across gain and loss periods. The valuation component, which reflects changes in real bond valuation from interest rate fluctuations and inflation realizations, is negative on average for both gain and loss periods because inflation plays a dominant role on average. The negative effect of valuation changes is much larger in loss periods, however, and the difference in this component across gain and loss periods almost entirely accounts for the average return difference. Figure 9 further shows that periods with losses in bonds are marked by sustained negative valuation effects. These results are consistent with the importance of inflation for bond outcomes as discussed in Section 4.2.

4.3.2 Macroeconomic conditions

In this section, we further characterize periods with long-horizon losses by examining macroeconomic conditions. For domestic stocks, in particular, the results in previous sections about the importance of real dividend growth are suggestive that real economic activity drives stock market performance over the long run. We examine real per capita GDP growth, nominal short-term interest rates, and inflation to describe economic conditions; these variables represent important economic indicators and they are available for our full sample of developed economies. We use a 30-year horizon and report in logs for ease of comparison across variables. We often express values as annualized percentages in our discussion below by dividing cumulative log variables by 30 and multiplying by 100%.

Table VIII shows average macroeconomic conditions for all periods and for periods with gains or losses in domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). Each panel reports means of the logs of the cumulative buy-and-hold return on the asset class under consideration, the cumulative growth in GDP, the cumulative nominal short-term interest rate, and the cumulative rate of inflation.

Panel A of Table VIII focuses on domestic stocks. The first row shows unconditional means. The average annual log real return is 4.4%, average real GDP growth is 1.8%, and the averages of both the nominal short-term rate and inflation are 4.5%.

Panel A demonstrates that macroeconomic conditions are poorer on average in periods with losses in domestic stocks. At a 30-year horizon, log GDP growth averages 1.9% per year in periods with gains in stocks versus only 1.0% per year in periods with losses. Short-term nominal rates are nearly indistinguishable across periods. Periods with real losses in stocks tend to be inflationary relative to periods with gains, with annual averages of 6.8% versus 4.2% for the two period categories.

Of particular note is the magnitude of long-horizon differences across gain and loss periods in returns versus in the macroeconomic variables. The difference in log payoffs for domestic stocks is 2.46 (implying an annual log return difference of 8.2% per year across gain and loss periods) versus only 0.25 for GDP growth (an annual log growth difference of 0.8%). The difference in cumulative inflation across gain and loss periods is only about a third of the size of the difference in real returns, and this effect overstates the importance of inflation in creating this gap in real returns given that the nominal returns of stocks are positively correlated with inflation as discussed in Section 4.2.1. Overall, long-horizon domestic stock losses tend to occur during periods that appear to have poor, but not necessarily devastating, economic outcomes.

Panels B, C, and D of Table VIII report macroeconomic conditions in gain and loss periods for international stocks, bonds, and bills. The annualized difference in log GDP growth across gain and loss periods for international stocks (0.5%) is smaller than for domestic stocks (0.8%), but larger than for bonds (0.1%) and bills (0.2%). Consistent with our findings in Section 4.2.1, gain and loss periods in international stocks have relatively similar inflation outcomes, whereas bond and bill outcomes show large differences in realized inflation that account for most of the return differentials across gain and loss periods for these asset classes.

Given the evidence in Table VIII that domestic stocks are most closely tied to economic growth, we further study the macroeconomic conditions that accompany poor outcomes for this asset class. Figure 10 shows cumulative sums for the logs of return, GDP growth, short rate, and inflation while sorting years within each 30-year period by the domestic stock return realization (i.e., Figure 10 is analogous to Figure 7). Loss periods tend to be punctuated by very poor economic periods with low real per capita GDP growth and high inflation in the handful of years with the worst stock returns. Whereas log GDP growth averages −1.8% for the worst year for stocks in gain periods, it experiences, on average, a large crash of −15.6% in the worst year of loss periods. This average economic outcome is indicative of the rare disaster periods discussed by Barro (2006) and Barro and Ursúa (2008), among others. In the worst five return years of the 30-year periods, cumulative GDP growth is 1.2% in gain periods compared with a dismal −20.9% in loss periods. Beyond these worst five years, gain and loss periods show similar economic growth (i.e., the cumulative log sums in Figure 10 are nearly parallel). Nearly two-thirds of the cumulative difference in inflation across gain and loss periods also occurs in the worst five years. Overall, the results in Figure 10 provide evidence that long-horizon periods with domestic stock losses tend to include an economic crash that is concentrated over a few years within the period.

Finally, the results in Tables VII and VIII and Figures 7 and 10 show that domestic stock losses are associated on average with drastically poor real dividend growth outcomes along with disappointing, but not necessarily catastrophic, cumulative real economic growth outcomes. We proceed to study their relative magnitudes and interpret our findings. For comparability with real per capita GDP growth, we construct a real per capita aggregate dividend growth series for each country. The aggregate dividend is the total, economy-wide dividend paid to shareholders of publicly listed firms. Aggregate dividend growth can differ from the index dividend growth we study in Sections 4.2.2 and 4.3.1 due to new listings, mergers and acquisitions, changes in shares outstanding from new issues or repurchases, and various other corporate transactions in addition to the adjustment to a per-capita variable.[12]

We also consider the ratio of the aggregate dividend to GDP to measure the proportion of total output that is paid to shareholders in the form of dividends. Kuvshinov and Zimmermann (2022) interpret the aggregate dividend-GDP ratio as the profit share of total output, which is the remainder of output after accounting for the labor share and the capital share. Karabarbounis and Neiman (2014) provide evidence of large shifts in labor shares, and Greenwald, Lettau, and Ludvigson (2022) attribute much of the recent stock market success in the US to a declining labor share. Barkai (2020) suggests that both the labor share and capital share have recently declined in the US, increasing the profit share. Fluctuations in the economy-wide profit share could be indicative of trends in firms' market power and price-cost markups [e.g., Basu (2019) and Syverson (2019)]. The change in the log aggregate dividend-GDP ratio is mathematically equivalent to log aggregate dividend growth minus log GDP growth, such that changes in the profit share provide an interpretation of persistent differences across the two growth rates.

Table IX reports statistics for the cumulative logs of returns (Panel A), GDP growth (Panel B), aggregate dividend growth (Panel C), and the change in the aggregate dividend-GDP ratio (Panel D) using a 30-year horizon. Each panel shows the mean, standard deviation, and percentiles for all periods, gain periods, and loss periods. The means of returns and GDP growth are repeated from Table VIII for convenience.

There are three primary takeaways from Table IX. First, the distributions of GDP growth and aggregate dividend growth are shifted downward in periods of losses in domestic stocks versus periods of gain, as expected. Second, despite this tendency for losses in domestic stocks to occur in periods of relatively poorer economic growth, losses are sometimes accompanied by good economic outcomes. Panel B of Table IX shows, for example, that the 75th percentile of GDP growth in loss periods is 2.3% per year, which exceeds the median GDP growth across all periods of 1.8%. In all, 35% of 30-year domestic stock losses occur in periods with above-median economic growth. Panel C also shows that some loss periods have relatively strong real dividend growth. These

[12] Across bootstrap draws, real index dividend growth and real per capita aggregate dividend growth have a correlation of 0.85.

results demonstrate that domestic stocks can experience long-term, real losses without economic catastrophe.

Third, Table IX shows that the average difference between gain and loss periods in aggregate dividend growth is much larger than the difference in GDP growth. Aggregate dividend growth in Panel C averages 3.7% per year in gain periods versus -1.6% in loss periods, whereas average GDP growth in Panel B is 1.9% versus 1.0%. The table also shows that the change in the log aggregate dividend-GDP ratio in Panel D averages 1.8% per year in gain periods versus -2.7% in loss periods. This finding suggests that the profit share tends to experience a large increase during long-horizon periods with stock market gains, whereas loss periods are characterized by a large average decline in the profit share. Our results thus provide circumstantial evidence of long-run shifts in labor shares and capital shares across countries and across time. These shifts lead to substantial (positive or negative) changes in the profit share of total output, and changes in profit share appear important for determining the stock market outcomes of long-horizon investors.

5 Conclusion

Quantitative evidence on long-horizon asset returns is important for retirement savers and other long-term investors such as pensions and endowments. We draw upon a broad sample of developed countries with data spanning nearly 2,500 years to characterize joint distributions of domestic stocks, international stocks, bonds, and bills with horizons ranging from one month to 30 years. Using this sample, which is constructed to mitigate survivor and easy data biases, we estimate large probabilities of real losses for domestic stocks (13%), bonds (27%), and bills (37%). Poor outcomes are correlated across asset classes, leading to the possibility that a highly diversified, long-horizon investor could realize an overall loss in buying power from her investments.

Poor asset returns tend to occur simultaneously with relatively poor economic outcomes, consistent with common intuition. Thirty-year periods with real losses in domestic stocks, for example, tend to include an economic crash of similar size to the rare disasters considered by Barro (2006). These large economic crashes, however, are dwarfed in magnitude by the shortfalls in real dividend growth that drive poor stock performance. Our results are suggestive of large swings in the profit share of total output, which correspond to the sustained movements in labor share and capital share that have been recently demonstrated in the literature. We also find that domestic fixed income markets do not, by any means, provide a safe haven for real growth in wealth. Inflationary periods quickly eliminate any potential gains from investing in government bonds or bills.

Our findings could prove distressing for retirement savers and other long-term investors. Real losses in major asset classes are not rare, even over long horizons. Long-horizon losses in domestic stocks and bonds tend to occur in periods of poor, but not necessarily catastrophic, cumulative economic outcomes. The retirement security of a generation and the long-run viability of pension and endowment funds are subject to the risk of substantial financial market shortcomings, even in the absence of economic crises. Despite this bleak outlook, our results are suggestive of some mitigating factors for long-horizon savers. International diversification seems likely to prove helpful, and (regardless of their investment strategies) higher savings rates would help investors persevere in the face of poor investment outcomes. Our evidence on the smaller magnitudes of economic shortfalls compared with financial market shortfalls is also suggestive that social safety nets, such as Social Security in the US, may survive in the eventuality of long-term asset market losses for retirement savers. Furthermore, the overall welfare implications for a cohort of retirement savers may be ambiguous if stock market losses are primarily driven by a falling profit share caused by an increase in the labor share. While these factors offer some hope of a softened blow, long-horizon investors should form their saving and investment plans while acknowledging a substantial risk of loss.

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Table I

Developed country sample periods.

The table shows developed countries, initial development dates, classification reasons for development, sample eligibility details, and sample coverage. The development year classifications are based on agricultural labor share or organizational membership in the Organisation for European Economic Co-operation (OEEC) or the Organisation for Economic Co-operation and Development (OECD). Sample eligibility for a given developed country requires that the country has issued long-term government bonds. The sample period start date is the later of the sample eligibility date and the first date with return data for stocks, bonds, and bills.

	Development details		Sample eligibility details		Sample coverage		
Country	Year	Reason for classification	Year	Reason for delayed sample eligibility	Start date	End date	Coverage (%)
United Kingdom	1841	Agricultural labor share	1890	Sample for study starts in 1890	1890:01	2019:12	100.0
Netherlands	1849	Agricultural labor share	1890	Sample for study starts in 1890	1914:01	2019:12	81.5
Belgium	1856	Agricultural labor share	1890	Sample for study starts in 1890	1897:01	2019:12	94.6
France	1866	Agricultural labor share	1890	Sample for study starts in 1890	1890:01	2019:12	100.0
Norway	1875	Agricultural labor share	1890	Sample for study starts in 1890	1914:02	2019:12	81.5
Germany	1882	Agricultural labor share	1890	Sample for study starts in 1890	1890:01	2019:12	100.0
Denmark	1890	Agricultural labor share	1890	n/a	1890:01	2019:12	100.0
Switzerland	1890	Agricultural labor share	1890	n/a	1914:01	2019:12	81.5
United States	1890	Agricultural labor share	1890	n/a	1890:01	2019:12	100.0
Canada	1891	Agricultural labor share	1891	n/a	1891:01	2019:12	100.0
Argentina	1895	Agricultural labor share	1895	n/a	1947:02	1966:12	27.7
New Zealand	1896	Agricultural labor share	1896	n/a	1896:01	2019:12	100.0
Australia	1901	Agricultural labor share	1901	n/a	1901:01	2019:12	100.0
Sweden	1910	Agricultural labor share	1910	n/a	1910:01	2019:12	100.0
Austria	1920	Agricultural labor share	1920	n/a	1925:02	2019:12	94.9
Chile period I	1920	Agricultural labor share	1920	n/a	1927:01	1970:12	86.3
Greece	1920	Agricultural labor share	1920	n/a	1981:02	2019:12	38.9
Czechoslovakia	1921	Agricultural labor share	1921	n/a	1926:01	1945:05	79.5
Japan	1930	Agricultural labor share	1930	n/a	1930:01	2019:12	100.0
Portugal	1930	Agricultural labor share	1930	n/a	1934:01	2019:12	95.6
Italy	1931	Agricultural labor share	1931	n/a	1931:01	2019:12	100.0
Ireland	1936	Agricultural labor share	1936	n/a	1936:01	2019:12	100.0
Singapore	1947	Agricultural labor share	1998	Long-term bonds first available in 1998	1998:07	2019:12	100.0
Iceland	1948	OEEC membership	1992	Long-term bonds first available in 1992	2002:01	2019:12	64.3
Luxembourg	1948	OEEC membership	1948	n/a	1982:01	2019:12	52.8
Türkiye	1948	OEEC membership	2010	Long-term bonds first available in 2010	2010:02	2019:12	100.0

(*continued on next page*)

Table I (*continued*)

	Development details		Sample eligibility details		Sample coverage		
Country	Year	Reason for classification	Year	Reason for delayed sample eligibility	Start date	End date	Coverage (%)
Spain	1959	OEEC membership	1959	n/a	1959:01	2019:12	100.0
Finland	1969	OECD membership	1969	n/a	1969:01	2019:12	100.0
Mexico	1994	OECD membership	2001	Long-term bonds first available in 2001	2001:08	2019:12	100.0
Czech Republic	1995	OECD membership	2000	Long-term bonds first available in 2000	2000:05	2019:12	100.0
Hungary	1996	OECD membership	1999	Long-term bonds first available in 1999	1999:02	2019:12	100.0
Poland	1996	OECD membership	1999	Long-term bonds first available in 1999	1999:06	2019:12	100.0
South Korea	1996	OECD membership	2000	Long-term bonds first available in 2000	2000:11	2019:12	100.0
Slovakia	2000	OECD membership	2000	n/a	2000:01	2019:12	100.0
Chile period II	2010	OECD membership	2010	n/a	2010:01	2019:12	100.0
Estonia	2010	OECD membership	—	No qualifying long-term bonds	—	—	—
Israel	2010	OECD membership	2010	n/a	2010:01	2019:12	100.0
Slovenia	2010	OECD membership	2010	n/a	2010:01	2019:12	100.0
Latvia	2016	OECD membership	2016	n/a	2016:01	2019:12	100.0
Lithuania	2018	OECD membership	2018	n/a	2018:01	2019:12	100.0

Table II

Summary statistics.

The table reports summary statistics for monthly real net returns for each developed country and for the pooled sample of all observations. For each country, the table shows the number of sample months, the arithmetic average return ($\bar{R}_a$), the geometric average return ($\bar{R}_g$), the standard deviation of return (SD), return skewness (Skew), return kurtosis (Kurt), and the minimum (Min) and the maximum (Max) return. Panels A, B, C, and D show results for domestic stocks, international stocks, bonds, and bills, respectively.

		Summary statistics for returns						
Country	Months	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel A: Real domestic stock returns								
Argentina	239	0.19	−0.18	8.53	0.09	7.65	−44.06	41.43
Australia	1,428	0.66	0.58	3.90	−0.94	16.02	−42.49	23.83
Austria	1,139	0.40	0.27	5.18	0.33	10.91	−32.63	38.96
Belgium	1,476	0.35	0.22	5.01	−0.90	16.90	−55.91	24.72
Canada	1,548	0.57	0.48	4.24	−0.53	7.20	−27.26	23.60
Chile period I	528	0.32	0.13	6.15	0.31	6.91	−32.81	30.28
Chile period II	120	0.05	−0.03	4.06	0.13	3.07	−10.54	11.05
Czech Republic	236	1.11	0.86	7.07	−0.00	5.40	−29.25	29.90
Czechoslovakia	233	0.16	−0.45	6.89	−9.09	119.91	−88.59	16.66
Denmark	1,560	0.39	0.33	3.54	−0.03	6.60	−18.38	18.89
Finland	612	0.98	0.78	6.31	0.26	6.38	−27.28	32.01
France	1,560	0.44	0.30	5.40	1.61	27.89	−22.01	75.61
Germany	1,560	0.64	0.26	8.35	3.38	76.04	−91.10	128.82
Greece	467	0.95	0.45	10.36	1.47	9.89	−27.83	65.50
Hungary	251	0.67	0.46	6.44	−0.37	4.54	−28.71	18.24
Iceland	216	0.37	−0.07	7.66	−4.45	40.76	−72.12	18.18
Ireland	1,008	0.57	0.46	4.67	−0.29	7.23	−27.26	25.54
Israel	120	0.06	−0.06	4.81	−0.17	3.33	−14.50	12.55
Italy	1,068	0.44	0.17	7.41	1.08	10.39	−34.89	58.61
Japan	1,080	0.52	0.30	6.67	0.57	16.81	−48.14	60.74
Latvia	48	1.03	0.97	3.54	1.11	5.47	−5.47	13.73
Lithuania	24	0.21	0.18	2.61	−0.06	3.29	−6.16	4.86
Luxembourg	456	0.74	0.58	5.50	−0.67	6.25	−26.69	18.01
Mexico	221	0.79	0.67	4.75	−0.49	4.12	−18.35	12.85
Netherlands	1,272	0.53	0.40	5.09	0.12	13.43	−33.15	50.24
New Zealand	1,488	0.56	0.50	3.65	−0.11	9.69	−28.76	23.61
Norway	1,271	0.52	0.39	5.06	−0.32	6.77	−27.49	25.26
Poland	247	0.50	0.32	5.98	−0.11	4.44	−24.32	19.85
Portugal	1,032	0.50	0.13	7.92	2.03	51.00	−89.24	86.10
Singapore	258	0.70	0.53	5.94	−0.19	6.67	−26.06	24.71
Slovakia	240	0.50	0.37	5.33	1.34	10.58	−18.87	33.34
Slovenia	120	0.37	0.29	4.03	0.29	4.61	−10.37	16.19
South Korea	230	0.89	0.70	6.15	0.20	4.73	−20.91	25.35
Spain	732	0.49	0.34	5.48	−0.01	4.90	−25.71	26.52
Sweden	1,320	0.59	0.47	4.82	−0.19	6.32	−27.01	28.01
Switzerland	1,272	0.48	0.39	4.31	−0.04	8.17	−24.95	32.66
Türkiye	119	0.26	0.05	6.44	−0.04	2.27	−14.03	14.56
United Kingdom	1,560	0.47	0.38	4.28	0.54	17.46	−26.87	50.05
United States	1,560	0.64	0.52	4.99	0.39	12.86	−29.47	42.52
Full sample	29,919	0.53	0.37	5.59	0.90	39.91	−91.10	128.82

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Table II (*continued*)

Country	Months	Summary statistics for returns $\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel B: Real international stock returns								
Argentina	239	1.32	0.64	15.34	8.57	86.15	−17.20	159.12
Australia	1,428	0.49	0.42	3.76	0.68	9.71	−13.71	31.56
Austria	1,139	0.95	0.57	12.43	17.54	376.11	−26.96	299.72
Belgium	1,476	0.49	0.38	4.54	0.49	13.27	−24.47	41.30
Canada	1,548	0.48	0.42	3.47	−0.08	6.19	−15.08	20.06
Chile period I	528	0.92	0.62	8.49	4.50	47.89	−27.62	100.08
Chile period II	120	0.84	0.78	3.54	−0.17	2.95	−8.69	11.34
Czech Republic	236	0.09	−0.00	4.18	−0.76	4.21	−14.07	10.08
Czechoslovakia	233	0.44	0.25	6.23	0.64	12.26	−28.07	38.41
Denmark	1,560	0.45	0.38	3.90	0.10	9.40	−20.61	32.01
Finland	612	0.51	0.41	4.31	−0.25	4.86	−19.01	20.53
France	1,560	0.60	0.42	6.67	7.48	129.69	−26.19	132.70
Germany	1,560	0.81	0.56	10.26	22.38	605.80	−23.68	301.53
Greece	467	0.65	0.54	4.71	−0.25	5.14	−21.27	19.02
Hungary	251	0.34	0.26	4.08	−0.35	3.45	−12.50	11.35
Iceland	216	0.43	0.31	4.86	−0.23	4.70	−16.63	18.00
Ireland	1,008	0.55	0.47	4.03	0.05	7.36	−19.49	30.68
Israel	120	0.72	0.66	3.36	0.30	4.18	−6.88	13.94
Italy	1,068	0.81	0.44	13.15	22.13	604.79	−22.10	372.03
Japan	1,080	1.06	0.49	16.21	16.96	343.49	−48.25	373.06
Latvia	48	0.66	0.61	2.96	−0.73	3.71	−7.59	7.34
Lithuania	24	0.67	0.61	3.52	−0.69	3.28	−7.34	7.67
Luxembourg	456	0.68	0.58	4.47	−0.50	4.47	−19.97	17.38
Mexico	221	0.60	0.53	3.53	−0.38	3.61	−10.68	9.32
Netherlands	1,272	0.51	0.41	4.37	0.47	12.22	−22.70	40.23
New Zealand	1,488	0.51	0.43	4.09	2.51	39.23	−19.60	60.87
Norway	1,271	0.52	0.44	4.21	0.22	7.64	−17.07	33.81
Poland	247	0.30	0.23	3.66	−0.59	3.56	−11.21	9.43
Portugal	1,032	0.53	0.45	4.03	−0.31	4.49	−18.75	17.46
Singapore	258	0.35	0.27	3.99	−0.85	4.79	−18.22	9.99
Slovakia	240	0.03	−0.06	4.13	−0.62	4.00	−15.06	12.62
Slovenia	120	0.91	0.86	3.18	−0.35	3.65	−8.14	9.31
South Korea	230	0.34	0.27	3.73	−0.70	4.39	−15.91	9.09
Spain	732	0.48	0.39	4.22	−0.30	4.65	−20.73	16.98
Sweden	1,320	0.53	0.44	4.14	0.05	10.10	−23.36	31.74
Switzerland	1,272	0.48	0.38	4.46	0.07	10.47	−24.23	40.78
Türkiye	119	1.25	1.13	5.04	1.10	12.48	−17.48	30.38
United Kingdom	1,560	0.53	0.45	4.09	0.47	12.06	−20.00	40.25
United States	1,560	0.40	0.33	3.78	−0.44	6.79	−22.80	17.00
Full sample	29,919	0.58	0.43	6.74	24.20	1,096.63	−48.25	373.06

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Table II (*continued*)

Country	Months	Summary statistics for returns $\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel C: Real bond returns								
Argentina	239	−1.62	−1.66	2.84	−0.69	5.09	−14.63	7.30
Australia	1,428	0.18	0.16	1.68	0.34	11.05	−11.48	12.74
Austria	1,139	0.20	0.16	2.67	−3.47	39.75	−30.05	18.00
Belgium	1,476	0.06	0.04	1.76	−0.03	6.82	−10.39	8.45
Canada	1,548	0.21	0.19	1.62	0.09	10.85	−11.90	12.62
Chile period I	528	−0.87	−0.92	3.38	0.24	19.09	−22.65	25.11
Chile period II	120	0.15	0.14	1.37	−0.78	8.64	−6.34	4.54
Czech Republic	236	0.27	0.25	2.16	−0.09	4.23	−8.47	6.80
Czechoslovakia	233	0.34	0.30	3.03	8.60	108.62	−5.16	38.47
Denmark	1,560	0.24	0.23	1.85	0.42	9.88	−8.95	14.96
Finland	612	0.34	0.32	2.21	−0.36	6.01	−10.77	8.91
France	1,560	−0.04	−0.06	2.27	−1.24	13.23	−21.05	10.06
Germany	1,560	1.41	−0.12	46.30	36.04	1,372.53	−90.26	1,771.67
Greece	467	0.52	0.36	5.55	−0.21	9.46	−30.84	26.45
Hungary	251	0.46	0.40	3.31	−0.10	3.62	−9.83	12.42
Iceland	216	0.41	0.36	3.30	−1.76	19.18	−24.03	15.62
Ireland	1,008	0.23	0.20	2.38	0.04	9.81	−15.75	15.45
Israel	120	0.60	0.59	1.86	0.80	8.38	−5.73	9.52
Italy	1,068	−0.09	−0.12	2.54	−1.31	11.74	−19.67	10.26
Japan	1,080	−0.11	−0.18	3.47	−4.76	53.45	−48.20	19.60
Latvia	48	0.06	0.05	1.33	−0.70	4.08	−3.74	2.74
Lithuania	24	0.17	0.16	1.31	0.83	3.79	−1.74	3.90
Luxembourg	456	0.40	0.39	1.76	−0.14	6.42	−9.77	7.53
Mexico	221	0.42	0.39	2.55	−0.12	3.68	−7.18	7.97
Netherlands	1,272	0.18	0.16	1.66	0.10	7.33	−9.14	10.17
New Zealand	1,488	0.17	0.15	1.80	−0.62	50.36	−24.19	22.90
Norway	1,271	0.17	0.15	1.70	−0.54	8.45	−11.26	8.60
Poland	247	0.47	0.44	2.48	0.06	4.53	−7.69	9.71
Portugal	1,032	0.09	0.05	2.80	0.43	7.92	−13.23	14.98
Singapore	258	0.24	0.22	1.99	−0.52	5.89	−8.86	7.75
Slovakia	240	0.52	0.49	2.89	4.37	40.68	−6.60	28.50
Slovenia	120	0.50	0.45	2.98	−0.35	4.81	−10.01	8.82
South Korea	230	0.39	0.37	1.90	0.50	7.20	−5.15	11.16
Spain	732	0.22	0.20	2.17	0.17	5.10	−9.92	9.47
Sweden	1,320	0.19	0.17	1.81	−1.24	19.23	−20.51	9.27
Switzerland	1,272	0.17	0.16	1.38	0.39	5.36	−5.07	7.48
Türkiye	119	0.12	0.00	4.88	−0.14	3.96	−15.21	13.70
United Kingdom	1,560	0.18	0.16	1.93	0.71	8.84	−9.11	12.99
United States	1,560	0.16	0.14	1.73	0.55	8.40	−9.20	11.71
Full sample	29,919	0.21	0.10	10.81	148.03	24,163.53	−90.26	1,771.67

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Table II (*continued*)

Country	Months	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
		Summary statistics for returns						
Panel D: Real bill returns								
Argentina	239	−1.52	−1.56	2.73	−0.87	5.64	−14.67	6.98
Australia	1,428	0.07	0.07	0.54	−0.92	7.35	−2.60	1.93
Austria	1,139	0.01	−0.00	1.50	−8.76	122.85	−27.20	3.26
Belgium	1,476	−0.02	−0.03	1.14	−0.20	15.04	−10.42	9.69
Canada	1,548	0.12	0.12	0.57	0.17	8.25	−2.80	3.62
Chile period I	528	−0.83	−0.86	2.34	0.37	7.47	−10.43	12.77
Chile period II	120	0.03	0.03	0.36	−0.19	7.79	−1.62	1.48
Czech Republic	236	−0.04	−0.04	0.43	−1.50	9.62	−2.61	1.34
Czechoslovakia	233	0.13	0.10	2.87	10.09	135.91	−5.22	38.37
Denmark	1,560	0.18	0.18	0.72	−1.03	16.82	−5.06	4.71
Finland	612	0.06	0.06	0.46	−1.08	7.60	−2.72	2.23
France	1,560	−0.15	−0.16	1.77	−2.88	30.50	−21.03	10.17
Germany	1,560	0.17	0.17	0.86	1.14	38.28	−5.95	12.10
Greece	467	0.17	0.16	1.27	−0.03	2.78	−3.17	4.37
Hungary	251	0.18	0.18	0.40	−0.65	3.67	−1.40	1.00
Iceland	216	0.23	0.23	0.53	−0.23	5.06	−2.25	2.01
Ireland	1,008	0.03	0.03	0.59	−0.80	7.27	−3.18	2.78
Israel	120	0.12	0.11	0.85	4.94	32.27	−0.89	6.07
Italy	1,068	−0.24	−0.25	1.71	−4.56	41.65	−20.31	7.94
Japan	1,080	−0.28	−0.33	2.67	−8.99	129.17	−48.21	12.30
Latvia	48	−0.21	−0.21	0.47	0.24	3.12	−1.26	0.89
Lithuania	24	−0.21	−0.21	0.49	−0.48	2.47	−1.32	0.62
Luxembourg	456	0.14	0.13	0.58	−0.64	4.51	−1.85	1.98
Mexico	221	0.15	0.15	0.38	0.06	3.49	−1.25	1.21
Netherlands	1,272	0.03	0.02	0.78	−0.80	8.36	−4.43	3.09
New Zealand	1,488	0.16	0.15	0.59	−0.36	11.62	−3.80	3.77
Norway	1,271	0.03	0.02	0.86	−0.06	11.83	−6.85	6.05
Poland	247	0.22	0.22	0.41	0.53	3.98	−0.93	1.64
Portugal	1,032	−0.05	−0.06	1.36	−0.00	12.28	−7.17	11.86
Singapore	258	−0.02	−0.02	0.47	−0.48	4.22	−1.84	1.51
Slovakia	240	−0.04	−0.04	0.58	−3.81	25.81	−4.51	1.03
Slovenia	120	−0.01	−0.02	0.76	1.33	5.74	−1.44	3.10
South Korea	230	0.09	0.09	0.34	−0.03	3.10	−0.92	1.17
Spain	732	0.02	0.02	0.69	−0.70	5.24	−3.84	2.37
Sweden	1,320	0.10	0.09	0.97	−8.51	171.12	−20.38	4.78
Switzerland	1,272	0.03	0.03	0.62	0.92	12.77	−2.84	4.55
Türkiye	119	0.06	0.06	0.94	−0.60	6.93	−4.27	3.31
United Kingdom	1,560	0.07	0.07	0.87	1.50	24.03	−4.26	10.58
United States	1,560	0.07	0.06	0.61	0.41	25.54	−5.53	7.57
Full sample	29,919	0.01	0.00	1.17	−5.15	207.38	−48.21	38.37

Table III

Bootstrap distributions of payoffs.

The table summarizes distributions of real payoffs from a $1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at various return horizons. The underlying sample is the pooled sample of all developed countries. Each panel shows statistics for the distribution of a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$]. The bootstrap sampling procedure is based on the stationary bootstrap approach of Politis and Romano (1994) as described in the text.

	Moments		Percentiles									
Horizon	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
Panel A: Real domestic stock payoffs												
1 month	1.01	0.06	0.86	0.92	0.95	0.98	1.00	1.03	1.06	1.08	1.15	0.428
1 year	1.08	0.26	0.53	0.72	0.81	0.93	1.06	1.19	1.35	1.48	1.85	0.371
5 years	1.45	0.92	0.17	0.52	0.68	0.94	1.28	1.72	2.35	2.86	4.36	0.290
10 years	2.01	1.77	0.14	0.45	0.67	1.06	1.63	2.44	3.62	4.64	8.79	0.223
20 years	3.89	5.57	0.13	0.42	0.70	1.38	2.58	4.56	7.85	11.08	23.83	0.162
30 years	7.45	16.82	0.13	0.46	0.82	1.87	4.06	8.23	15.76	23.88	56.15	0.126
Panel B: Real international stock payoffs												
1 month	1.01	0.07	0.88	0.93	0.96	0.98	1.01	1.03	1.05	1.07	1.11	0.417
1 year	1.07	0.23	0.62	0.75	0.84	0.96	1.06	1.17	1.29	1.37	1.64	0.333
5 years	1.42	0.70	0.48	0.64	0.75	0.99	1.30	1.72	2.14	2.48	3.61	0.259
10 years	2.01	1.69	0.44	0.64	0.79	1.17	1.68	2.46	3.39	4.09	6.86	0.181
20 years	3.99	5.90	0.48	0.82	1.08	1.70	2.78	4.66	7.34	9.69	20.95	0.084
30 years	7.80	16.61	0.58	1.09	1.52	2.61	4.68	8.47	14.79	21.40	54.34	0.042
Panel C: Real bond payoffs												
1 month	1.00	0.11	0.93	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.06	0.431
1 year	1.03	0.46	0.67	0.85	0.91	0.97	1.02	1.07	1.14	1.19	1.33	0.380
5 years	1.14	0.80	0.19	0.59	0.76	0.95	1.11	1.30	1.52	1.67	2.09	0.310
10 years	1.32	1.52	0.08	0.41	0.64	0.93	1.24	1.59	2.01	2.34	3.02	0.300
20 years	1.76	2.66	0.03	0.19	0.48	0.93	1.50	2.25	3.18	3.91	5.65	0.283
30 years	2.34	4.22	0.02	0.12	0.35	0.94	1.79	3.03	4.66	5.96	9.48	0.268
Panel D: Real bill payoffs												
1 month	1.00	0.01	0.96	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.03	0.405
1 year	1.00	0.07	0.76	0.89	0.94	0.99	1.01	1.03	1.06	1.08	1.17	0.379
5 years	1.04	0.22	0.27	0.66	0.79	0.94	1.04	1.15	1.28	1.37	1.60	0.382
10 years	1.09	0.36	0.11	0.50	0.69	0.90	1.07	1.28	1.52	1.68	2.11	0.384
20 years	1.20	0.59	0.03	0.28	0.52	0.84	1.14	1.50	1.92	2.24	3.02	0.376
30 years	1.32	0.81	0.03	0.16	0.40	0.80	1.21	1.72	2.31	2.76	3.97	0.369

Table IV

Bootstrap distributions of payoffs conditional on performance of domestic stocks.

The table summarizes distributions of real payoffs from a $1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at a 30-year return horizon. The underlying sample is the pooled sample of all developed countries. Each panel shows statistics for the unconditional and conditional distributions of a given asset class: international stocks (Panel A), bonds (Panel B), and bills (Panel C). In each panel, the first row shows the unconditional distribution of real payoffs, and the second and third rows show the distributions conditional on a real gain or loss in domestic stocks in the bootstrap simulation. The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each distribution, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Outcome	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
Panel A: Real international stock payoffs conditional on domestic stock outcome												
All	7.80	16.61	0.58	1.09	1.52	2.61	4.68	8.47	14.79	21.40	54.34	0.042
Gain	8.09	15.96	0.69	1.25	1.70	2.86	4.99	8.85	15.20	21.74	53.72	0.029
Loss	5.85	20.46	0.35	0.64	0.88	1.50	2.72	5.23	10.64	17.72	58.39	0.129
Panel B: Real bond payoffs conditional on domestic stock outcome												
All	2.34	4.22	0.02	0.12	0.35	0.94	1.79	3.03	4.66	5.96	9.48	0.268
Gain	2.52	4.46	0.04	0.24	0.55	1.10	1.95	3.21	4.87	6.18	9.81	0.219
Loss	1.07	1.32	0.00	0.02	0.04	0.19	0.70	1.52	2.58	3.39	5.51	0.610
Panel C: Real bill payoffs conditional on domestic stock outcome												
All	1.32	0.81	0.03	0.16	0.40	0.80	1.21	1.72	2.31	2.76	3.97	0.369
Gain	1.38	0.80	0.04	0.27	0.51	0.86	1.26	1.76	2.36	2.80	4.03	0.335
Loss	0.93	0.77	0.01	0.03	0.05	0.35	0.80	1.33	1.91	2.34	3.40	0.604

Table V

Unconditional and conditional loss probabilities.

The table shows unconditional and conditional loss probabilities across 10,000,000 bootstrap simulations at a 30-year return horizon. The underlying sample is the pooled sample of all developed countries. For each asset class, the table reports the unconditional loss probability (repeated from Table III) and loss probabilities conditional on a real gain or loss in one of the other asset classes. The reported unconditional loss probabilities are the proportions of payoff draws that are less than one given a $1.00 buy-and-hold investment. The conditional loss probabilities are the proportions of payoff draws that are less than one conditional on the payoff draw (i.e., gain or loss) for the other asset class.

		$\mathbb{P}(W_{H,A}^{(m)} < 1 \| W_{H,B}^{(m)} \geq 1)$				$\mathbb{P}(W_{H,A}^{(m)} < 1 \| W_{H,B}^{(m)} < 1)$			
		Asset class B				Asset class B			
Asset class A	$\mathbb{P}(W_{H,A}^{(m)} < 1)$	Domestic stocks	International stocks	Bonds	Bills	Domestic stocks	International stocks	Bonds	Bills
Domestic stocks	0.126	0.000	0.115	0.067	0.079	1.000	0.391	0.288	0.207
International stocks	0.042	0.029	0.000	0.027	0.024	0.129	1.000	0.081	0.072
Bonds	0.268	0.219	0.257	0.000	0.068	0.610	0.526	1.000	0.610
Bills	0.369	0.335	0.357	0.196	0.000	0.604	0.640	0.839	1.000

Table VI
Bootstrap distributions of payoffs for US data.

The table summarizes distributions of real payoffs from a \$1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at various return horizons. The underlying sample is the US sample. Each panel shows statistics for the distribution of a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Horizon	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
Panel A: Real domestic stock payoffs												
1 month	1.01	0.05	0.87	0.93	0.95	0.98	1.01	1.03	1.06	1.08	1.12	0.407
1 year	1.08	0.20	0.62	0.76	0.84	0.96	1.08	1.20	1.32	1.40	1.56	0.318
5 years	1.47	0.59	0.55	0.71	0.81	1.04	1.39	1.77	2.24	2.57	3.32	0.218
10 years	2.12	1.15	0.59	0.77	0.92	1.31	1.86	2.68	3.68	4.26	5.84	0.128
20 years	4.37	3.32	0.70	1.11	1.41	2.16	3.46	5.55	8.53	10.65	16.39	0.036
30 years	8.89	8.48	0.95	1.69	2.29	3.76	6.45	11.00	18.02	24.20	41.90	0.012
Panel B: Real international stock payoffs												
1 month	1.00	0.04	0.89	0.94	0.96	0.99	1.00	1.02	1.04	1.06	1.10	0.425
1 year	1.06	0.18	0.61	0.80	0.87	0.96	1.04	1.14	1.25	1.35	1.74	0.365
5 years	1.32	0.59	0.42	0.69	0.78	0.98	1.18	1.49	1.99	2.44	3.66	0.275
10 years	1.70	0.98	0.36	0.66	0.82	1.09	1.44	2.02	3.06	3.62	4.98	0.196
20 years	2.80	2.26	0.39	0.71	0.93	1.43	2.15	3.50	5.36	6.76	11.36	0.118
30 years	4.60	4.68	0.44	0.82	1.15	1.93	3.25	5.72	9.23	12.51	22.68	0.076
Panel C: Real bond payoffs												
1 month	1.00	0.02	0.96	0.98	0.98	0.99	1.00	1.01	1.02	1.03	1.06	0.452
1 year	1.02	0.08	0.84	0.89	0.92	0.98	1.02	1.06	1.11	1.15	1.28	0.362
5 years	1.11	0.24	0.62	0.77	0.85	0.97	1.08	1.25	1.40	1.53	1.83	0.309
10 years	1.25	0.40	0.60	0.72	0.79	0.97	1.17	1.47	1.80	1.98	2.42	0.280
20 years	1.57	0.75	0.54	0.69	0.79	1.01	1.42	1.92	2.55	3.04	4.03	0.243
30 years	1.95	1.16	0.51	0.70	0.82	1.13	1.68	2.44	3.43	4.22	6.06	0.185
Panel D: Real bill payoffs												
1 month	1.00	0.01	0.98	0.99	1.00	1.00	1.00	1.00	1.01	1.01	1.02	0.394
1 year	1.01	0.04	0.86	0.93	0.97	0.99	1.01	1.03	1.05	1.07	1.13	0.354
5 years	1.05	0.15	0.69	0.78	0.87	0.96	1.06	1.13	1.23	1.30	1.44	0.342
10 years	1.11	0.24	0.61	0.72	0.79	0.94	1.11	1.25	1.42	1.50	1.70	0.337
20 years	1.22	0.37	0.54	0.64	0.76	0.97	1.19	1.45	1.70	1.85	2.22	0.276
30 years	1.35	0.49	0.49	0.65	0.76	1.00	1.30	1.62	1.98	2.21	2.75	0.250

Table VII

Return decompositions.

The table reports mean ending log real wealth and mean components of ending log real wealth across 10,000,000 bootstrap simulations at a 30-year return horizon. The underlying sample is the pooled sample of all developed countries. Each panel corresponds to a specific asset class: domestic stocks (Panel A), international stocks (Panel B), and bonds (Panel C). Each panel shows unconditional mean return and component outcomes and mean return and component outcomes conditional on a gain or loss in the indicated asset class.

	Mean return decomposition						
Outcome	Component (1)	+	Component (2)	+	Component (3)	$\approx$	Return
Panel A: Domestic stocks							
	Valuation component $\rho_s[(p_H - d_H) - (p_0 - d_0)]$	+	Dividend growth component $\rho_s \sum_{t=1}^{H}(\Delta d_t - \pi_t)$	+	Dividend income component $(1-\rho_s)\sum_{t=1}^{H}(d_t - p_{t-1} - \pi_t) + Hq_s$	$\approx$	Return w_H
All	−0.007	+	0.154	+	1.049	$\approx$	1.331
Gain	0.028	+	0.413	+	1.063	$\approx$	1.644
Loss	−0.245	+	−1.626	+	0.953	$\approx$	−0.816
Panel B: International stocks							
	Foreign stocks component $\log(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1} R_{j,t}^{Stocks})$	+	PPP component $\log(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}\frac{\Pi_{j,t}}{\Pi_{i,t}}\Delta E_t^{i,j})$	+	n/a	$\approx$	Return w_H
All	1.548	+	0.062	+	n/a	$\approx$	1.562
Gain	1.610	+	0.088	+	n/a	$\approx$	1.650
Loss	0.184	+	−0.511	+	n/a	$\approx$	−0.319
Panel C: Bonds							
	Valuation component $\rho_b \sum_{t=1}^{H}(\tilde{p}_t - p_{t-1} - \pi_t)$	+	Default component $\rho_b \sum_{t=1}^{H}\log(1 - L_t)$	+	Coupon income component $(1-\rho_b)\sum_{t=1}^{H}(c_t - p_{t-1} - \pi_t) + Hq_b$	$\approx$	Return w_H
All	−1.283	+	−0.040	+	1.405	$\approx$	0.359
Gain	−0.775	+	−0.010	+	1.398	$\approx$	0.903
Loss	−2.670	+	−0.122	+	1.424	$\approx$	−1.127

Table VIII

Mean economic outcomes conditional on asset class performance.

The table reports mean economic outcomes across 10,000,000 bootstrap simulations at a 30-year horizon. The underlying sample is the pooled sample of all developed countries. Each panel shows unconditional mean macroeconomic outcomes and mean macroeconomic outcomes conditional on a gain or loss in a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). Each panel reports the mean of the log of the cumulative buy-and-hold return on the asset class under consideration, the mean of log cumulative GDP growth, the mean of the log cumulative nominal short-term interest rate, and the mean of log cumulative inflation.

Outcome	Return	GDP growth	Short rate	Inflation
Panel A: Domestic stocks				
All	1.331	0.532	1.363	1.352
Gain	1.644	0.564	1.358	1.252
Loss	−0.816	0.311	1.393	2.036
Panel B: International stocks				
All	1.562	0.532	1.363	1.352
Gain	1.650	0.537	1.363	1.333
Loss	−0.319	0.375	1.144	1.479
Panel C: Bonds				
All	0.359	0.532	1.363	1.352
Gain	0.903	0.543	1.353	0.995
Loss	−1.127	0.502	1.389	2.327
Panel D: Bills				
All	0.011	0.532	1.363	1.352
Gain	0.493	0.554	1.444	0.951
Loss	−0.811	0.494	1.225	2.036

Table IX

GDP and dividend outcomes conditional on domestic stock performance.

The table summarizes distributions of domestic stock returns, aggregate dividend growth, GDP growth, and the change in the aggregate dividend-GDP ratio across 10,000,000 bootstrap simulations at a 30-year horizon. The underlying sample is the pooled sample of all developed countries. Each panel shows statistics for the unconditional and conditional distributions of a given macroeconomic outcome: the log cumulative buy-and-hold return for domestic stocks (Panel A), the log cumulative GDP growth (Panel B), the log cumulative aggregate dividend growth (Panel C), and the cumulative change in the log dividend-GDP ratio (Panel D). In each panel, the first row shows the unconditional distribution of the indicated macroeconomic outcome, and the second and third rows show the distributions conditional on a real gain or loss in domestic stocks in the bootstrap simulation.

	Moments		Percentiles				
Outcome	Mean	SD	5%	25%	50%	75%	95%
Panel A: Log domestic stock return							
All	1.331	1.221	−0.791	0.622	1.402	2.121	3.202
Gain	1.644	0.923	0.265	0.954	1.576	2.231	3.280
Loss	−0.816	0.762	−2.347	−1.156	−0.592	−0.251	−0.046
Panel B: Log GDP growth							
All	0.532	0.480	−0.239	0.249	0.537	0.820	1.279
Gain	0.564	0.454	−0.155	0.284	0.559	0.834	1.292
Loss	0.311	0.581	−0.750	−0.013	0.339	0.686	1.190
Panel C: Log aggregate dividend growth							
All	0.911	1.611	−1.579	0.065	0.892	1.753	3.504
Gain	1.114	1.474	−1.013	0.266	1.023	1.858	3.630
Loss	−0.484	1.804	−3.880	−1.367	−0.317	0.594	2.138
Panel D: Change in the log dividend-GDP ratio							
All	0.379	1.541	−1.963	−0.485	0.350	1.220	2.831
Gain	0.550	1.431	−1.523	−0.319	0.468	1.317	2.938
Loss	−0.796	1.746	−4.014	−1.687	−0.643	0.269	1.730

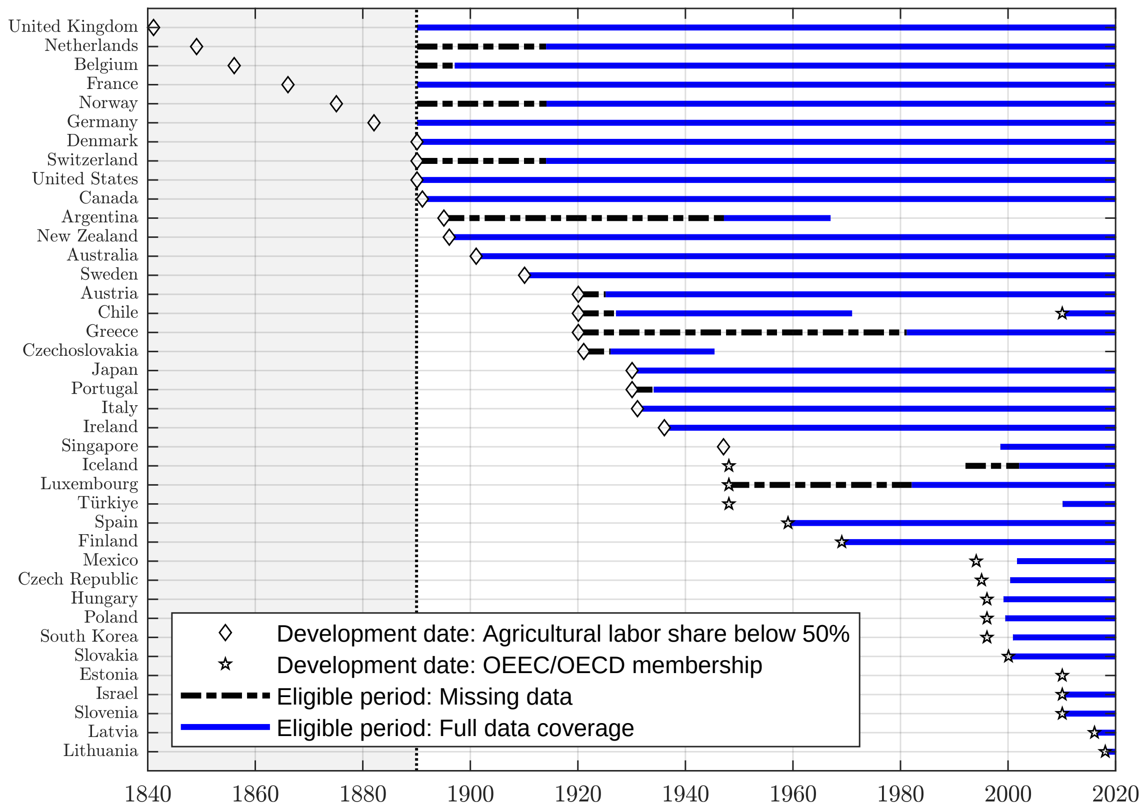

Figure 1. Development periods and data availability by country. The figure details the development date, the eligible sample period, and the period with data coverage for each country in the sample. The development year classifications are based on agricultural labor share, organizational membership in the Organisation for European Economic Co-operation (OEEC), or organizational membership in the Organisation for Economic Co-operation and Development (OECD). The line for each country shows the period over which that country is eligible to be included in the sample. The earliest possible sample eligibility for any country is 1890, and the shaded area of the plot denotes the pre-eligibility period. Sample eligibility on a given date also requires that a country is classified as developed and has outstanding long-term government bonds. The dashed portion of each line denotes the eligible period over which some returns data are missing, and the solid portion denotes the period with valid returns data for stocks, bonds, and bills.

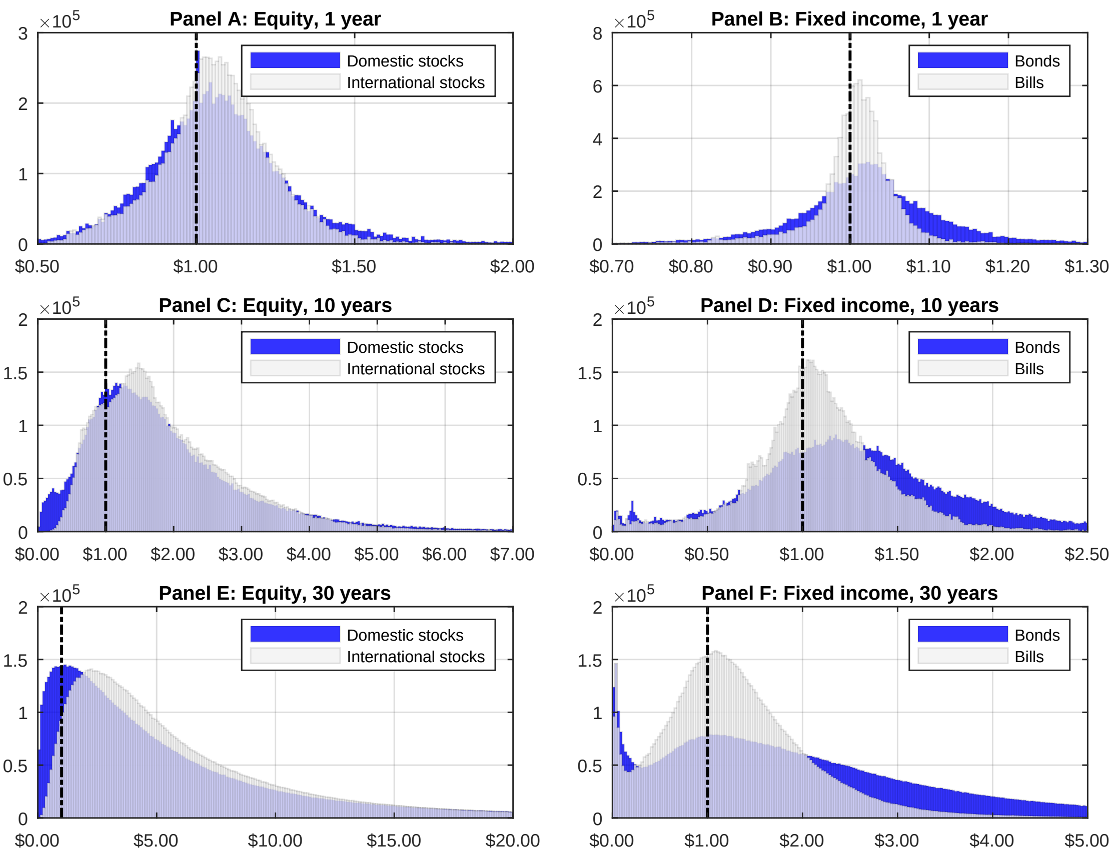

Figure 2. Cumulative payoffs. The figure shows histograms of real payoffs across 10,000,000 bootstrap simulations at various return horizons for four asset classes: domestic stocks, international stocks, bonds, and bills. The underlying sample for the simulated returns is the pooled sample of all developed countries. The dashed line in each plot separates the regions of real loss and gain on a $1.00 initial investment.

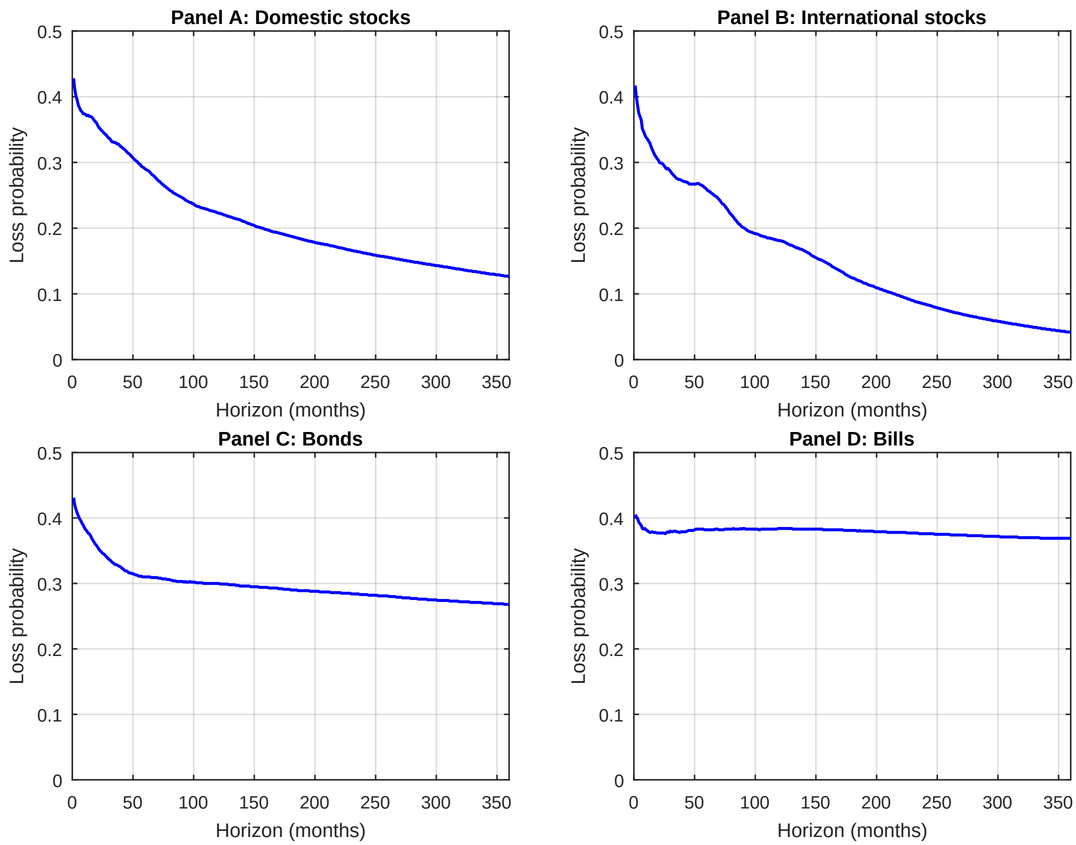

Figure 3. Loss probabilities for alternative investment horizons. The figure shows the proportion of real payoffs that are less than the initial investment across 10,000,000 bootstrap simulations at various return horizons. Each panel corresponds to a specific asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D).

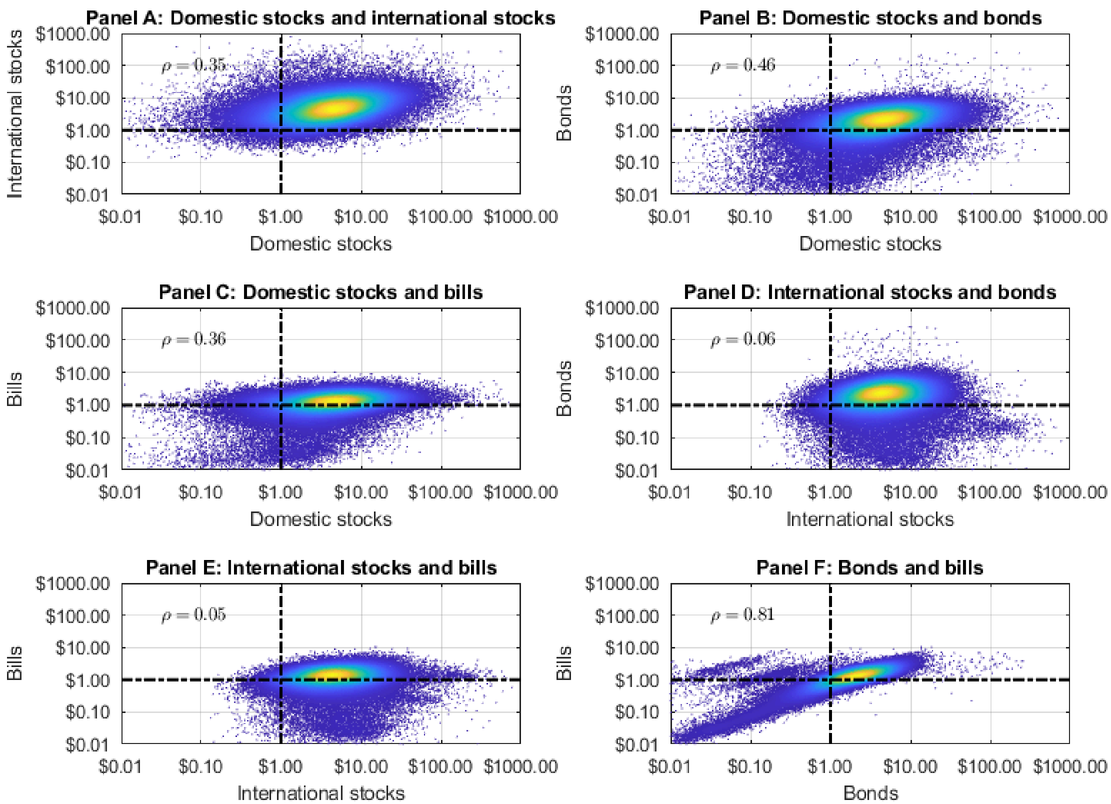

Figure 4. Joint distributions of cumulative 30-year payoffs. The figure shows heat maps of the joint distributions of real payoffs across 100,000 bootstrap simulations at a 30-year return horizon. The underlying sample for the simulated returns is the pooled sample of all developed countries. Each panel corresponds to the joint distribution of real payoffs for two asset classes. Each dot represents a joint payoff outcome for the indicated asset classes. The dots in more (less) dense areas are shaded yellow (blue).

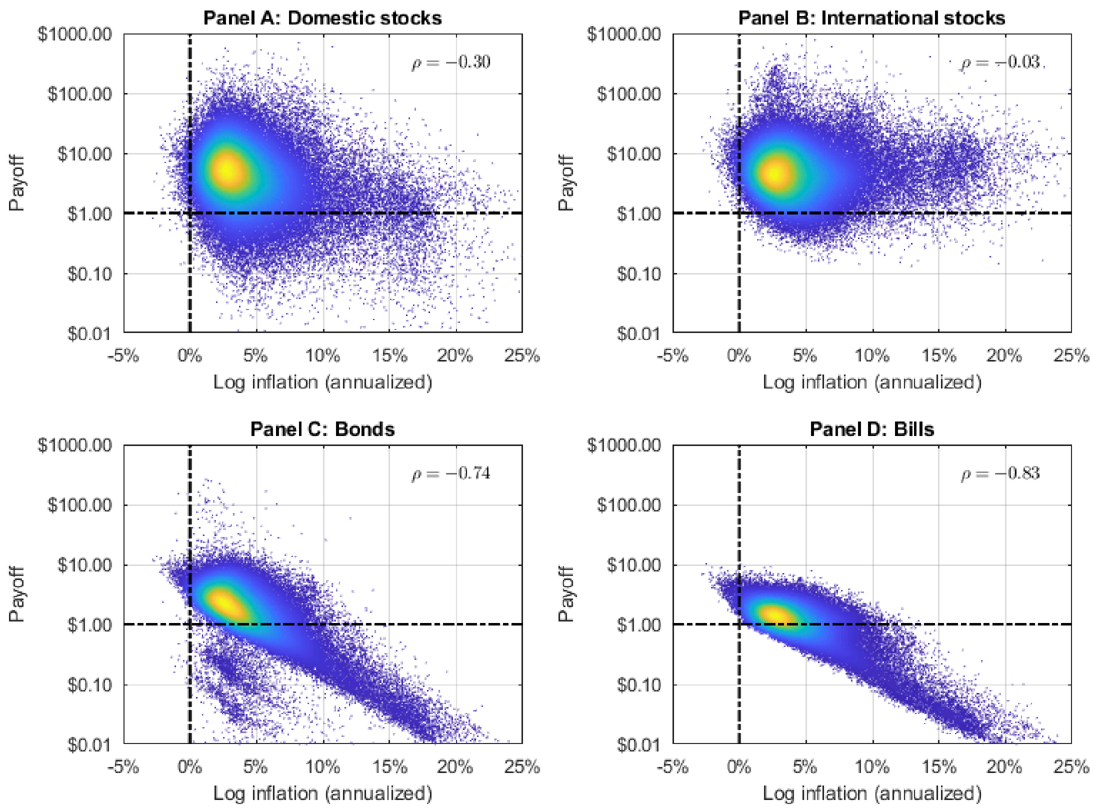

Figure 5. Inflation and cumulative 30-year payoffs. The figure shows heat maps of the joint distributions of inflation and real payoffs across 100,000 bootstrap simulations at a 30-year return horizon. The underlying sample for the simulated returns is the pooled sample of all developed countries. Each panel corresponds to the joint distribution of inflation and real payoffs for a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). Each dot represents a joint inflation-payoff outcome. The dots in more (less) dense areas are shaded yellow (blue).

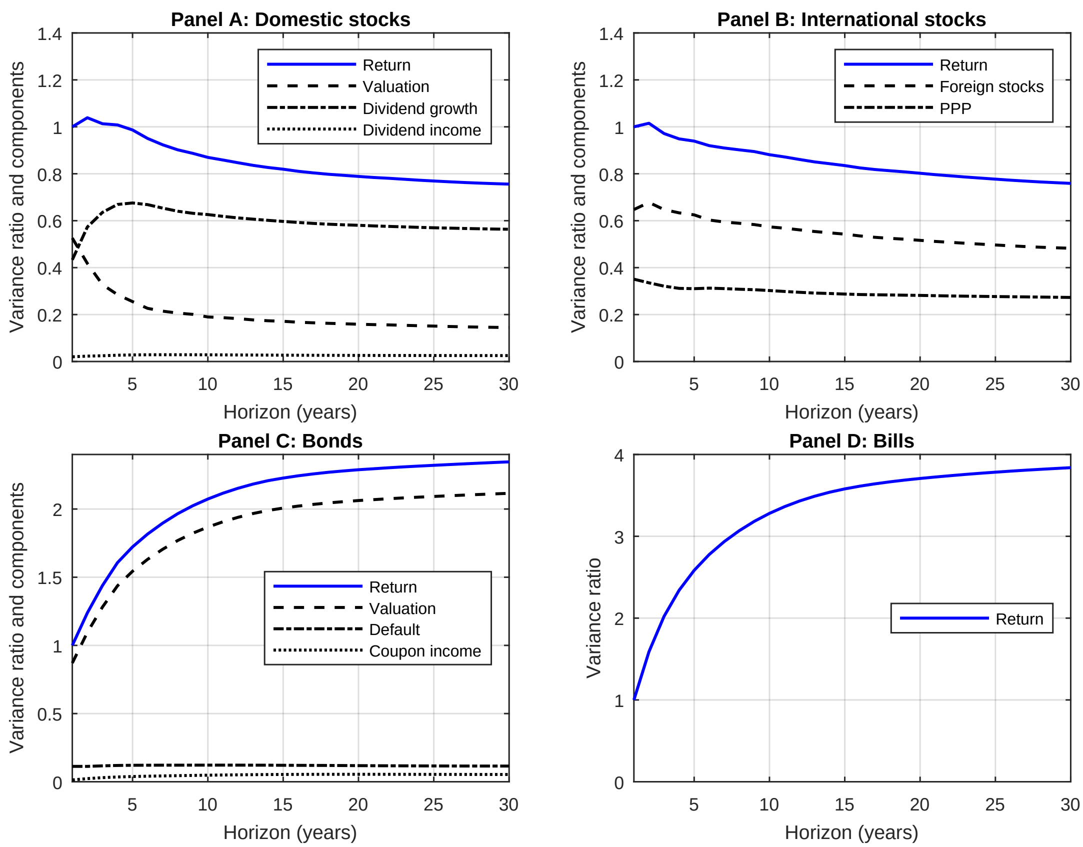

Figure 6. Variance ratios. The figure shows variance ratios and components of variance ratios across 10,000,000 bootstrap simulations at various return horizons. Each panel corresponds to a specific asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D).

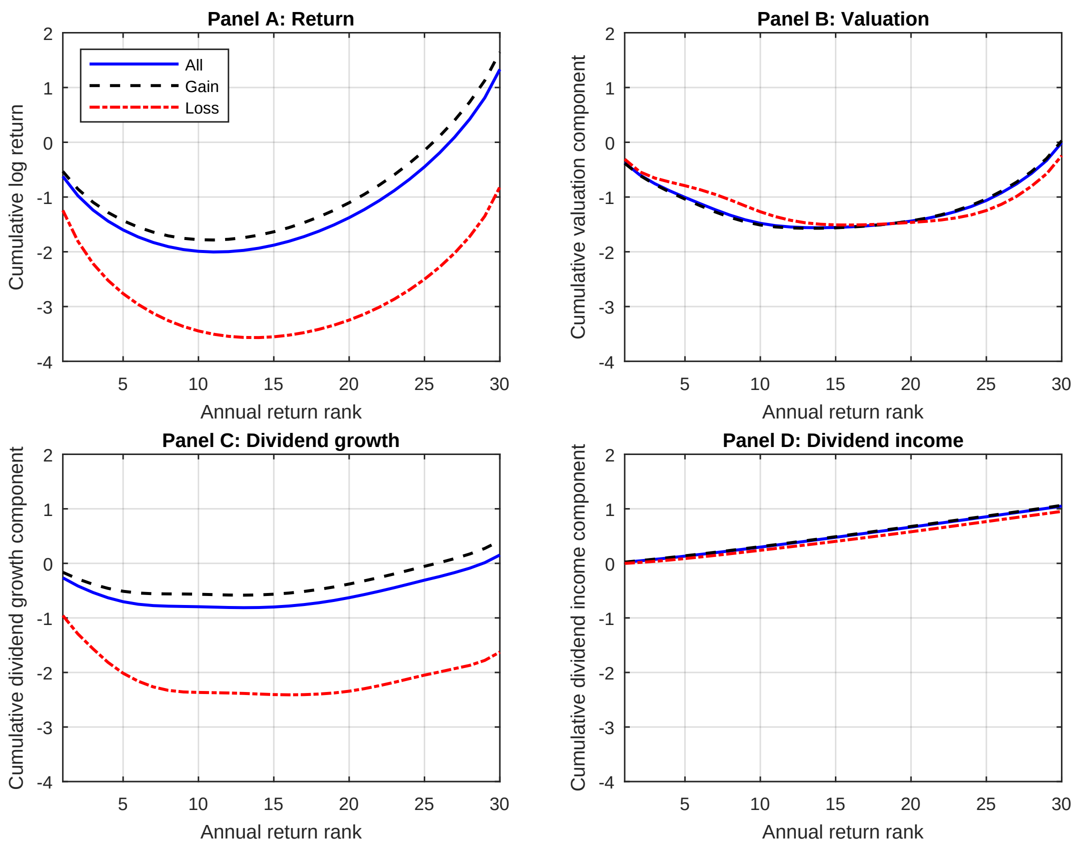

Figure 7. Mean domestic stock return components by sorted domestic stock returns. The figure characterizes the relation between domestic stock performance and components of domestic stock returns across 10,000,000 bootstrap simulations for a 30-year return horizon. For each 30-year draw of domestic stock returns from the bootstrap procedure, we first sort the 30 annual observations based on the real return rank. We then compute the cumulative sum of the log returns, valuation component, real dividend growth component, and real dividend income component. The figure shows the unconditional averages of these cumulative components across bootstrap draws and the averages of these cumulative components conditional on a gain or loss in domestic stocks over the 30-year period.

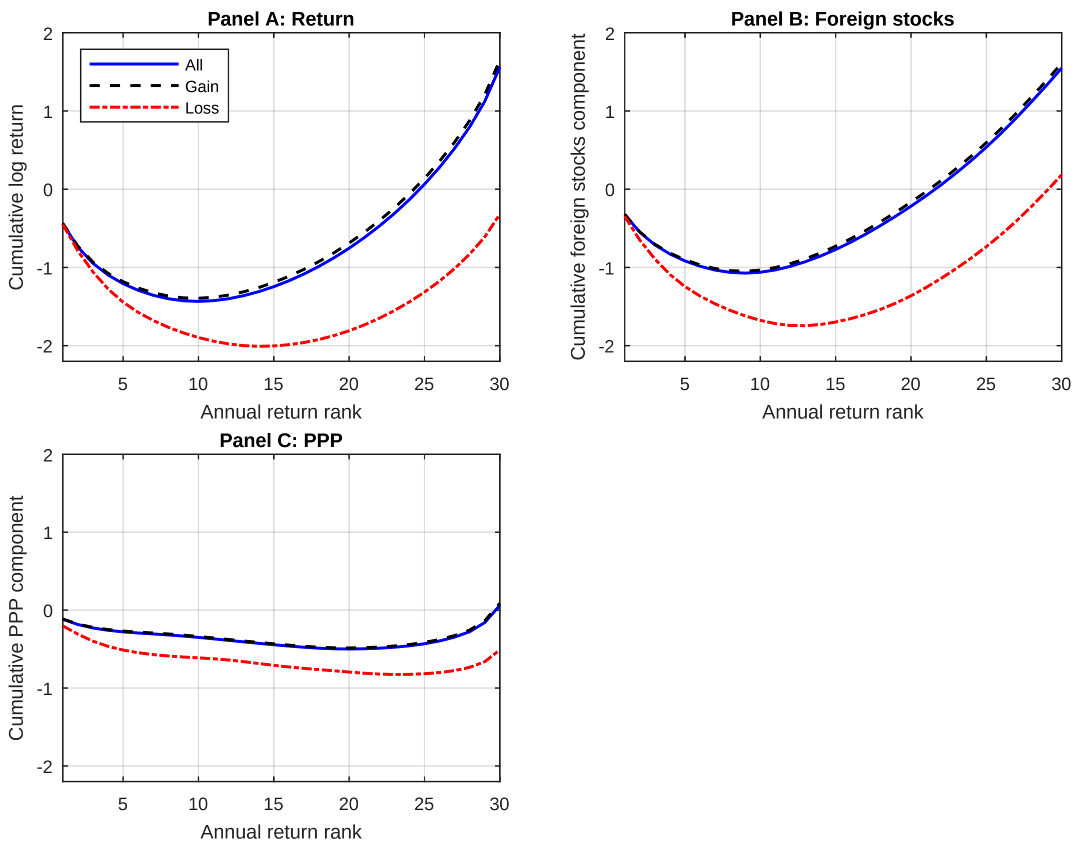

Figure 8. Mean international stock return components by sorted international stock returns. The figure characterizes the relation between international stock performance and components of international stock returns across 10,000,000 bootstrap simulations for a 30-year return horizon. For each 30-year draw of international stock returns from the bootstrap procedure, we first sort the 30 annual observations based on the real return rank. We then compute the cumulative sums of the log returns, value-weighted average foreign stock market performance component, and changes in real exchange rates (PPP) component. The figure shows the unconditional averages of these cumulative components across bootstrap draws and the averages of these cumulative components conditional on a gain or loss in international stocks over the 30-year period.

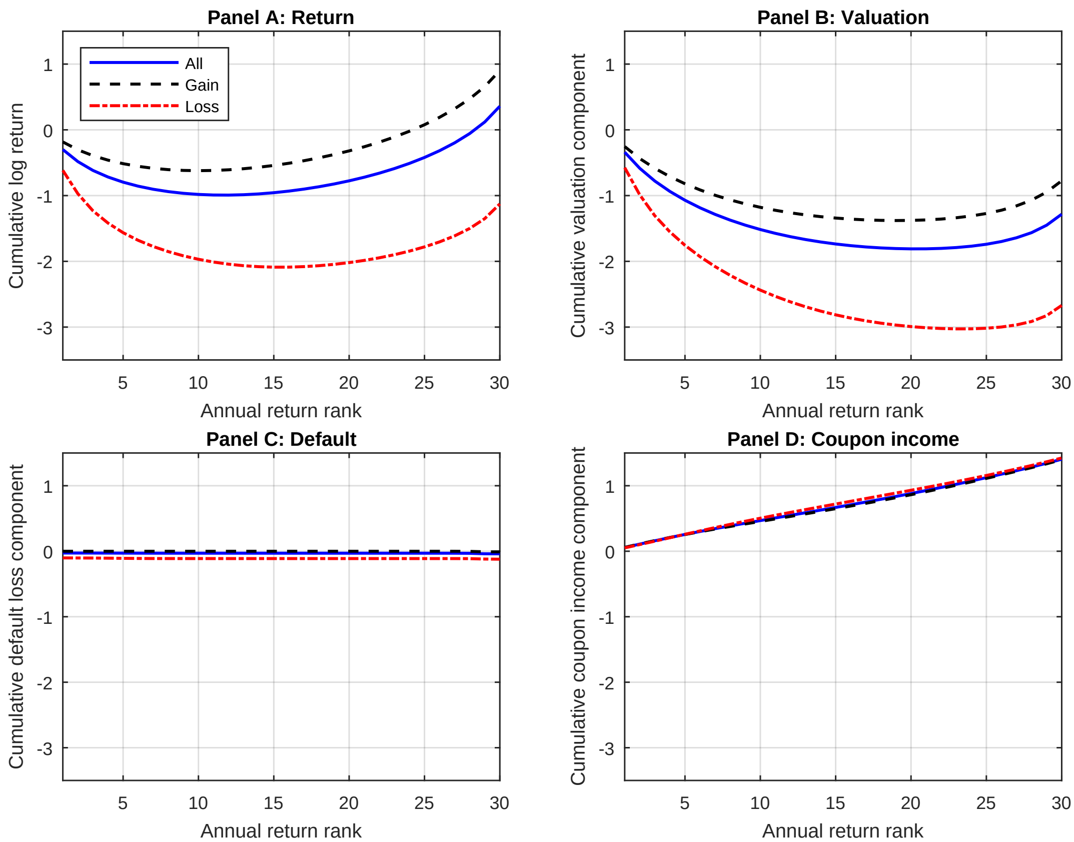

Figure 9. Mean bond return components by sorted bond returns. The figure characterizes the relation between bond performance and components of bond returns across 10,000,000 bootstrap simulations for a 30-year return horizon. For each 30-year draw of bond returns from the bootstrap procedure, we first sort the 30 annual observations based on the real return rank. We then compute the cumulative sums of the log returns, real valuation component, default loss component, and real coupon income component. The figure shows the unconditional averages of these cumulative components across bootstrap draws and the averages of these cumulative components conditional on a gain or loss in bonds over the 30-year period.

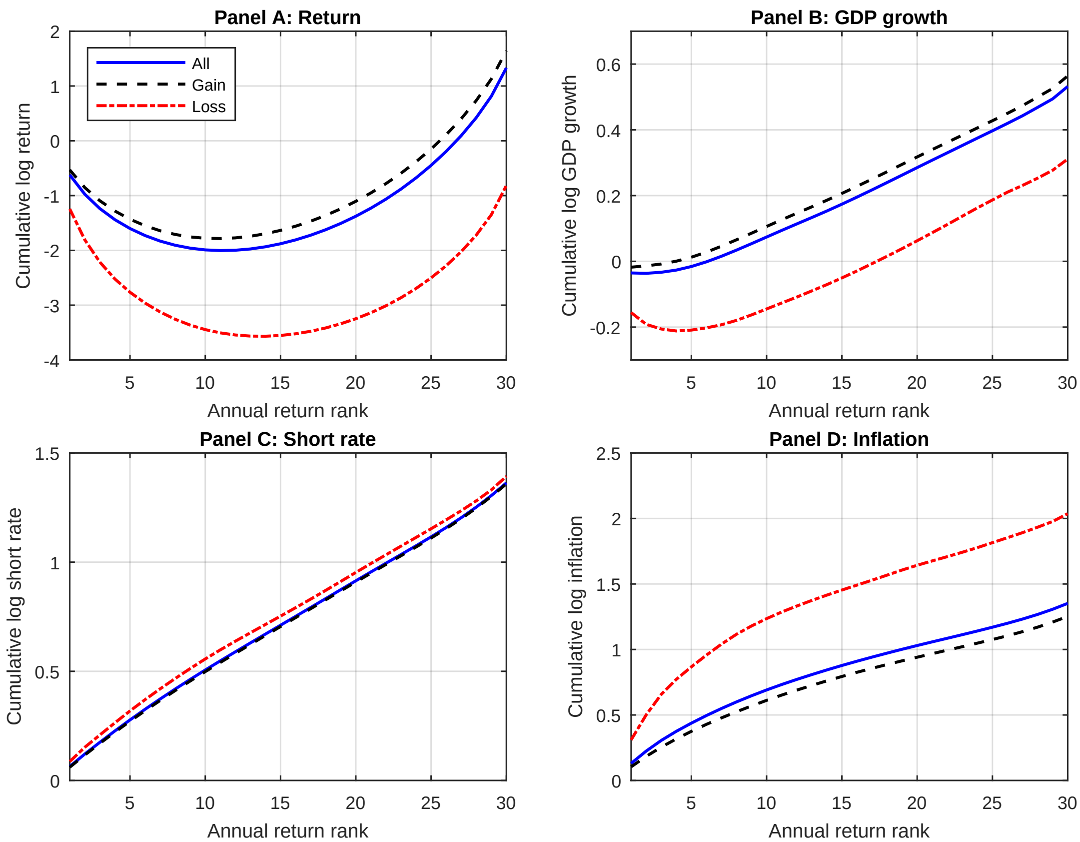

Figure 10. Mean economic variables by sorted domestic stock returns. The figure characterizes the relation between domestic stock performance and macroeconomic conditions across 10,000,000 bootstrap simulations for a 30-year return horizon. For each 30-year draw of domestic stock returns from the bootstrap procedure, we first sort the 30 annual observations based on the real return rank. We then compute the cumulative sums of log domestic stock returns, log GDP growth, log short rate, and log inflation. The figure shows the unconditional averages of these cumulative sums across bootstrap draws and the averages of these cumulative sums conditional on a gain or loss in domestic stocks over the 30-year period.

Internet Appendix

Long-Horizon Losses in Stocks, Bonds, and Bills: Evidence from a Broad Sample of Developed Markets

November 11, 2022

Abstract

This internet appendix contains material that is supplemental to the paper "Long-Horizon Losses in Stocks, Bonds, and Bills: Evidence from a Broad Sample of Developed Markets."

A Data appendix

This appendix outlines our data sources and construction methods. The primary source of data for our study is the GFDatabase from Global Financial Data (GFD). Table A.I reports the data series we use to compute monthly stock, bond, and bill returns for each country. As noted in the footnotes to Table A.I, we supplement the data from GFD with data from other sources. Additional details on these data sources and the required data adjustments are provided in Sections A.1 to A.4. Section A.5 compares our data on stock and bond returns with data from alternative sources. Section A.6 describes additional data sources and adjustments required to construct our annual dataset.

A.1 Stock returns and dividend-price ratios

Full details on the data adjustments required to compute nominal and real stock returns for our developed country sample are available in Anarkulova, Cederburg, and O'Doherty (2022) and the corresponding internet appendix. These sources outline the approach to constructing monthly returns from data on either total return indexes or price indexes and dividend-price ratios. They also describe adjustments for missing return and dividend-price ratio observations and the calculation of stock returns for Germany over the period of extreme inflation from 1917 to 1923.

The internet appendix for Anarkulova, Cederburg, and O'Doherty (2022) outlines the smoothing procedures used to fill gaps in return series for short periods in a few sample countries. In addition to those cases, we apply a smoothing procedure to convert quarterly return data for Belgium over the period from May 1919 to January 1926 into a time series of monthly returns. In particular, we make the assumption of constant monthly returns within each quarterly period.

One difference between our sample construction approach and the one in Anarkulova, Cederburg, and O'Doherty (2022) relates to the handling of multi-month return observations associated with stock market disruptions and closures. Table A.II reports cases of exchange closures or heavily restricted trading during our sample period along with the corresponding nominal and real returns. The bootstrap procedure in Anarkulova, Cederburg, and O'Doherty (2022) treats each of these events as a single return observation covering a multi-month period. This treatment reflects that most investors would have been unable to trade during these periods, such that they could only wait for the eventual realizations of the longer-period returns. This treatment is not ideal for our multi-asset analysis, however, as we would like to maintain a balanced panel of monthly asset returns for each country. At the same time, we need the data to reflect the economic outcomes of stock market investors.

In our current approach to handling multi-month returns, we take the perspective on an investor in a hypothetical fund attempting to track the market index for a given country. Although this investor could not directly liquidate her stock holdings via exchange trades during times of market closure, she could sell her shares in the hypothetical fund. The fund's managers, in turn, could either rely on black market data for valuation purposes or produce an estimate of the historical event's impact on asset prices at the beginning of the closure period. Based on this perspective, we apply one of two approaches to handling multi-month returns:

1. For events during which GFD provides black market prices, we use these values to estimate stock market index returns.

2. For events without corresponding data in GFD, we assign the total multi-month real return to the first monthly observation and zero real return to the remaining monthly observations.

The two exceptions to this general approach correspond to Switzerland's 24-month return from August 1914 to July 1916 and Czechoslovakia's 26-month return from April 1943 to May 1945.

For Switzerland, GFD reports limited black market data in January 1916 and July 1916. We use these intermittent values and assign the remaining part of the total real return to August 1914. For Czechoslovakia, the April 1943 to May 1945 period corresponds to an episode that starts with severe trading restrictions and price controls and ends with the permanent stock exchange closure in Prague on May 5, 1945. For this period, we assign a terminal nominal return of −90.00% to May 1945 and zero nominal returns to the other months. This treatment is consistent with the economic experience of investors over this period, as detailed in Anarkulova, Cederburg, and O'Doherty (2022).

Finally, we rely on external sources to calculate dividend-price ratios for Slovakia and Latvia. In both cases, GFD lacks comprehensive information to compute these ratios. For Slovakia, we use dividend-price ratio data from the Bratislava Stock Exchange's official website.[1] For Latvia, we calculate dividend-price ratios using data on total dividends paid by companies from Nasdaq Baltic and data on total market capitalization from GFD.[2]

A.2 Bond returns

Nominal and real country-level bond returns are defined in Section 2.1.3. The calculations require data on monthly yields for ten-year government bonds, and this section considers several issues related to the underlying yield data.

A.2.1 Bond data availability

For several countries in our sample, there are no ten-year government bonds in circulation at the time the country is initially classified as developed (Figure 1). For example, ten-year government bonds are first issued in Iceland in 1992, Singapore in 1998, Hungary in 1999, Poland in 1999, the Czech Republic in 2000, South Korea in 2000 [Kang, Kim, and Rhee (2005)], Mexico in 2001 [Jeanneau and Verdia (2005)], and Türkiye in 2010.[3] These circumstances create gaps between the development dates and the sample eligibility dates for these countries.

Estonia issued its only domestic bond in 1993, and all tranches were redeemed by 2004.[4] As a result, Estonia is excluded from our sample because the country has no domestic bond data for the developed period.

A.2.2 Data gaps and errors

Table A.III shows periods over which we are missing monthly bond yields. In these cases, we use a smoothing procedure to fill gaps in the monthly bond return series. This procedure uses the country-level yield data from before and after the missing observations to produce a series of constant monthly returns across a given period.

The bond yield data in GFD for Slovenia from December 2018 to December 2019 and Türkiye in November 2019 are incorrect, so we use data from alternative sources as detailed in the footnotes

[1] See http://www.bsse.sk/%C5%A0tatistika/Mesa%C4%8Dn%C3%A1.aspx.

[2] The dividend data for Latvia are available at https://nasdaqbaltic.com/statistics/en/statistics.

[3] See http://www.lanamal.is/asset/12732/special-report-markadsvidskipti_agust-2019.pdf for Iceland, https://eservices.mas.gov.sg/statistics/fdanet/BenchmarkPricesAndYields.aspx for Singapore, https://stats.oecd.org/OECDStat_Metadata/ShowMetadata.ashx?Dataset=GOV_DEBT&Coords=%5BCOU%5D.%5BHUN%5D&ShowOnWeb=true&Lang=en for Hungary, https://www.gov.pl/web/finance/transaction-database for Poland, https://www.cnb.cz/en/financial-markets/treasury-securities-market/government-bonds/ for the Czech Republic, and https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Statistics/Markets+Data/Treasury+Auction/ for Türkiye.

[4] See https://www.rahandusministeerium.ee/en/objectivesactivities/state-treasury/financial-reserves-and-liabilities/debt-management.

to Table A.I.

We also adjust an apparent error in the GFD bond yield data for Switzerland. The stated source for the GFD data is the Swiss National Bank. In comparing the GFD data to the Swiss National Bank data, however, the yields match only through December 1941. The Swiss National Bank reports yields of 3.11% in January 1942, 3.14% in February 1942, 3.12% in March 1942, and 3.08% in April 1942. GFD reports yields of 3.14%, 3.12%, and 3.07% for January through March 1942. From April 1942 to December 1990, the GFD data lead the Swiss National Bank data by one month. We adjust the GFD data by entering a 3.11% yield for January 1942 and shifting the original GFD data from January 1942 to November 1990 so that it covers February 1942 to December 1990.

A.2.3 Merging multiple sources

As shown in Table A.I, constructing a series of bond returns for a given country often requires us to combine yield data from multiple sources. We make additional adjustments in linking the data series for two sample countries. The GFD data for Chile end in March 2015, and we use data from Federal Reserve Economic Data (FRED) from April 2015 to December 2019. GFD reports a yield of 2.23% for March 2015, whereas the yields from FRED are 4.34% for March 2015 and 4.49% for April 2015. Merging these data series without adjustment would result in a return calculation of −17.76% for April 2015. This return likely provides a poor characterization of investment outcomes, given the relative stability in yields in the FRED data. To address this issue, we use March 2015 and April 2015 yields from FRED to compute the April 2015 bond return. We make an analogous adjustment for Iceland in March 2004.

A.2.4 Alternative bond return calculations

As described in Section 2.1.3, our primary bond return calculations use yield data with an assumption that the coupon rate is equal to the bond yield for a hypothetical new ten-year bond. In three cases, we use an alternative approach of separately measuring the capital gain and the coupon income due to data availability. We use data on current yields and coupon rates from the Central Bank of Argentina to infer bond prices for each month end from January 1947 to December 1966. We compute the capital gain based on the change in bond price and add one month of coupon income based on the 3% coupon rate from February 1947 to July 1960 and the 8% coupon rate from August 1960 to December 1966. We use London quotes from the International Center for Finance at Yale for Chile (December 1926 to September 1929) and Czechoslovakia (December 1925 to January 1927). We compute monthly bond returns based on price changes and monthly coupon income at the coupon rate of 4.5% for Chile and 8.0% for Czechoslovakia.

A.2.5 Bond conversion in Argentina

Argentina issued a 3% bond in 1955. In August 1960, the government allowed for a voluntary conversion of these old bonds to new 8% bonds. The conversion was favorable for bondholders, as they could receive bonds with higher interest payments. According to Duggan (1963), the 3% bonds were exchanged at 79 pesos for the nominal value of 100 pesos. Because the terms of the conversion were favorable, the majority of existing bondholders took the offer. In constructing our bond series for Argentina, we assume conversion at the 79:100 rate. We compute the price change and multiply by 0.79 to reflect the conversion when computing the capital gain for August 1960, and we add one month of coupon income at the 8% coupon rate to calculate the return.

A.2.6 Germany in 1919 to 1924 and 1948

To maintain consistency with our treatment of stock returns in Germany in the inflationary period from 1917 to 1923 (see Section 2.3), we also compute bond returns in gold marks. We use bond prices in paper marks from Fischer (1923, 1924, 1925) and convert paper mark prices to gold marks by using the USD exchange rate because the United States was on the gold standard during that period. The change in gold mark bond prices provides an estimate of the capital appreciation of the bonds. We compute the total bond return by including interest payments based on the 3% coupon rate of the bonds. We use this approach from February 1919 to January 1924.

Germany exchanged Reichsmarks for Deutschemarks in June 1948. For government bonds, the exchange was 10:1 [Schnabl (2019)]. To reflect the economic value of the currency exchange, we adjust the bond price at the end of June 1948 by dividing the price of the bond by ten. The resulting nominal bond return in June 1948 is −90.0%.

A.3 Bill returns

We compute monthly nominal bill returns from annual yields or rates as

$$R_{i,t}^{Nominal\ bills} = (1 + R_{i,t-1}^{Annual\ rate})^{1/12}, \tag{A1}$$

where $R_{i,t-1}^{Annual\ rate}$ is the annualized short-term government bill yield, central bank rate, or interbank rate reported at the end of month $t-1$.

We have a few periods over which there are no bill data from GFD or alternative sources, and we are required to make assumptions to fill these gaps in the data. For Canada, we use a yield of 5.75% for the seven-month period from January 1914 to July 1914. This value is an average of the 6.50% interbank rate for December 1913 from GFD and the 5.00% advance rate for August 1914 from Shearer and Clark (1984). For Chile, the central bank rate series ends in September 2019, and we use the September 2019 value of 2.00% for October 2019 to December 2019. The Netherlands is missing data for February 2014, so we average the short-term government bill yields from GFD of 0.09% for January 2014 and 0.13% for March 2014. Similarly, Türkiye is missing data for September 1995. The GFD bill yield is 68.52% for August 1995 and 92.24% for October 1995, so we use the average value of 80.38% for September 1995.

For New Zealand from January 1896 to December 1914, we use short-term yields on bills held by the Post Office Savings Bank Fund. The Post Office Savings Bank Fund did not hold Treasury bills in 1913, so we are missing data for that year. The yields are 3.00% in December 1912 and 4.00% in January 1914, and we use the average of 3.50% to fill in the data gap. We are also missing yield data for New Zealand from January 1915 to December 1919. The yields for December 1914 and January 1920 are both 4.00%, however, so we assume a 4.00% yield over the adjoining period with missing data.

A.4 Other variables

We follow the data adjustments noted in Anarkulova, Cederburg, and O'Doherty (2022) and the corresponding internet appendix to estimate country-level inflation and exchange rate changes.

The data for nominal GDP, market capitalization, and population are from GFD. These series are typically reported at an annual frequency. There are missing data for some country-year observations of these series. For nominal GDP and population, we fill data gaps using linear interpolation. For market capitalization, which is reported in USD, we fill data gaps by interpolating changes in proportion to USD nominal stock index returns. We adjust an apparent error in the 2017 GFD population data for Chile (by linearly interpolating the 2016 and 2018 values), and we correct an error in the units for the nominal GDP data for Türkiye from February 2010 to December 2019. We use nominal GDP and market capitalization series for Germany from 1917 to 1923 that are denominated in gold marks rather than paper marks. This approach is consistent with Anarkulova, Cederburg, and O'Doherty's (2022) calculation of the total return index for Germany over this period.

We adjust the GDP numbers for Germany in the GFDatabase by a factor of ten starting in 1948 to account for the currency reform noted in Section A.2.6.

We also adjust the GFD GDP series for Japan in 1945 and 1946 to create a closer match between our final series and those from other sources. The raw GFD data for Japan suggest that there was approximately a 150% increase in real per capita GDP between 1939 and 1954. Ohkawa and Rosovsky (1973) suggest that the real per capita GDP levels in 1939 and 1954 were equal to each other, and Fukao and Settsu (2021) suggest that real per capita GDP in 1955 was 10% below that in 1940. Based on this evidence, we subtract an equal amount from GDP growth in 1945 and 1946 to make real per capita GDP for 1939 and 1954 equal to each other. This adjustment creates a time series of GDP that more closely agrees with alternative sources and has a time-series pattern closely matching the one for aggregate dividends.

A.5 External validation tests

This section details the external validation tests for our stock and bond return data.

A.5.1 Comparison of stock data from GFD and Jordà et al. (2019)

Anarkulova, Cederburg, and O'Doherty (2022) compare their data on stock returns from GFD with the stock returns from the overlapping periods in Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019). They find that the data from these two sources have very similar characteristics in terms of country-level average returns, standard deviations, and extreme returns. They also show that the return correlation across the two datasets exceeds 0.90 for nearly all countries. Given that our approach to constructing country-level stock returns closely follows the approach in Anarkulova, Cederburg, and O'Doherty (2022), these tests also provide external validation of our stock data.

A.5.2 Comparison of bond data from GFD and Datastream

As described in Section 2 of the paper, we calculate bond returns using bond yield data from GFD and other sources. In this section, we perform an external validation exercise by comparing our bond returns with those from Datastream over the periods and countries for which they are available. This analysis serves to both ensure that our approach to converting bond yields to returns is empirically accurate and assess whether our bond return data and the bond data from a popular alternative source exhibit common characteristics.

Table A.IV shows results from the external validation analysis. Panel A reports statistics for nominal returns and Panel B for real returns. Our sample overlaps with Datastream for 27 countries. Datastream data begin in 1989 for several countries and more recently for others. The table reports the sample size, the arithmetic and geometric means, standard deviation, and minimum and maximum returns for our data, the corresponding statistics for Datastream data, and the correlation between our returns and those from Datastream. The table also shows pooled statistics across countries.

Table A.IV indicates a close correspondence between our bond return data and those from Datastream. For nearly all countries, the means, standard deviations, and extreme returns are highly similar across the two data sources. In both Panels A and B, 24 of the 27 countries have return correlations above 0.90. Only Hungary, Mexico, and Singapore have correlations below 0.90.

Of the 24 countries with high correlations, Greece is unique in Table A.IV as the only country with economically meaningful differences in the remaining summary statistics. We proceed to discuss these four exceptions.

Hungary and Singapore appear to be the simplest cases. We examine bond yields and returns across the two datasets. The GFDatabase and Datastream bond yields differ, sometimes substantially, for these two countries. To reconcile the differences, we collect ten-year historical bond yield data from the Magyar Nemzeti Bank (the central bank of Hungary) and the Monetary Authority of Singapore.[5] For Hungary, the correlation in yield changes from the central bank data and our data is 0.997, whereas the correlation between yield changes from the central bank and Datastream is only 0.817. For Singapore, the GFDatabase and Singaporean government data exactly match. The large deviations between Datastream and these other sources primarily occur in the first seven months of the sample, and the reported returns in Datastream imply changes in yields that are not reflected in the data from the Monetary Authority. Excluding the first seven months, the correlation between returns in our data and Datastream is 0.97. Our data appear reliable for these countries.

The bond yields for Mexico in our data and in Datastream are relatively similar. For several months in the sample, the reported Datastream return seems inconsistent with the reported yield change. For example, the reported yield increases by 0.08% in June 2015, but the reported return is 8.12%. We compare our calculated returns and the reported Datastream returns with the returns on the S&P/BMV Mexico Sovereign Bond Index in these months.[6] The S&P/BMV index tracks bonds with several maturities, and its duration is low compared with the other two series. Nonetheless, the returns from this index are much more consistent with our data versus Datastream. In June 2015, for example, the S&P/BMV index reports a return of −0.15%, which is close to our return calculation of −0.10% but far from the 8.12% reported return in Datastream. Given the consistency between the GFDatabase and the S&P/BMV index, the deviations between our data and Datastream appear to be reporting errors for returns in Datastream.

The largest deviations in bond returns for Greece are related to the Greek bond default in 2012. As discussed in Section 2 of the paper, we calculate a bond return in March 2012 that accounts for the bond exchange and the associated haircut. Our return calculation, which reflects information from ten-year bond yields and the default, is −22.80% in this month, which differs substantially from the −4.16% return reported by Datastream. Our study focuses on domestic debt, so we take the perspective of a hypothetical domestic investor. Participation rates in the exchange were higher among domestic investors compared with international investors [Zettelmeyer, Trebesch, and Gulati (2013)]. We do not have information on Datastream's return calculation for this month, but the difference could arise from a different assumption about participation in the exchange. Late in 2012, Greece announced a voluntary bond buyback to be executed in December 2012, and the buyback led to an increase in market prices [Zettelmeyer, Trebesch, and Gulati (2013)]. We observe a 4.32% decrease in bond yield in December 2012 and calculate a return of 26.12%. Datastream reports a 3.21% decrease in bond yield and reports a return of 41.47%, such that the return is much larger than that implied by the yield change. Given that the buyback occurred at prevailing market prices, our view is that any effect of the buyback should be reflected in the change in yields. The return differences for these two months account for much of the difference in average returns for Greece in Table A.IV.

[5]See https://www.mnb.hu/en/statistics/statistical-data-and-information/statistical-time-series/xi-money-and-capital-markets and https://eservices.mas.gov.sg/statistics/fdanet/BenchmarkPricesAndYields.aspx.

[6]See https://www.spglobal.com/spdji/en/indices/fixed-income/sp-bmv-mexico-sovereign-bond-index/.

A.6 Annual dataset

Several analyses in the paper focus on return decompositions or the relations between returns and macroeconomic outcomes. For these tests, we use an annual version of the dataset because the components of the return decompositions and GDP growth are better measured at an annual frequency. This section outlines data cleaning and construction issues unique to the annual data.

A.6.1 Variable construction

The annual asset class returns are constructed by compounding the monthly returns over a given calendar year. The annual data correspond to country-level observations that cover a full calendar year with just one exception: Czechoslovakia's period from January 1945 to May 1945 (i.e., the month corresponding to the permanent closure of the stock exchange in Czechoslovakia) is included as an observation for 1945.

The return decompositions for domestic stocks presented in Sections 4.2.2 and 4.3.1 require annual dividend-price ratio data for each country-year observation. Anarkulova, Cederburg, and O'Doherty (2022) detail three cases in which dividend-price ratio data are missing in the GFDatabase (i.e., Austria from June 1939 to June 1969, Chile from January 1967 to December 1970, and Czechoslovakia from April 1938 to March 1943) and outline approaches to correct for the missing data. Table A.V shows additional periods over which annual dividend-price ratio data are missing in the GFDatabase.[7] We estimate dividend-price ratios for these periods with missing data using the methods described in the table.

The return decompositions for domestic stocks presented in Sections 4.2.2 and 4.3.1 also require price index data for each country-year observation. Table A.VI shows periods over which we are missing price index data or the reported price index data are inconsistent with the reported total return index data. For each case in the table, we use total return and dividend yield data to estimate the level of the year-end price index.

The return decomposition for domestic stocks in equation (19) uses data on price-dividend ratios, dividend growth, and dividend yields. In addition, the relations between domestic stock returns and macroeconomic conditions discussed in Section 4.3.2 use data on real per capita GDP growth, real per capita aggregate dividend growth, and the aggregate dividend-GDP ratio. We use the following approach to construct these variables for each country-year in the sample:

1. Given data on the dividend-price ratio and price index, the annual dividend is the product of the dividend-price ratio and the price index. To avoid problems with computing dividend growth around years with zero dividends, we assume a minimum bound of 0.001 on the dividend-price ratio. This design choice replaces zero dividend observations with small positive dividend values. The conclusions from our analyses are unchanged if we impose minimum bounds of 0.0001 or 0.01 rather than 0.001.

2. The dividend yield is the annual dividend divided by the lag of the price index.

3. Real per capita GDP is real GDP divided by population.

4. The aggregate dividend per capita is the product of the dividend-price ratio and market capitalization (measured in local currency) divided by population.

5. The aggregate dividend-GDP ratio is the annual nominal dividend divided by nominal GDP.

[7] There are more periods with missing dividend-price ratio data in our paper because the dataset construction in Anarkulova, Cederburg, and O'Doherty (2022) requires dividend-price ratio data only in years for which total return index data are unavailable. Our dataset construction, in contrast, requires dividend-price ratio data for each country-year observation.

A.6.2 Periods of stock exchange closure

We make adjustments to the calculations described in Section A.6.1 for variables used in conjunction with domestic stocks to account for the periods of stock exchange closures detailed in Table A.II. These adjustments are necessary for country-year observations for which (i) the observation occurs during a period of exchange closure that starts in one year and ends in a subsequent year and (ii) we use adjustment method 2 to infer monthly returns as indicated in Table A.II.[8] Note that the adjustments detailed below impact the calculations for domestic stocks, but do not impact the calculations for international stocks, bonds, and bills.

Our overarching theme is to create a match between our treatment of stock returns and the other annual variables. For the real growth rate variables (i.e., real per capita GDP growth and real per capita dividend growth), we compute the cumulative real growth rate covering the period from January of the year in which the stock exchange closure starts to the month in which the exchange closure ends. We assign this cumulative real growth rate as the annual observation for the year in which the exchange closure starts. Each annual observation following the year in which the exchange closure starts and preceding the year in which the exchange closure ends is assigned a real growth rate of zero. The cumulative real growth rate covering the period from the month following the reopening of the exchange through December of that year is assigned to the year in which the exchange closure ends. As an example, consider the six-month period of stock exchange closure in France from August 1914 to January 1915. We assign the cumulative real growth from January 1914 to January 1915 to the year 1914, we assign the remaining 11-month real growth rate from February 1915 to December 1915 to the year 1915. We apply similar adjustments to the calculations of the cumulative short-term interest rate and cumulative inflation. The change in the log aggregate dividend-GDP ratio is mathematically equivalent to the difference between log aggregate dividend growth and log GDP growth, so we compute this difference to calculate the cumulative change in the ratio.

As discussed in Section A.1, the 1914–1916 period in Switzerland and the 1943–1945 period in Czechoslovakia are exceptions to our typical approach to stock market closures. We make adjustments to the annual data in these cases. Switzerland has a 24-month period of exchange closure from August 1914 to July 1916, but we observe black market return data in January 1916 and July 1916. For the real growth rate variables, we assign the cumulative real growth rate from January 1914 to December 1915 to year 1914, zero to year 1915, and the cumulative real growth rate from January 1916 to December 1916 to 1916. Czechoslovakia has a 26-month period of exchange closure from April 1943 to May 1945. For the real growth rate variables, we assign the cumulative real growth rate from January 1943 to March 1943 to year 1943, zero to year 1944, and the cumulative real growth rate from April 1943 to May 1945 to year 1945 to match our treatment of the return. We calculate changes in the log aggregate dividend-GDP ratio using the growth rates from these calculations.

The calculation of the components of the return decompositions for domestic stocks also requires adjustments around periods of stock exchange closure. In particular, calculations for portions of the closure periods covering partial calendar years require a modified ρ_s parameter:

$$\rho_s^{(N)} = \frac{1}{1 + \exp(\overline{d_{t+1} - p_{t+1}} - \log(12/N))}, \tag{A2}$$

where N is the number of months in the partial calendar year.[9] We demonstrate our treatment of the data in these periods using the 113-month exchange closure in Austria from July 1939 to

[8] The adjustments are also necessary for Switzerland over the period from 1914 to 1916 and Czechoslovakia over the period from 1943 to 1945.

[9] The derivation and calibration of ρ_s are detailed in Appendix C.

November 1948 as an example:

1. For the valuation component, we first compute the change in the log price-dividend ratio for the period from December 1938 to December 1947 and multiply this value by the annual ρ_s coefficient. We then compute the change in the log price-dividend ratio from December 1947 to December 1948 and multiply this value by $\rho_s^{(11)}$. We sum the valuation components from the two subperiods and assign this value to year 1939. We assign zero for the valuation component for years 1940 to 1948.

2. We follow a similar approach for the real dividend growth component. There are nine 12-month periods from 1939 to 1947 and one 11-month period from January 1948 to November 1948. We multiply the log real dividend growth for each of the 12-month periods by the annual ρ_s coefficient, and we multiply the 11-month log real dividend growth by $\rho_s^{(11)}$. The sum of these dividend growth components is assigned to year 1939. We assign zero for the real dividend growth component for years 1940 to 1947. The one-month log real dividend growth rate for December 1948 is multiplied by $\rho_s^{(1)}$, and this value is assigned to year 1948.

3. We again follow a similar approach for the real dividend income component. We compute the sum of the nine annual log dividend yields for the years 1939 to 1947 less the sum of log inflation over the corresponding period and multiply this value by $(1 - \rho_s)$. We calculate the log dividend yield for the first 11 months in 1948 by dividing the sum of monthly dividends from January 1948 to November 1948 by the price index in December 1947, subtract the corresponding 11-month log inflation, and multiply this value by $(1 - \rho_s^{(11)})$. The sum of the two real dividend income components and $9q_s + q_s^{(11)}$ is assigned to year 1939. We assign zero for the real dividend income component for years 1940 to 1947. We compute the one-month dividend yield for December 1948, subtract the corresponding one-month inflation, multiply this quantity by the corresponding $(1 - \rho_s^{(1)})$, and assign the sum of this value and $q_s^{(1)}$ to year 1948.

Table A.I
Data sources.

The table summarizes the data series used to compute returns for each developed country in the sample. For each country and asset class (i.e., stocks, bonds, and bills), the table reports the data series used to construct returns, along with the corresponding start and end dates. The data series symbols correspond to those in the GFDatabase from Global Financial Data. For stocks and bills, the table also indicates the data series type. Stock returns are based on either total return indexes (TRI) or combinations of price indexes and dividend-price ratios (PI/DP). Bill returns are based on short-term Treasury yields (TBY), central bank interest rates (CBR), interbank interest rates (IIR), one-year government bond yields (GBY-1), deposit interest rates (DIR), interest rates on advances (IRA), overnight interest rates (OIR), or time money rates (TMR). All bond returns correspond to returns on ten-year government bonds. We provide details on alternative data sources in the footnotes.

	Stocks				Bonds			Bills			
Country	Series	Type	Start	End	Series	Start	End	Series	Type	Start	End
Argentina	_IBGD, SYARGYM	PI/DP	1947:02	1966:12	❸	1947:02	1966:12	IDARGD	CBR	1947:02	1966:12
Australia	_AORDAD	TRI	1901:01	2019:12	IGAUS10D	1901:01	2019:12	❷	TBY	1901:01	1920:06
								IDAUSD	CBR	1920:07	1928:06
								ITAUS3D	TBY	1928:07	2019:12
Austria	_WBKID, SYAUTYM	PI/DP	1925:02	1969:12	IGAUT10D	1925:02	2019:12	IDAUTD	CBR	1925:02	1959:12
	_ATXTRD	TRI	1970:01	2019:12				ITAUT3M	TBY	1960:01	1990:12
								IGAUT1D	GBY-1	1991:01	2019:12
Belgium	_BCSHD	TRI	1897:01	2019:12	IGBEL10D	1897:01	2019:12	IDBELD	CBR	1897:01	1947:12
								ITBEL3D	TBY	1948:01	2019:12
Canada	_TRGSPTSE	TRI	1891:01	2019:12	IGCAN10D	1891:01	2019:12	✚	DIR	1891:01	1901:12
								IMCANMOM	OIR	1902:01	1913:12
								✲	IRA	1914:08	1934:02
								ITCAN3D	TBY	1934:03	2019:12
Chile period I	_IGPAD, SYCHLYM	PI/DP	1927:01	1970:12	❹	1927:01	1929:09	IDCHLD	CBR	1927:01	1970:12
					❺	1929:10	1930:12				
					IGCHLCM	1931:01	1956:02				
					❻	1956:03	1970:12				
Chile period II	_IPSAD	TRI	2010:01	2019:05	IGCHLIM	2010:01	2015:03	ITCHL3D	TBY	2010:01	2012:09
	_IGPAD, SYCHLYM	PI/DP	2019:06	2019:12	❼	2015:04	2019:12	IDCHLD	CBR	2012:10	2019:12
Czech Republic	_PXTRD	TRI	2000:05	2019:12	IGCZE10D	2000:05	2019:12	ITCZE3D	TBY	2000:05	2017:02
								IDCZED	CBR	2017:03	2019:11
								❼	IIR	2019:12	2019:12
Czechoslovakia	CZINDXM, SYCZEYM	PI/DP	1926:01	1937:11	❹	1926:01	1927:01	IDCZED	CBR	1926:01	1945:05
	CZINDEXM, SYCZEYM	PI/DP	1937:12	1943:03	❺	1927:02	1944:06				

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Table A.I (*continued*)

Country	Stocks				Bonds			Bills			
	Series	Type	Start	End	Series	Start	End	Series	Type	Start	End
Denmark	_OMXCGID	TRI	1890:01	2019:12	IGDNK10D	1890:01	2019:12	IDDNKD	CBR	1890:01	1975:12
								ITDNK3D	TBY	1976:01	2019:12
Finland	_OMXHGID	TRI	1969:01	2019:12	IGFIN10D	1969:01	2019:12	IDFIND	CBR	1969:01	1996:08
								IGFIN1D	GBY-1	1996:09	2012:01
								ITFIN1D	TBY	2012:02	2013:05
								IGFIN1D	GBY-1	2013:06	2014:07
								IDFIND	CBR	2014:08	2019:12
France	TRSBF250D	TRI	1890:01	2019:12	IGFRA10D	1890:01	2019:12	IDFRAD	CBR	1890:01	1930:12
								ITFRA3D	TBY	1931:01	2019:12
Germany	_CDAXD	TRI	1890:01	2019:12	IGDEU10D	1890:01	2019:12	IDDEUD	CBR	1890:01	1952:12
								ITDEU3D	TBY	1953:01	2019:12
Greece	_RETMD	TRI	1981:02	2019:12	IGGRC10D	1981:02	2014:01	ITGRC3D	TBY	1981:02	2019:12
					❼	2014:02	2014:02				
					IGGRC10D	2014:03	2019:12				
Hungary	_BUXD	TRI	1999:02	2019:12	IGHUN10D	1999:02	2019:12	ITHUN3D	TBY	1999:02	2019:12
Iceland	_OMXIPID, SYISLYM	PI/DP	2002:01	2002:06	❼	2002:01	2004:02	ITISL3D	TBY	2002:01	2013:01
	_OMXIGID	TRI	2002:07	2019:12	IGISL10D	2004:03	2019:12	IDISLD	CBR	2013:02	2019:12
Ireland	_IVRTD	TRI	1936:01	2019:12	IGIRL10D	1936:01	2019:12	IDIRLD	CBR	1936:01	1969:11
								ITIRL3M	TBY	1969:12	2008:12
								❼	IIR	2009:01	2019:12
Israel	TRISRSTM	TRI	2010:01	2019:11	❼	2010:01	2014:12	ITISR3D	TBY	2010:01	2019:12
	ILTLVGD, SYISRYM	PI/DP	2019:12	2019:12	IGISR10IM	2015:01	2019:12				
Italy	_BCIPRD	TRI	1931:01	2019:12	IGITA10D	1931:01	2019:12	IDITAD	CBR	1931:01	1939:12
								ITITA3D	TBY	1940:01	2019:12
Japan	_TOPXDVD	TRI	1930:01	2019:12	IGJPN10D	1930:01	2019:12	IDJPND	CBR	1930:01	1959:12
								ITJPN3D	TBY	1960:01	2019:12
Latvia	_OMXRGID	TRI	2016:01	2019:12	❼	2016:01	2019:12	❼	IIR	2016:01	2019:12
Lithuania	_OMXVGID	TRI	2018:01	2019:12	IGLTU10D	2018:01	2019:12	❼	IIR	2018:01	2019:12
Luxembourg	_LUXXD, SYLUXYM	PI/DP	1982:01	1984:12	IGLUX10D	1982:01	2019:12	IMLUXM	OIR	1982:01	1998:12
	_LUXXRD	TRI	1985:01	2016:11				❼	IIR	1999:01	2019:12
	❶	TRI	2016:12	2019:12							
Mexico	_IRTD	TRI	2001:08	2019:12	IGMEX10D	2001:08	2019:12	ITMEX3D	TBY	2001:08	2019:12

(*continued on next page*)

Table A.I (*continued*)

Country	Stocks				Bonds			Bills			
	Series	Type	Start	End	Series	Start	End	Series	Type	Start	End
Netherlands	_AAXGRD	TRI	1914:01	2019:12	IGNLD10D	1914:01	1944:08	IDNLDBD	CBR	1914:01	1940:12
					❷	1944:09	1945:12	ITNLD3D	TBY	1941:01	2019:12
					IGNLD10D	1946:01	2019:12				
New Zealand	_NZGID	TRI	1896:01	2019:12	IGNZL10D	1896:01	2019:12	■	TBY	1896:01	1919:12
								■	DIR	1920:01	1922:12
								IDNZLD	CBR	1923:01	1978:02
								ITNZL3D	TBY	1978:03	2019:12
Norway	_OBXPD, ❷	PI/DP	1914:02	1969:12	IGNOR10D	1914:02	2019:12	IDNORD	CBR	1914:02	1941:11
	_OSEAXD	TRI	1970:01	2019:12				ITNOR3D	TBY	1941:12	2019:12
Poland	_WIGD	TRI	1999:06	2019:12	IGPOL10D	1999:06	2019:12	ITPOL3D	TBY	1999:06	2019:12
Portugal	_IBTAD, ❷	PI/DP	1934:01	1988:01	IGPRT10D	1934:01	1974:04	IDPRTD	CBR	1934:01	1988:12
	_BVLGD	TRI	1988:02	2019:12	❷	1974:05	1975:12	ITPRT6D	TBY	1989:01	1999:01
					IGPRT10D	1976:01	2019:12	IDPRTD	CBR	1999:02	2001:12
								❷	TBY	2002:01	2010:09
								ITPRT6D	TBY	2010:10	2019:12
Singapore	_TFTFSTD	TRI	1998:07	2019:12	IGSGP10D	1998:07	2019:12	ITSGP3D	TBY	1998:07	2019:12
Slovakia	_SAXD	TRI	2000:01	2019:12	IGSVK10D	2000:01	2019:12	IDSVKD	CBR	2000:01	2008:12
								❼	IIR	2009:01	2019:12
Slovenia	_SBITOPD, SYSVNYM	PI/DP	2010:01	2019:12	IGSVN10D	2010:01	2018:11	ITSVN3M	TBY	2010:01	2019:12
					❽	2018:12	2019:12				
South Korea	TRKORSTM	TRI	2000:11	2019:12	IGKOR10D	2000:11	2019:12	IGKOR1D	GBY-1	2000:11	2019:12
Spain	_BCNPR30	TRI	1959:01	2019:12	IGESP10D	1959:01	2019:12	IDESPD	CBR	1959:01	1978:12
								ITESP12D	TBY	1979:01	2019:12
Sweden	_OMXSBGI	TRI	1910:01	2019:12	IGSWE10D	1910:01	2018:12	IDSWED	CBR	1910:01	1954:12
					❼	2018:12	2019:12	ITSWE3D	TBY	1955:01	2019:12
					IGSWE10D	2019:02	2019:12				
Switzerland	_SSHID	TRI	1914:01	2019:12	IGCHE10D	1914:01	1941:12	IDCHED	CBR	1914:01	1979:12
					❾	1942:01	1942:01	ITCHE3D	TBY	1980:01	2019:12
					IGCHE10D	1942:02	2019:12				
Türkiye	TRRBILED	TRI	2010:02	2019:12	IGTUR10D	2010:02	2019:10	ITTUR3D	TBY	2010:02	2014:09
					❿	2019:11	2019:11	IGTUR1D	GBY-1	2014:10	2019:12
					IGTUR10D	2019:12	2019:12				
United Kingdom	_TFTASD	TRI	1890:01	2019:12	IGGBR10D	1890:01	2019:12	IDGBRD	CBR	1890:01	1899:12
								ITGBR3D	TBY	1900:01	2019:12

(*continued on next page*)

Table A.I (*continued*)

	Stocks				Bonds			Bills			
Country	Series	Type	Start	End	Series	Start	End	Series	Type	Start	End
United States	_SPXTRD	TRI	1890:01	2019:12	IGUSA10D	1890:01	2019:12	▲	TMR	1890:01	1914:10
								IDUSAD	CBR	1914:11	1919:12
								ITUSA3CMD	TBY	1920:01	2019:12

Footnotes:

❶ Stock returns for Luxembourg for the period from 2016:12 to 2019:12 are from the Luxembourg Stock Exchange. See https://www.bourse.lu/home.

❷ Dividend-price ratios, bond returns, and bill returns for several countries are from Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019).

❸ Bond returns for Argentina for the period from 1947:02 to 1966:12 are based on data from the Central Bank of Argentina. See http://www.bcra.gov.ar/PublicacionesEstadisticas/Boletin_estadistico.asp.

❹ Bond returns for select periods in Chile and Czechoslovakia are based on London quotes from the International Center for Finance at Yale. See https://som.yale.edu/faculty-research/our-centers-initiatives/international-center-finance/data/historical-financial-research-data/london-stock-exchange.

❺ Bond returns for select periods in Chile and Czechoslovakia are based on London quotes from the League of Nations reports.

❻ Bond returns for Chile for the period from 1956:03 to 1970:12 are based on data from the Central Bank of Chile. See https://repositoriodigital.bcentral.cl/xmlui/handle/20.500.12580/26/browse?type=dateissued.

❼ Bond and bill returns for several countries are based on data from Federal Reserve Economic Data (FRED) at the Federal Reserve Bank of St. Louis. See https://fred.stlouisfed.org/.

❽ Bond returns for Slovenia for the period from 2018:12 to 2019:12 are based on data from http://www.worldgovernmentbonds.com/bond-historical-data/slovenia/10-years/.

❾ The bond return in Switzerland for 1942:01 is based on data from the Swiss National Bank (https://www.snb.ch/de/iabout/stat/statrep/statpubdis/id/statpub_histz_arch#t2). We also shift a portion of the series IGCHE10D from GFD, which originally covers the period from 1942:01 to 1990:11, to cover the period from 1942:02 to 1990:12.

❿ The bond return in Türkiye for 2019:11 is based on data from http://www.worldgovernmentbonds.com/bond-historical-data/turkey/10-years/.

✚ Bill returns for Canada for the period from 1891:01 to 1901:12 are based on interest rates on deposits in government savings banks. See p. 363 of https://www66.statcan.gc.ca/eng/1901-eng.htm.

✲ Bill returns for Canada for the period from 1914:08 to 1934:02 are based on data from Shearer and Clark (1984).

■ Bill returns for New Zealand for the period from 1896:01 to 1922:12 are based on data from the annual New Zealand Official Year-book. See, for example, https://www3.stats.govt.nz/New_Zealand_Official_Yearbooks/1896/NZOYB_1896.html.

▲ Bill returns for the United States for the period from 1890:01 to 1914:10 are based on data from Macaulay (1938).

Table A.II

Multi-month stock returns.

The table reports periods of multi-month stock returns associated with exchange closures and details our approach to converting each return to a series of monthly returns. For each multi-month return observation, the table reports the number of months, the start and end dates of the period, the nominal and real net stock market returns earned over the period, and the adjustment method. For adjustment method 1, we use alternative data sources from GFD (e.g., black market trading data) to fill in a complete series of monthly returns. For adjustment method 2, we assign the full multi-month real return to the first month of the period and assign zero real returns to the remaining months. The cases marked with a ✚ are discussed in Section A.1. Panels A and B show events corresponding to World War I and World War II, respectively, Panel C shows periods with revolutions, Panel D shows financial and banking crises, and Panel E shows labor strikes.

Country	Months	Start date	End date	Nominal return (%)	Real return (%)	Adjustment
Panel A: World War I						
Australia	6	1914:08	1915:01	−0.45	−0.39	Method 1
Belgium	52	1914:08	1918:11	25.12	−55.91	Method 2
Canada	7	1914:08	1915:02	1.38	−3.59	Method 1
Denmark	4	1914:08	1914:11	−2.42	−3.37	Method 2
France	6	1914:08	1915:01	−3.68	−21.68	Method 2
Germany	42	1914:08	1918:01	20.03	−38.87	Method 1
Netherlands	7	1914:08	1915:02	−1.23	−3.50	Method 1
Norway	3	1914:08	1914:10	−3.26	−3.81	Method 2
Sweden	4	1914:08	1914:11	−5.91	−8.96	Method 2
Switzerland	24	1914:08	1916:07	0.17	−18.71	✚
United Kingdom	6	1914:08	1915:01	−0.26	−3.30	Method 1
United States	5	1914:08	1914:12	−2.14	−3.11	Method 1
Panel B: World War II						
Austria	2	1938:04	1938:05	6.34	5.62	Method 2
Austria	113	1939:07	1948:11	300.73	−19.66	Method 2
Belgium	5	1940:06	1940:10	22.38	12.54	Method 2
Belgium	11	1944:08	1945:06	−0.29	−17.08	Method 2
Czechoslovakia	16	1938:10	1940:01	31.95	16.66	Method 2
Czechoslovakia	4	1942:01	1942:04	20.59	12.25	Method 2
Denmark	2	1940:05	1940:06	−7.64	−10.67	Method 2
France	2	1939:09	1939:10	−2.96	0.53	Method 1
France	10	1940:06	1941:03	94.57	75.61	Method 2
Germany	67	1943:01	1948:07	−87.62	−91.10	Method 2
Japan	45	1945:09	1949:05	449.38	−87.15	Method 1
Netherlands	5	1940:05	1940:09	20.63	15.21	Method 2
Netherlands	21	1944:09	1946:05	−14.33	−33.15	Method 2
Norway	2	1940:04	1940:05	−16.75	−17.98	Method 2
Switzerland	2	1940:06	1940:07	−3.57	−5.11	Method 1
Panel C: Revolution						
Czechoslovakia	26	1943:04	1945:05	−90.00	−88.95	✚
Portugal	35	1974:05	1977:03	−80.39	−89.24	Method 2

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Table A.II (*continued*)

Country	Months	Start date	End date	Nominal return (%)	Real return (%)	Adjustment
Panel D: Financial or banking crisis						
Austria	2	1931:10	1931:11	6.86	6.20	Method 2
Germany	2	1931:08	1931:09	−24.58	−23.01	Method 2
Germany	7	1931:10	1932:04	−8.22	1.78	Method 2
Greece	2	2015:07	2015:08	−21.53	−20.13	Method 2
Panel E: Labor strike						
France	2	1974:04	1974:05	−6.17	−8.76	Method 2
France	2	1979:03	1979:04	12.79	10.69	Method 2

Table A.III

Bond return smoothing.

The table summarizes periods over which we are missing bond yield data. In each case, we use the country-level yield data from before and after the missing observations to produce a series of constant monthly returns across the period noted in the table. For each period with missing bond data, the table reports the country, the number of missing observations, and the start and end dates of the period.

Country	Months	Start date	End date
Argentina	4	1948:08	1948:11
	11	1949:01	1949:11
	11	1950:01	1950:11
	11	1951:01	1951:11
	11	1952:01	1952:11
	11	1953:01	1953:11
	11	1954:01	1954:11
	24	1955:01	1956:12
	1	1958:02	1958:02
	1	1958:08	1958:08
	1	1959:05	1959:05
	1	1959:08	1959:08
Belgium	3	1940:05	1940:07
Czechoslovakia	15	1938:10	1939:12
Finland	1	1991:06	1991:06
Germany	8	1931:08	1932:03
	25	1943:12	1945:12
Greece	44	1989:01	1992:08
Netherlands	2	1940:05	1940:06
	3	1944:09	1944:11
	11	1945:01	1945:11
Portugal	7	1974:05	1974:11
	11	1975:01	1975:11
	1	2014:02	2014:02
Switzerland	5	1914:08	1914:12

Table A.IV

External validation test results.

The table reports summary statistics for monthly net bond returns for each developed country with a return sample that overlaps with the sample from Datastream. For each country, the table shows the number of sample months. The table also shows the following summary statistics for our sample and for the Datastream sample: the arithmetic average return ($\bar{R}_a$), the geometric average return ($\bar{R}_g$), the standard deviation of return (SD), the minimum (Min) and the maximum (Max) return, and the correlation between the return samples (Corr). Statistics for the pooled sample of all observations are also reported. Panel A (Panel B) shows results for nominal returns (real returns).

		Summary statistics for returns										
		Our data					Datastream					
Country	Months	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Min (%)	Max (%)	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Min (%)	Max (%)	Corr
Panel A: Nominal returns												
Australia	372	0.73	0.71	2.08	−5.52	7.42	0.75	0.73	2.06	−5.34	7.93	0.96
Austria	372	0.51	0.50	1.59	−5.05	5.66	0.55	0.54	1.45	−3.47	5.21	0.95
Belgium	366	0.57	0.55	1.77	−5.92	7.51	0.62	0.61	1.73	−5.41	8.38	0.98
Canada	372	0.58	0.57	1.86	−6.33	6.01	0.60	0.59	1.84	−5.20	6.32	0.96
Czech Republic	236	0.27	0.25	2.16	−8.47	6.80	0.34	0.32	2.04	−8.49	7.41	0.94
Denmark	371	0.59	0.57	1.93	−5.56	6.76	0.60	0.59	1.80	−4.95	6.19	0.98
Finland	340	0.61	0.59	1.99	−5.93	8.75	0.64	0.62	1.79	−7.35	8.17	0.96
France	372	0.56	0.54	1.73	−3.97	5.59	0.59	0.58	1.64	−4.39	4.73	0.96
Germany	372	0.50	0.49	1.65	−6.23	5.39	0.52	0.51	1.55	−5.99	5.04	0.96
Greece	249	0.57	0.38	6.08	−31.06	26.12	0.81	0.53	7.41	−41.54	41.47	0.93
Hungary	251	0.78	0.73	3.28	−9.47	13.20	0.76	0.72	3.09	−15.97	12.84	0.83
Ireland	372	0.64	0.60	2.52	−14.96	15.57	0.64	0.61	2.35	−14.34	14.66	0.97
Italy	345	0.73	0.70	2.41	−7.67	10.36	0.75	0.73	2.24	−10.93	8.93	0.94
Japan	372	0.30	0.28	1.48	−8.13	5.67	0.33	0.32	1.34	−6.53	5.67	0.95
Mexico	114	0.55	0.52	2.26	−6.58	5.74	0.62	0.59	2.20	−6.50	8.12	0.85
Netherlands	372	0.51	0.49	1.66	−4.04	6.33	0.54	0.53	1.57	−3.59	5.09	0.97
New Zealand	345	0.68	0.66	1.95	−5.96	7.11	0.70	0.68	1.83	−5.81	6.76	0.95
Norway	325	0.57	0.55	1.86	−5.75	5.97	0.57	0.55	1.73	−6.40	5.71	0.97
Poland	228	0.74	0.71	2.27	−7.01	9.80	0.72	0.70	2.22	−6.10	11.17	0.91
Portugal	317	0.72	0.67	3.12	−12.81	15.07	0.77	0.72	3.12	−14.43	20.23	0.95
Singapore	132	0.21	0.19	1.66	−5.96	4.13	0.41	0.40	1.78	−4.07	12.08	0.81
South Korea	93	0.42	0.41	1.35	−4.04	4.37	0.43	0.42	1.25	−3.27	4.14	0.97
Spain	349	0.72	0.69	2.30	−9.43	9.62	0.77	0.74	2.17	−9.27	9.79	0.95

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Table A.IV (*continued*)

		Summary statistics for returns										
		Our data					Datastream					
Country	Months	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Min (%)	Max (%)	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Min (%)	Max (%)	Corr
Panel A: Nominal returns (continued)												
Sweden	372	0.65	0.62	2.10	−5.60	6.51	0.68	0.66	1.90	−5.63	5.99	0.97
Switzerland	372	0.35	0.34	1.49	−4.19	5.63	0.39	0.38	1.39	−3.82	5.30	0.92
United Kingdom	372	0.63	0.61	2.03	−5.38	7.26	0.64	0.62	1.92	−4.45	7.45	0.97
United States	372	0.54	0.52	2.09	−7.24	9.57	0.52	0.50	2.04	−5.88	9.55	0.98
Full sample	8,525	0.58	0.55	2.28	−31.06	26.12	0.61	0.59	2.31	−41.54	41.47	0.94
Panel B: Real returns												
Australia	372	0.51	0.49	2.09	−5.63	6.80	0.53	0.51	2.07	−5.57	7.84	0.96
Austria	372	0.34	0.32	1.65	−5.14	5.99	0.38	0.37	1.51	−3.65	4.99	0.96
Belgium	366	0.40	0.39	1.81	−6.06	7.47	0.46	0.44	1.78	−5.56	8.33	0.98
Canada	372	0.42	0.40	1.90	−6.24	6.47	0.43	0.42	1.88	−6.11	6.36	0.96
Czech Republic	236	0.27	0.25	2.16	−8.47	6.80	0.34	0.32	2.04	−8.49	7.41	0.94
Denmark	371	0.44	0.42	1.98	−6.00	6.40	0.45	0.44	1.86	−5.40	5.83	0.98
Finland	340	0.49	0.47	2.04	−6.13	8.59	0.52	0.50	1.84	−7.55	8.01	0.96
France	372	0.43	0.41	1.79	−4.44	5.86	0.46	0.45	1.69	−4.62	5.19	0.97
Germany	372	0.35	0.34	1.72	−6.62	5.31	0.37	0.36	1.62	−6.39	4.94	0.96
Greece	249	0.43	0.23	6.27	−30.84	26.45	0.67	0.37	7.55	−41.35	41.84	0.94
Hungary	251	0.46	0.40	3.31	−9.83	12.42	0.44	0.39	3.12	−16.31	12.81	0.83
Ireland	372	0.47	0.44	2.58	−14.79	15.45	0.47	0.44	2.41	−14.16	14.54	0.97
Italy	345	0.54	0.52	2.41	−8.03	10.26	0.57	0.54	2.24	−11.27	8.62	0.94
Japan	372	0.25	0.24	1.50	−7.77	5.29	0.28	0.28	1.37	−6.16	5.19	0.95
Mexico	114	0.22	0.19	2.33	−7.18	5.22	0.29	0.26	2.28	−7.18	7.95	0.86
Netherlands	372	0.34	0.32	1.72	−3.95	6.71	0.38	0.36	1.63	−3.97	5.21	0.97
New Zealand	345	0.52	0.50	1.96	−6.05	7.28	0.54	0.52	1.84	−6.19	6.93	0.95
Norway	325	0.40	0.38	1.89	−6.24	6.01	0.39	0.38	1.77	−6.48	5.50	0.97
Poland	228	0.56	0.54	2.33	−7.59	9.71	0.55	0.52	2.28	−6.24	10.73	0.92
Portugal	317	0.54	0.59	3.19	−13.23	14.98	0.59	0.54	3.19	−14.84	20.14	0.95
Singapore	132	0.09	0.07	1.72	−6.13	4.94	0.29	0.27	1.79	−4.24	11.07	0.82
South Korea	93	0.33	0.32	1.42	−3.90	4.57	0.34	0.33	1.32	−3.13	4.33	0.97

(*continued on next page*)

Table A.IV (*continued*)

		Summary statistics for returns										
		Our data					Datastream					
Country	Months	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Min (%)	Max (%)	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Min (%)	Max (%)	Corr
Panel B: Real returns (continued)												
Spain	349	0.51	0.48	2.41	−9.92	9.47	0.56	0.54	2.49	−9.76	9.65	0.95
Sweden	372	0.48	0.45	2.19	−5.77	6.77	0.51	0.49	2.00	−5.83	5.62	0.98
Switzerland	372	0.26	0.24	1.57	−4.28	5.70	0.29	0.28	1.46	−4.33	5.06	0.93
United Kingdom	372	0.37	0.35	2.11	−5.98	8.23	0.38	0.36	1.99	−6.14	7.03	0.97
United States	372	0.34	0.32	2.16	−7.34	11.71	0.32	0.29	2.13	−6.24	11.69	0.98
Full sample	8,525	0.41	0.38	2.34	−30.84	26.45	0.44	0.41	2.36	−41.35	41.84	0.94

Table A.V

Data gaps for dividend-price ratios.

The table shows periods over which we are missing annual dividend-price ratio data. For each period, the table reports the country, the number of missing annual observations, the start and end dates of the period, the dates of the nearest preceding and ensuing dividend-price ratio observations, and the method used to estimate the missing ratios. For estimation method 1, we infer annual dividend-price ratios using total return index and price index data. For estimation method 2, we fill in missing dividend-price ratio data using the average of dividend-price ratios from before and after the period. For estimation method 3, we fill in missing dividend-price ratio data using the dividend-price ratio for the observation from before or after the period.

Country	Years	Start date	End date	Preceding observation	Ensuing observation	Method
Austria	1	1924:12	1924:12	–	1925:12	Method 3
Czechoslovakia	1	1925:12	1925:12	–	1926:12	Method 3
Denmark	31	1938:12	1968:12	–	–	Method 1
France	1	1914:12	1914:12	1914:07	1915:02	Method 2
	4	1915:12	1918:12	–	–	Method 1
	1	1940:12	1940:12	1940:03	1941:03	Method 2
Germany	7	1944:12	1950:12	1944:09	1951:05	Method 2
Iceland	1	2001:12	2001:12	–	2002:07	Method 3
	13	2007:12	2019:12	–	–	Method 1
Italy	1	1945:12	1945:12	–	–	Method 1
Japan	4	1945:12	1948:12	1945:02	1949:06	Method 2
Luxembourg	1	1981:12	1981:12	–	1982:12	Method 3
	5	1995:12	1999:12	1994:12	2000:12	Method 2
	20	2000:12	2019:12	–	–	Method 1
Mexico	1	2014:12	2014:12	2014:11	2015:01	Method 2
Slovakia	1	1999:12	1999:12	–	2000:12	Method 3
Switzerland	1	1913:12	1913:12	–	1914:12	Method 3
	1	1914:12	1914:12	–	–	Method 1
	1	1915:12	1915:12	1914:12	–	Method 3
	2	1916:12	1917:12	–	–	Method 1

Table A.VI

Data gaps for price indexes.

The table summarizes periods over which we are missing annual price index data or the reported price index data are inconsistent with the reported total return index series. For each period, the table reports the country, the number of missing annual observations, the start and end dates of the period, and the reason for the data gap. In each case, we use total return and dividend-price ratio data to produce a series of year-end price indexes for the corresponding years.

Country	Years	Start date	End date	Reason for data gap
Canada	1	1914:12	1914:12	Price index missing
Denmark	25	1889:12	1913:12	Price index missing
	106	1914:12	2019:12	Price index inconsistent with total return index
Germany	4	1914:12	1917:12	Price index missing
	1	1923:12	1923:12	Price index inconsistent with total return index
Hungary	22	1998:12	2019:12	Price index missing
Japan	1	1945:12	1945:12	Price index missing
	3	1946:12	1948:12	Price index inconsistent with total return index
Latvia	5	2015:12	2019:12	Price index missing
Lithuania	3	2017:12	2019:12	Price index missing
Luxembourg	6	1995:12	2000:12	Price index inconsistent with total return index
	20	2000:12	2019:12	Price index missing
Norway	50	1970:12	2019:12	Price index missing
Portugal	14	2006:12	2019:12	Price index missing
Slovakia	21	1999:12	2019:12	Price index missing
United Kingdom	44	1889:12	1932:12	Price index missing

B Additional results appendix

This appendix presents supplementary empirical results.

B.1 Nominal payoffs

Our primary analysis in the paper is based on real payoffs for domestic stocks, international stocks, bonds, and bills. We focus on real payoffs rather than nominal payoffs because nominal payoffs during periods of extreme inflation are often a poor reflection of true economic outcomes. For completeness, we present results based on nominal payoffs in this section. Table B.I shows summary statistics for each country's nominal returns for domestic stocks, international stocks, bonds, and bills. Table B.II summarizes the marginal bootstrap distribution of nominal payoffs for each of these four asset classes at various investment horizons.

B.2 Impact of mean block length parameter

We construct bootstrap joint distributions of payoffs for domestic stocks, international stocks, bonds, and bills by resampling with replacement from the sample of returns in developed markets. We use a stationary block bootstrap approach, and our base case design draws blocks of consecutive returns, where the length of each block has a geometric distribution with a mean of 120 months. In this section, we consider the impact of using alternative values for the mean block length parameter in the bootstrap procedure. We present results for mean block lengths of one (i.e., i.i.d. resampling), 12, 60, 120 (base case), and 240 months.

Table B.III shows estimated loss probabilities at various return horizons for each value of the block length parameter. The most pronounced differences in loss probabilities across block lengths are seen for real bill payoffs in Panel D. In particular, the loss probabilities for longer-horizon bill payoffs tend to decrease with increases in the block length parameter. The general conclusion, however, is that the choice of block length has a minor impact on the results.

B.3 Alternative construction of international stock portfolio

As described in Section 2.1.2, we construct the international stock portfolio for a given country as the weighted investment across all developed stock markets excluding the local stock market. The international stock portfolio is value weighted by total market capitalization, and we place no restriction on the maximum weight in a given foreign market. For robustness, we consider an alternative construction method for the international stock portfolio, in which we cap the weight on any individual country at 25%.

We summarize the bootstrap distributions of real payoffs using this constrained version of the international stock portfolio in Table B.IV. These results can be compared with those using the unconstrained version of the international stock portfolio in Panel B of Table III. The constrained version of the international stock portfolio leads to slightly lower payoff standard deviations and slightly lower loss probabilities, likely owing to greater diversification benefits from capping individual country weights at 25%. The differences in the two marginal distributions for international stocks, however, are modest, suggesting that our base case construction of the international stock portfolio is robust to reasonable alternative construction methods.

B.4 Alternative samples

The marginal distributions of asset class payoffs presented in Section 4.1.1 are based on a broad cross section of 38 developed countries. One potential concern with these results is that they are driven by asset performance in countries that are less economically relevant. Among developed countries, for example, there is large variance in population and equity market size relative to economic output. To assess the impact of economic relevance on our results, we consider samples of developed countries with additional screens based on population or equity market size. We examine two samples based on population and two based on the market capitalization-GDP ratio. To construct the samples based on population, we start with our base sample of developed countries, but exclude data for a given country prior to the year in which the country's population reaches a threshold percentage of the total world population. The threshold values are 0.2% and 0.5%. We follow a similar approach for the samples based on market capitalization-GDP ratio, with threshold values of 0.5 and 1.0.

Another potential concern with our base case results in Section 4.1.1 is that the US data may exhibit considerable influence on the results for international stocks. The US stock market is typically among the largest stock markets in terms of market capitalization, such that the US stock market receives considerable weight in the international stock market portfolio for any non-US country. Given that the US stock market performed well relative to most other stock markets, it is possible that the strong performance of international stocks shown in Panel B of Table III is largely attributable to the strong performance of US stocks. To address this issue, we consider a sample that excludes all US data and compare the results with those from our base case design.

The results for the alternative samples are presented in Table B.V. For brevity, we focus on the marginal distributions of 30-year payoffs. The general conclusions from the base case design continue to hold for each of the alternative sample formation approaches.

B.5 Conditional loss probabilities by investment horizon

In Section 4.1.2 of the paper, we study 30-year loss probabilities for each asset class conditional on a loss in another asset class over the same horizon. For completeness, Figure B.1 presents the corresponding results for each investment horizon. For each asset class, the figure plots the unconditional loss probability and loss probabilities conditional on a loss in another asset class as a function of horizon.

B.6 Subperiod analyses

The full developed sample period in the paper includes asset class returns dating back to 1890. To address potential concerns that asset performance in the early portion of the sample may be less relevant to today's investors, we conduct a subperiod analysis. Table B.VI summarizes the marginal distributions of real returns for domestic stocks, international stocks, bonds, and bills for the post-World War II period. The simulations used to produce these results are identical to those used to construct the results in Table III, but they exclude observations prior to October 1945. The distributions in Table B.VI are generally similar to those in Table III, suggesting that our findings are robust to simulations that rely on more recent data. The longer-horizon loss probabilities for domestic stocks and international stocks estimated from the post-World War II data are lower than the corresponding loss probabilities estimated from the full sample data, but the differences are not dramatic. Moreover, many countries experienced poor equity market performance during the World War II era, suggesting that the loss probabilities in Table B.VI are understated owing to survivor bias.

Another potential concern with the results for international stocks in Panel B of Table III is that a portion of our country-month observations correspond to the period of fixed exchange rates following the 1944 Bretton Woods Agreement. International stock returns during periods of fixed parity rates may not fully reflect the forward-looking distribution of international stock returns in the current period dominated by free-floating exchange rates. To address this issue, we simulate international stock payoffs using data from the post-Bretton Woods period. These bootstrap distributions are summarized in Table B.VII. Relative to our base-case results in Panel B of Table III, the distributions of international stock payoffs using the post-Bretton Woods data exhibit less volatility. The loss probabilities across the two samples are relatively similar.

Figure B.2 shows variance ratios and components of variance ratios for international stocks in the post-Bretton Woods period. Consistent with the distributional results, the variance ratios based on the post-Bretton Woods sample suggest greater mean reversion in international stock returns relative to those based on the full developed sample (see, e.g., Panel B of Figure 6).

B.7 Currency hedging

Our base case international stock portfolio reflects the currency conversions needed to implement the investment strategy. We do not consider the potential for hedging exchange rate risk in this base case. In this section, we consider the potential for currency hedging. This analysis serves two purposes. First, it is informative about the short-term and long-term relations between exchange rates and local inflation, and it serves as additional support for our discussions in the paper. Second, it is informative about the practical issue of whether or not currency hedging can reduce risk for investors in international stocks. We examine hypothetical currency-hedged international stock portfolios along with unhedged portfolios. We also consider nominal performance, in addition to real performance, in this section for comparison to past literature.

Market data for currency hedging instruments are unavailable for much of our sample. As such, we cannot form the precise strategies that would have been available to investors at a given time. Even without such data, however, studying strategy performance in the absence of exchange rate risk may be informative about the potential benefits of currency hedging. In our analysis, we make the simplifying assumptions that investors can perfectly hedge their currency exposure and that the forward exchange rate equals the spot exchange rate in each month. That is, we assume that the effective change in exchange rates is equal to zero in all months for our hypothetical currency hedged portfolios.

From equation (14), our base case of real international stock returns is given by

$$R_{i,t}^{International\ stocks} = \sum_{j \neq i} w_{j,t-1} \frac{R_{j,t}^{Nominal\ stocks}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right). \tag{B1}$$

Log wealth at a horizon of H periods can be approximately decomposed as

$$w_H^{International\ stocks} \approx \log \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Nominal\ stocks} \right) - \pi_{i,t} + \log \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} \frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right), \tag{B2}$$

which demonstrates that real international stock returns for an investor in country i are affected by the nominal performance of foreign markets, local inflation, and changes in exchange rates. When considering nominal returns, the local inflation term is absent, and when considering currency hedging, the exchange rate term is absent given the assumption that the forward and spot rates are equal. As such, equation (B2) provides us with a way of tracing the differences in the nominal and real performance of unhedged and hedged strategies.

We use equation (B2) to produce a variance decomposition for log wealth from international stocks. The covariance structure across the three terms turns out to be important for interpreting the results, so we decompose the variance of real international stock returns as follows:

$$\begin{aligned}\text{Var}(w_H^{International\ stocks}) \approx & \text{Var}\left(\log\left(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}R_{j,t}^{Nominal\ stocks}\right)\right) + \text{Var}(\pi_{i,t}) \\ & + \text{Var}\left(\log\left(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}\frac{E_t^{i,j}}{E_{t-1}^{i,j}}\right)\right) \\ & - 2\text{Cov}\left(\log\left(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}R_{j,t}^{Nominal\ stocks}\right), \pi_{i,t}\right) \\ & + 2\text{Cov}\left(\log\left(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}R_{j,t}^{Nominal\ stocks}\right), \log\left(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}\frac{E_t^{i,j}}{E_{t-1}^{i,j}}\right)\right) \\ & - 2\text{Cov}\left(\pi_{i,t}, \log\left(\prod_{t=1}^{H}\sum_{j\neq i} w_{j,t-1}\frac{E_t^{i,j}}{E_{t-1}^{i,j}}\right)\right). \qquad \text{(B3)}\end{aligned}$$

Analogous variance decompositions exist for the nominal returns on the unhedged portfolio as well as for the nominal and real returns on the hedged portfolio, where the inflation (exchange rate) terms disappear when considering nominal (currency-hedged) returns.

As a starting point, Figure B.3 plots the annualized variance of log wealth from investing in international stocks for unhedged and hedged strategies in nominal (Panel A) and real (Panel B) terms. We plot annualized variance for horizons from one to 30 years. Panel A demonstrates the large benefits of currency hedging for international investments in nominal terms that have been touted by prior literature. At a one-year horizon, currency hedging reduces strategy variance by 42% and the standard deviation of the log payoff declines from 20.1% to 15.3%. The reduction in risk increases with horizon. With a 30-year investment period, the hedged strategy variance is 72% lower than the unhedged variance. The annualized standard deviation of the international stock portfolio is 24.2% without hedging versus only 12.9% with hedging. When considering nominal returns, currency hedging has a clear and economically large benefit, particularly over long investment horizons.

Panel B of Figure B.3 shows that the evaluation of currency hedging benefits depends crucially on whether one considers nominal or real performance. For the log real payoffs in Panel B, the benefits of eliminating exchange rate risk are muted over short horizons and nonexistent over long horizons. Currency hedging reduces variance by 20% at a one-year horizon, and the standard deviation of the log real payoff declines from 19.5% to 17.5%. For all horizons that are four years or longer, however, the unhedged strategies have lower variance in real terms. The currency-hedged strategy has 30% higher variance than the unhedged strategy with a 30-year horizon. The annualized standard deviation of the hedged strategy is 19.4% versus 17.0% for the unhedged strategy.

Figure B.3 demonstrates that conclusions about the value of currency hedging depend crucially on (i) whether performance is measured in nominal or real terms and (ii) the investment horizon. Prior literature on currency hedging typically considers nominal performance over short (often monthly) horizons. For long-horizon investors who are concerned about the real buying power gained from their investments, removing exchange rate risk through currency hedging actually produces a deleterious effect on strategy risk.

To examine further the underlying relations that produce the results in Figure B.3, Figure B.4

plots the components of variance from equation (B3) for the nominal returns of a currency-hedged strategy (Panel A), the nominal returns of an unhedged strategy (Panel B), the real returns of a currency-hedged strategy (Panel C), and the real returns of an unhedged strategy (Panel D). Each panel plots annualized strategy variance for horizons from one to 30 years and the relevant annualized variances and covariances from equation (B3).

Panel A of Figure B.4 plots the variance of nominal log payoffs of the currency hedged strategy. This strategy earns the weighted average of the nominal returns of foreign markets, and there are no additional components that include inflation or exchange rate risk. As such, the plot in Panel A of Figure B.4 matches the hedged strategy in Panel A of Figure B.3, and annualized variance of this strategy declines with horizon. Panel B shows variance for nominal payoffs on the unhedged strategy. Annualized variance increases with horizon, and the figure shows that increasing variance from exchange rate risk contributes to this pattern. There is also a positive covariance between international stock performance and exchange rate changes (for all horizons longer than one year). That is, there is some tendency for the local currency to depreciate (appreciate) when foreign stocks have relatively good (poor) nominal performance. This positive covariance further increases strategy risk for the unhedged portfolio.

Panel C of Figure B.4 shows variance for real returns on the currency-hedged strategy. The annualized variance increases somewhat with horizon. Inflation produces a large positive effect on the variance of long-horizon returns due to the persistence of the inflation process, but there is a negative covariance between foreign stock performance and local inflation that offsets some of this effect.

Finally, Panel D of Figure B.4 plots the variance and components for our base case international stock strategy. We measure the real returns of an unhedged strategy, so this analysis contains all components of equation (B3). The annualized variance decreases with horizon, and each of the six components (three variances and three covariances) has an important impact on overall strategy risk. The variances of inflation and exchange rates are large and increasing with horizon. Both components contribute more than 0.03 to the annualized variance of real log international stock payoffs. Inflation and exchange rate fluctuations do, however, have a very large negative covariance, which is less than -0.05 for a 30-year horizon. This large negative correlation implies that the net effect of inflation and exchange rate risks is muted because the two risks largely offset for long-horizon investments. In contrast, the variance of the hedged strategy in Panel C includes the large, positive effect on risk from inflation without an offsetting effect from exchange rate fluctuations.

The results in Figure B.4 demonstrate the potential pitfalls from currency hedging for long-horizon investors who care about real returns. The apparent reduction in risk from hedging exchange rate risk destroys the natural hedge for local inflation that is gained with exposure to foreign currencies. We return to the caveat that we do not have historical data for currency hedging instruments, such that we are operating under the simplifying assumption that the spot and forward rates are equal across all months. Our results are suggestive, however, that the optimality of currency hedging for international investments is crucially dependent on the nominal or real measurement of performance and on the investment horizon.

Table B.I
Summary statistics for nominal returns.

The table reports summary statistics for monthly nominal net returns for each developed country and for the pooled sample of all observations. For each country, the table shows the number of sample months, the arithmetic average return ($\bar{R}_a$), the geometric average return ($\bar{R}_g$), the standard deviation of return (SD), return skewness (Skew), return kurtosis (Kurt), and the minimum (Min) and the maximum (Max) return. Panels A, B, C, and D show results for domestic stocks, international stocks, bonds, and bills, respectively.

		Summary statistics for returns						
Country	Months	$\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel A: Nominal domestic stock returns								
Argentina	239	2.11	1.79	8.12	0.44	9.68	−41.47	45.64
Australia	1,428	0.97	0.89	3.88	−0.88	16.20	−42.13	22.14
Austria	1,139	0.93	0.66	10.26	21.97	642.06	−32.56	300.73
Belgium	1,476	0.73	0.62	4.82	0.24	7.85	−31.22	26.38
Canada	1,548	0.80	0.71	4.23	−0.58	7.47	−28.07	22.87
Chile period I	528	1.83	1.63	6.38	0.69	8.36	−31.00	38.27
Chile period II	120	0.31	0.22	4.08	0.16	3.08	−10.46	11.28
Czech Republic	236	1.29	1.04	7.07	0.00	5.41	−29.44	30.08
Czechoslovakia	233	0.45	−0.23	7.20	−8.04	110.10	−90.00	31.95
Denmark	1,560	0.67	0.61	3.48	0.06	6.83	−18.47	18.80
Finland	612	1.34	1.15	6.31	0.20	6.41	−26.88	32.61
France	1,560	0.95	0.81	5.51	3.28	56.95	−21.82	94.57
Germany	1,560	0.81	0.45	8.25	3.47	77.43	−87.62	128.82
Greece	467	1.56	1.06	10.41	1.64	11.13	−27.83	68.46
Hungary	251	0.99	0.78	6.47	−0.34	4.49	−28.42	18.54
Iceland	216	0.72	0.29	7.61	−4.52	41.48	−71.52	18.08
Ireland	1,008	0.98	0.87	4.67	−0.22	7.84	−27.24	28.81
Israel	120	0.02	−0.10	4.73	−0.21	3.38	−14.24	12.78
Italy	1,068	1.18	0.91	7.61	1.69	13.02	−26.44	59.87
Japan	1,080	1.11	0.92	6.31	1.82	20.19	−30.24	67.39
Latvia	48	1.22	1.16	3.56	1.13	5.60	−5.38	13.95
Lithuania	24	0.39	0.36	2.62	−0.04	3.01	−5.55	5.03
Luxembourg	456	0.93	0.78	5.47	−0.72	6.47	−26.81	18.11
Mexico	221	1.14	1.03	4.77	−0.46	3.97	−17.81	13.29
Netherlands	1,272	0.80	0.67	5.05	0.45	13.69	−23.24	52.45
New Zealand	1,488	0.86	0.80	3.63	0.02	10.16	−28.29	25.00
Norway	1,271	0.85	0.72	5.07	−0.20	6.87	−27.42	26.10
Poland	247	0.71	0.53	5.99	−0.06	4.39	−24.01	20.73
Portugal	1,032	0.97	0.65	7.85	2.68	49.68	−80.39	87.83
Singapore	258	0.82	0.65	5.87	−0.18	6.92	−25.69	25.47
Slovakia	240	0.77	0.63	5.29	1.40	10.91	−18.54	33.75
Slovenia	120	0.41	0.33	3.97	0.42	5.16	−9.85	17.45
South Korea	230	1.08	0.90	6.17	0.24	4.85	−20.98	26.71
Spain	732	0.99	0.84	5.44	−0.02	5.08	−25.27	26.95
Sweden	1,320	0.89	0.78	4.76	−0.15	6.24	−27.11	27.58
Switzerland	1,272	0.66	0.57	4.26	0.02	8.81	−24.62	33.78
Türkiye	119	1.03	0.83	6.38	0.01	2.17	−13.40	14.03
United Kingdom	1,560	0.75	0.66	4.24	0.92	21.97	−26.51	54.10
United States	1,560	0.87	0.75	4.95	0.31	13.11	−29.63	42.89
Full sample	29,919	0.91	0.75	5.83	5.69	269.21	−90.00	300.73

(*continued on next page*)

Table B.I (*continued*)

Country	Months	Summary statistics for returns $\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel B: Nominal international stock returns								
Argentina	239	3.25	2.62	15.03	8.87	89.78	−13.90	159.60
Australia	1,428	0.81	0.74	3.75	0.69	10.01	−13.48	32.38
Austria	1,139	1.33	0.96	12.55	17.64	371.31	−23.89	299.72
Belgium	1,476	0.89	0.79	4.49	0.49	13.76	−24.14	43.68
Canada	1,548	0.71	0.65	3.42	−0.12	6.33	−14.92	19.35
Chile period I	528	2.41	2.13	8.35	4.40	44.20	−23.88	95.97
Chile period II	120	1.10	1.04	3.51	−0.21	3.01	−8.36	11.42
Czech Republic	236	0.27	0.18	4.17	−0.77	4.19	−13.62	9.96
Czechoslovakia	233	0.62	0.47	5.51	−0.53	9.19	−27.19	23.32
Denmark	1,560	0.74	0.67	3.86	0.13	9.54	−20.26	31.50
Finland	612	0.87	0.78	4.29	−0.25	5.01	−18.85	21.08
France	1,560	1.11	0.93	6.54	7.92	129.06	−25.37	125.15
Germany	1,560	1.00	0.75	10.40	22.51	605.34	−24.01	302.95
Greece	467	1.26	1.16	4.64	−0.02	5.66	−18.79	22.79
Hungary	251	0.67	0.58	4.10	−0.33	3.48	−12.15	11.85
Iceland	216	0.78	0.67	4.83	−0.17	4.54	−14.87	17.30
Ireland	1,008	0.96	0.88	4.00	0.03	7.58	−19.47	31.09
Israel	120	0.68	0.63	3.12	−0.15	2.77	−6.52	7.61
Italy	1,068	1.56	1.18	13.95	23.99	684.12	−22.84	408.31
Japan	1,080	1.70	1.12	17.35	18.57	399.42	−27.03	423.92
Latvia	48	0.85	0.80	2.99	−0.76	4.02	−7.94	7.84
Lithuania	24	0.86	0.80	3.59	−0.76	3.38	−7.94	7.84
Luxembourg	456	0.87	0.78	4.44	−0.52	4.50	−19.96	16.78
Mexico	221	0.94	0.88	3.51	−0.37	3.58	−10.23	9.57
Netherlands	1,272	0.77	0.68	4.32	0.49	13.53	−23.73	41.54
New Zealand	1,488	0.81	0.74	4.07	2.42	37.87	−19.90	60.14
Norway	1,271	0.85	0.76	4.13	0.08	7.04	−16.99	31.42
Poland	247	0.51	0.45	3.64	−0.57	3.58	−10.93	9.56
Portugal	1,032	1.05	0.97	3.92	−0.24	5.05	−17.84	19.47
Singapore	258	0.47	0.39	3.92	−0.86	4.86	−17.82	9.87
Slovakia	240	0.29	0.21	4.04	−0.63	4.08	−14.82	12.55
Slovenia	120	0.95	0.91	3.05	−0.46	3.97	−8.05	9.42
South Korea	230	0.53	0.46	3.70	−0.74	4.59	−15.98	9.04
Spain	732	0.98	0.89	4.23	−0.23	5.15	−20.26	20.82
Sweden	1,320	0.83	0.75	4.04	0.34	9.75	−19.50	31.56
Switzerland	1,272	0.66	0.56	4.41	0.03	10.88	−24.64	40.94
Türkiye	119	2.04	1.92	5.11	1.63	14.25	−15.28	33.37
United Kingdom	1,560	0.81	0.73	4.04	0.49	12.53	−19.61	40.76
United States	1,560	0.63	0.56	3.74	−0.45	7.00	−22.48	17.71
Full sample	29,919	0.96	0.81	6.88	27.40	1,346.81	−27.19	423.92

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Table B.I (*continued*)

Country	Months	Summary statistics for returns $\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel C: Nominal bond returns								
Argentina	239	0.27	0.27	0.91	1.74	28.89	−5.58	6.78
Australia	1,428	0.49	0.48	1.59	0.23	11.01	−10.41	11.69
Austria	1,139	0.57	0.55	2.17	−2.96	51.86	−29.81	18.40
Belgium	1,476	0.45	0.44	1.29	0.04	7.91	−6.25	7.51
Canada	1,548	0.43	0.42	1.50	0.37	14.31	−11.51	13.54
Chile period I	528	0.59	0.56	2.45	−1.07	54.52	−23.11	24.37
Chile period II	120	0.40	0.39	1.32	−0.80	9.11	−6.00	4.84
Czech Republic	236	0.45	0.43	2.09	−0.04	4.36	−8.08	6.69
Czechoslovakia	233	0.53	0.52	0.97	2.74	24.62	−3.53	8.30
Denmark	1,560	0.53	0.51	1.70	0.84	12.45	−8.88	15.23
Finland	612	0.70	0.68	2.11	−0.32	6.22	−10.33	9.77
France	1,560	0.46	0.45	1.41	0.17	9.38	−9.45	9.69
Germany	1,560	1.59	0.07	46.28	36.08	1,374.67	−89.96	1,771.67
Greece	467	1.12	0.97	5.46	−0.12	10.13	−31.06	26.12
Hungary	251	0.78	0.73	3.28	−0.06	3.87	−9.47	13.20
Iceland	216	0.77	0.71	3.21	−1.45	17.57	−22.40	15.62
Ireland	1,008	0.64	0.61	2.33	−0.00	10.83	−15.47	15.57
Israel	120	0.56	0.55	1.50	−0.27	5.92	−5.44	6.40
Italy	1,068	0.63	0.61	1.83	0.40	7.66	−7.67	10.36
Japan	1,080	0.47	0.45	2.17	−2.66	49.41	−27.11	19.95
Latvia	48	0.24	0.24	1.21	−0.93	4.27	−3.55	2.20
Lithuania	24	0.35	0.34	1.12	0.63	3.87	−1.67	3.48
Luxembourg	456	0.60	0.58	1.68	−0.23	6.63	−9.15	7.13
Mexico	221	0.77	0.74	2.53	−0.13	3.76	−6.58	8.75
Netherlands	1,272	0.44	0.43	1.44	0.47	10.46	−8.15	11.35
New Zealand	1,488	0.47	0.45	1.70	−0.32	59.07	−23.42	23.15
Norway	1,271	0.49	0.47	1.49	−0.95	11.98	−11.09	8.60
Poland	247	0.68	0.65	2.40	0.19	4.66	−7.01	9.80
Portugal	1,032	0.61	0.58	2.47	1.00	12.91	−12.81	18.72
Singapore	258	0.36	0.34	1.93	−0.58	5.95	−8.69	7.54
Slovakia	240	0.79	0.75	3.04	5.12	49.20	−6.66	31.68
Slovenia	120	0.54	0.50	2.87	−0.34	5.15	−9.75	9.37
South Korea	230	0.58	0.56	1.88	0.63	7.19	−4.48	11.21
Spain	732	0.72	0.70	2.03	0.28	6.08	−9.43	9.62
Sweden	1,320	0.48	0.47	1.46	0.08	7.43	−5.99	8.25
Switzerland	1,272	0.35	0.34	1.18	0.14	5.58	−4.37	7.29
Türkiye	119	0.90	0.78	4.89	0.16	4.44	−14.34	17.47
United Kingdom	1,560	0.46	0.45	1.72	1.29	12.44	−8.11	13.82
United States	1,560	0.38	0.37	1.58	0.78	9.90	−7.92	12.32
Full sample	29,919	0.58	0.48	10.74	150.82	24,771.96	−89.96	1,771.67

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Table B.I (*continued*)

Country	Months	Summary statistics for returns: $\bar{R}_a$ (%)	$\bar{R}_g$ (%)	SD (%)	Skew	Kurt	Min (%)	Max (%)
Panel D: Nominal bill returns								
Argentina	239	0.38	0.38	0.10	0.19	1.04	0.29	0.49
Australia	1,428	0.38	0.38	0.28	1.44	5.12	0.06	1.49
Austria	1,139	0.39	0.39	0.20	−0.09	2.93	−0.06	1.02
Belgium	1,476	0.37	0.37	0.22	0.63	3.59	−0.08	1.10
Canada	1,548	0.35	0.35	0.25	1.25	5.44	0.01	1.59
Chile period I	528	0.63	0.63	0.39	1.09	2.43	0.33	1.53
Chile period II	120	0.28	0.28	0.10	−0.27	2.84	0.04	0.45
Czech Republic	236	0.14	0.31	0.13	0.80	2.66	−0.04	0.44
Czechoslovakia	233	0.32	0.32	0.08	0.94	2.73	0.25	0.53
Denmark	1,560	0.47	0.47	0.32	1.43	5.22	−0.09	1.58
Finland	612	0.42	0.42	0.27	−0.30	1.63	−0.02	0.76
France	1,560	0.35	0.35	0.26	1.22	4.43	−0.08	1.45
Germany	1,560	0.36	0.36	0.29	10.72	185.51	−0.08	5.49
Greece	467	0.77	0.77	0.53	0.68	4.48	0.08	3.90
Hungary	251	0.50	0.50	0.33	−0.06	2.04	−0.00	1.22
Iceland	216	0.58	0.58	0.29	1.24	3.39	0.23	1.46
Ireland	1,008	0.44	0.44	0.33	1.20	5.67	−0.03	2.84
Israel	120	0.08	0.08	0.08	0.77	2.27	−0.06	0.27
Italy	1,068	0.48	0.48	0.38	1.03	3.24	−0.06	1.68
Japan	1,080	0.30	0.30	0.20	−0.36	1.82	−0.03	0.67
Latvia	48	−0.03	−0.03	0.00	1.33	6.43	−0.03	−0.01
Lithuania	24	−0.03	−0.03	0.00	−1.47	3.56	−0.03	−0.03
Luxembourg	456	0.33	0.33	0.27	0.46	2.26	−0.03	1.03
Mexico	221	0.50	0.50	0.16	−0.00	1.80	0.24	0.90
Netherlands	1,272	0.29	0.29	0.20	0.77	3.95	−0.09	1.08
New Zealand	1,488	0.46	0.45	0.29	1.84	8.44	0.10	2.03
Norway	1,271	0.35	0.35	0.26	1.02	3.67	0.03	1.23
Poland	247	0.43	0.43	0.34	1.53	4.54	0.12	1.43
Portugal	1,032	0.47	0.47	0.47	1.44	3.94	−0.04	1.88
Singapore	258	0.10	0.10	0.07	0.87	2.96	0.01	0.34
Slovakia	240	0.23	0.23	0.25	0.68	2.08	−0.03	0.71
Slovenia	120	0.03	0.03	0.04	1.10	3.12	0.00	0.13
South Korea	230	0.28	0.28	0.12	0.21	1.99	0.10	0.57
Spain	732	0.52	0.52	0.40	1.04	4.18	−0.05	2.35
Sweden	1,320	0.39	0.39	0.27	0.98	3.74	−0.07	1.39
Switzerland	1,272	0.21	0.21	0.15	0.71	3.97	−0.12	0.74
Türkiye	119	0.84	0.84	0.35	1.63	5.13	0.38	2.03
United Kingdom	1,560	0.35	0.35	0.28	1.05	3.69	0.01	1.26
United States	1,560	0.29	0.29	0.22	0.92	4.43	0.00	1.21
Full sample	29,919	0.38	0.38	0.30	1.96	14.75	−0.12	5.49

Table B.II

Bootstrap distributions of nominal payoffs.

The table summarizes distributions of nominal payoffs from a \$1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at various return horizons. The underlying sample is the pooled sample of all developed countries. Each panel shows statistics for the distribution of a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). The nominal payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of nominal payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Horizon	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
Panel A: Nominal domestic stock payoffs												
1 month	1.01	0.06	0.86	0.93	0.95	0.98	1.01	1.03	1.06	1.09	1.16	0.392
1 year	1.13	0.29	0.58	0.77	0.85	0.98	1.10	1.23	1.40	1.55	2.05	0.293
5 years	1.84	1.48	0.34	0.69	0.87	1.16	1.54	2.10	2.98	3.80	6.77	0.154
10 years	3.41	4.74	0.30	0.78	1.06	1.59	2.37	3.70	5.96	8.60	20.69	0.087
20 years	12.16	35.70	0.42	1.14	1.74	3.14	5.71	10.88	21.85	36.31	122.12	0.040
30 years	42.94	223.65	0.66	1.88	3.09	6.49	13.93	31.26	73.49	135.82	513.81	0.020
Panel B: Nominal international stock payoffs												
1 month	1.01	0.07	0.89	0.94	0.96	0.99	1.01	1.03	1.05	1.07	1.12	0.371
1 year	1.13	0.29	0.66	0.80	0.89	1.01	1.10	1.21	1.34	1.43	1.89	0.240
5 years	1.95	3.04	0.60	0.82	0.95	1.21	1.57	2.03	2.74	3.63	7.96	0.123
10 years	4.23	12.35	0.73	1.03	1.25	1.69	2.37	3.60	6.03	9.37	39.70	0.046
20 years	20.89	159.79	1.16	1.82	2.29	3.42	5.82	11.43	24.33	53.26	322.95	0.006
30 years	100.48	1,476.55	1.93	3.32	4.43	7.49	14.98	34.40	96.02	248.64	1,533.85	0.001
Panel C: Nominal bond payoffs												
1 month	1.01	0.11	0.95	0.98	0.99	1.00	1.00	1.01	1.02	1.03	1.07	0.276
1 year	1.07	0.41	0.89	0.96	0.99	1.02	1.05	1.10	1.16	1.22	1.37	0.142
5 years	1.39	0.85	0.87	1.07	1.11	1.18	1.29	1.47	1.75	1.98	2.63	0.020
10 years	1.93	1.72	0.55	1.24	1.31	1.46	1.70	2.09	2.78	3.46	5.20	0.015
20 years	3.84	4.63	0.25	1.70	1.89	2.29	2.96	4.26	6.46	8.69	15.47	0.019
30 years	7.59	12.12	0.28	2.39	2.83	3.69	5.29	8.48	14.08	19.52	38.13	0.024
Panel D: Nominal bill payoffs												
1 month	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	0.034
1 year	1.05	0.04	1.00	1.00	1.01	1.02	1.04	1.06	1.09	1.12	1.18	0.030
5 years	1.27	0.21	0.99	1.03	1.07	1.14	1.22	1.33	1.53	1.72	2.10	0.014
10 years	1.64	0.54	1.03	1.11	1.18	1.33	1.50	1.76	2.25	2.70	3.83	0.002
20 years	2.78	1.64	1.22	1.40	1.54	1.85	2.31	3.07	4.47	5.84	9.58	0.000
30 years	4.69	3.67	1.53	1.86	2.10	2.66	3.58	5.28	8.44	11.48	20.00	0.000

Table B.III

Loss probabilities for alternative block sampling lengths.

The table shows the proportion of real payoffs that are less than the initial investment across 10,000,000 bootstrap simulations at various return horizons for alternative mean block sampling lengths. The underlying sample is the pooled sample of all developed countries. Each panel shows loss probabilities for a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	$\mathbb{P}(W_H^{(m)} < 1)$				
	Bootstrap block length parameter				
Horizon	1	12	60	120	240
Panel A: Real domestic stock loss probability					
1 month	0.428	0.428	0.428	0.428	0.428
1 year	0.385	0.374	0.372	0.371	0.371
5 years	0.285	0.302	0.294	0.290	0.288
10 years	0.221	0.251	0.232	0.223	0.218
20 years	0.152	0.193	0.174	0.162	0.154
30 years	0.113	0.156	0.139	0.126	0.117
Panel B: Real international stock loss probability					
1 month	0.417	0.417	0.417	0.417	0.417
1 year	0.365	0.342	0.334	0.333	0.332
5 years	0.239	0.252	0.257	0.259	0.260
10 years	0.159	0.186	0.183	0.181	0.181
20 years	0.079	0.109	0.097	0.084	0.071
30 years	0.042	0.067	0.055	0.041	0.029
Panel C: Real bond loss probability					
1 month	0.431	0.431	0.431	0.431	0.431
1 year	0.407	0.388	0.381	0.380	0.380
5 years	0.349	0.335	0.315	0.310	0.307
10 years	0.314	0.310	0.300	0.300	0.301
20 years	0.273	0.282	0.280	0.283	0.288
30 years	0.247	0.265	0.269	0.268	0.268
Panel D: Real bill loss probability					
1 month	0.405	0.405	0.405	0.405	0.405
1 year	0.435	0.386	0.380	0.379	0.378
5 years	0.449	0.392	0.382	0.382	0.382
10 years	0.452	0.399	0.384	0.384	0.384
20 years	0.454	0.407	0.383	0.376	0.371
30 years	0.454	0.411	0.383	0.369	0.355

Table B.IV

Bootstrap distributions of real international stock payoffs with alternative international stock portfolio.

The table summarizes distributions of real payoffs from a $1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at various return horizons. The underlying sample is the pooled sample of all developed countries. The table shows statistics for the distribution of international stocks with a 25% cap on the weight of any individual country in the international portfolio construction. The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Horizon	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
1 month	1.01	0.07	0.89	0.94	0.96	0.99	1.01	1.03	1.05	1.06	1.11	0.414
1 year	1.07	0.22	0.63	0.77	0.85	0.96	1.06	1.17	1.28	1.36	1.60	0.334
5 years	1.40	0.63	0.49	0.66	0.77	1.01	1.31	1.68	2.08	2.39	3.39	0.244
10 years	1.95	1.38	0.45	0.68	0.83	1.19	1.70	2.39	3.24	3.87	6.12	0.169
20 years	3.75	4.41	0.51	0.86	1.13	1.75	2.79	4.48	6.87	8.98	17.33	0.074
30 years	7.12	11.48	0.62	1.16	1.60	2.70	4.68	8.06	13.60	19.17	43.56	0.035

Table B.V

Bootstrap distributions of 30-year payoffs with additional sample screens.

The table summarizes distributions of real payoffs from a \$1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at a 30-year return horizon for alternative samples. The "full sample" results in each panel underlying sample correspond to the pooled sample of all developed countries (i.e., the base case sample used in the paper). The "POP 0.2%" and "POP 0.5%" samples exclude data for a given country prior to the year in which the country's population reaches 0.2% or 0.5% of the total world population, respectively. The "M/GDP 0.5" and "M/GDP 1.0" samples exclude data for a given country prior to the year in which the country's market capitalization-GDP ratio reaches 0.5 or 1.0, respectively. The "Ex-US" sample excludes all US data. Each panel shows statistics for the distribution of a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Sample	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
Panel A: Real domestic stock payoffs												
Full sample	7.45	16.82	0.13	0.46	0.82	1.87	4.06	8.23	15.76	23.88	56.15	0.126
POP 0.2%	6.97	14.92	0.11	0.38	0.69	1.65	3.72	7.65	14.66	22.39	54.05	0.149
POP 0.5%	6.86	13.42	0.08	0.30	0.59	1.57	3.71	7.68	14.70	22.29	52.63	0.166
M/GDP 0.5	6.96	11.22	0.17	0.57	0.95	2.00	4.14	8.05	14.77	21.73	47.12	0.106
M/GDP 1.0	4.93	5.81	0.17	0.46	0.77	1.60	3.24	6.13	10.60	14.81	27.85	0.141
Ex-US	7.36	15.07	0.13	0.44	0.78	1.79	3.94	8.07	15.59	23.82	56.71	0.134
Panel B: Real international stock payoffs												
Full sample	7.80	16.61	0.58	1.09	1.52	2.61	4.68	8.47	14.79	21.40	54.34	0.042
POP 0.2%	8.54	21.19	0.58	1.10	1.54	2.66	4.81	8.81	15.85	23.81	68.00	0.040
POP 0.5%	9.48	30.19	0.59	1.12	1.55	2.66	4.78	8.76	16.09	25.46	98.76	0.038
M/GDP 0.5	8.55	20.60	0.65	1.21	1.67	2.81	4.92	8.81	15.59	23.09	67.36	0.032
M/GDP 1.0	6.50	6.18	0.68	1.23	1.68	2.76	4.70	8.10	13.22	17.65	30.31	0.030
Ex-US	5.63	8.95	0.51	0.94	1.28	2.12	3.67	6.35	10.81	15.42	35.20	0.058
Panel C: Real bond payoffs												
Full sample	2.34	4.22	0.02	0.12	0.35	0.94	1.79	3.03	4.66	5.96	9.48	0.268
POP 0.2%	2.14	6.84	0.02	0.07	0.21	0.77	1.59	2.77	4.30	5.52	8.80	0.322
POP 0.5%	2.21	10.59	0.01	0.04	0.10	0.66	1.61	2.84	4.32	5.47	8.72	0.337
M/GDP 0.5	2.29	5.97	0.02	0.17	0.42	0.98	1.82	2.93	4.32	5.40	8.30	0.256
M/GDP 1.0	2.22	1.64	0.06	0.34	0.60	1.12	1.89	2.91	4.21	5.24	7.80	0.211
Ex-US	2.37	6.88	0.02	0.11	0.33	0.92	1.79	3.07	4.73	6.05	9.65	0.273
Panel D: Real bill payoffs												
Full sample	1.32	0.81	0.03	0.16	0.40	0.80	1.21	1.72	2.31	2.76	3.97	0.369
POP 0.2%	1.23	0.77	0.02	0.09	0.28	0.70	1.15	1.65	2.20	2.59	3.58	0.409
POP 0.5%	1.22	0.78	0.02	0.04	0.15	0.71	1.18	1.64	2.16	2.54	3.57	0.393
M/GDP 0.5	1.29	0.75	0.02	0.19	0.43	0.82	1.19	1.65	2.22	2.63	3.70	0.363
M/GDP 1.0	1.20	0.63	0.05	0.31	0.48	0.79	1.11	1.52	2.01	2.36	3.09	0.408
Ex-US	1.32	0.82	0.02	0.14	0.38	0.78	1.20	1.72	2.33	2.78	4.02	0.375

Table B.VI
Bootstrap distributions of payoffs for the post-World War II period.

The table summarizes distributions of real payoffs from a \$1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at various return horizons. The underlying sample is the pooled sample of all developed countries. Each panel shows statistics for the distribution of a given asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). The simulations exclude all data prior to October 1945. The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Horizon	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
Panel A: Real domestic stock payoffs												
1 month	1.01	0.06	0.85	0.92	0.95	0.98	1.01	1.03	1.06	1.09	1.15	0.432
1 year	1.09	0.27	0.54	0.72	0.80	0.93	1.07	1.21	1.37	1.51	1.91	0.372
5 years	1.51	0.97	0.23	0.56	0.71	0.96	1.31	1.80	2.52	3.09	4.73	0.277
10 years	2.20	1.97	0.18	0.54	0.74	1.11	1.73	2.66	3.97	5.19	9.98	0.200
20 years	4.63	6.64	0.18	0.56	0.88	1.62	2.96	5.33	9.41	13.56	29.27	0.123
30 years	9.61	19.30	0.20	0.67	1.14	2.42	5.06	10.33	20.39	31.45	74.85	0.085
Panel B: Real international stock payoffs												
1 month	1.01	0.06	0.89	0.93	0.95	0.98	1.01	1.03	1.05	1.07	1.11	0.409
1 year	1.08	0.21	0.62	0.76	0.85	0.97	1.08	1.18	1.29	1.37	1.58	0.316
5 years	1.45	0.62	0.52	0.68	0.78	1.02	1.37	1.77	2.14	2.47	3.47	0.235
10 years	2.09	1.27	0.48	0.68	0.84	1.26	1.82	2.63	3.53	4.18	6.42	0.156
20 years	4.26	3.82	0.54	0.93	1.22	1.92	3.19	5.43	8.29	10.59	19.00	0.061
30 years	8.59	10.04	0.68	1.31	1.83	3.18	5.68	10.45	17.97	24.82	47.25	0.027
Panel C: Real bond payoffs												
1 month	1.00	0.02	0.93	0.97	0.98	0.99	1.00	1.01	1.02	1.04	1.07	0.435
1 year	1.02	0.11	0.69	0.87	0.91	0.97	1.02	1.08	1.14	1.19	1.33	0.388
5 years	1.14	0.33	0.23	0.62	0.79	0.97	1.12	1.31	1.52	1.69	2.12	0.294
10 years	1.33	0.59	0.10	0.42	0.67	0.97	1.28	1.62	2.04	2.39	3.05	0.272
20 years	1.81	1.21	0.04	0.24	0.51	0.98	1.59	2.37	3.33	4.07	5.75	0.258
30 years	2.44	2.09	0.03	0.17	0.41	1.02	1.94	3.30	5.02	6.35	9.76	0.243
Panel D: Real bill payoffs												
1 month	1.00	0.01	0.97	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.02	0.408
1 year	1.00	0.06	0.77	0.93	0.96	0.99	1.01	1.03	1.05	1.06	1.09	0.384
5 years	1.02	0.19	0.28	0.72	0.84	0.95	1.03	1.12	1.23	1.29	1.39	0.388
10 years	1.06	0.31	0.14	0.50	0.73	0.91	1.06	1.22	1.43	1.57	1.80	0.390
20 years	1.14	0.51	0.04	0.27	0.54	0.85	1.10	1.41	1.78	2.04	2.55	0.393
30 years	1.23	0.69	0.03	0.18	0.39	0.80	1.15	1.59	2.11	2.47	3.35	0.390

Table B.VII

Bootstrap distributions of real international stock payoffs for the post-Bretton Woods period.

The table summarizes distributions of real payoffs from a \$1.00 buy-and-hold investment across 10,000,000 bootstrap simulations at various return horizons. The underlying sample is the pooled sample of all developed countries. The table shows statistics for the distribution of international stocks. The simulations exclude all data prior to September 1971. The real payoff for bootstrap iteration m at the H-month horizon is $W_H^{(m)}$. For each horizon, the table reports the mean, standard deviation, and distribution percentiles of real payoffs. The last column in the table shows the proportion of payoff draws that are less than one [$\mathbb{P}(W_H^{(m)} < 1)$].

	Moments		Percentiles									
Horizon	Mean	SD	1%	5%	10%	25%	50%	75%	90%	95%	99%	$\mathbb{P}(W_H^{(m)} < 1)$
1 month	1.01	0.04	0.88	0.93	0.95	0.98	1.01	1.03	1.06	1.07	1.11	0.414
1 year	1.07	0.19	0.61	0.73	0.82	0.96	1.08	1.18	1.28	1.36	1.52	0.322
5 years	1.40	0.57	0.52	0.66	0.74	0.95	1.33	1.74	2.11	2.42	3.07	0.288
10 years	1.90	1.01	0.48	0.67	0.81	1.16	1.67	2.44	3.25	3.84	5.05	0.182
20 years	3.45	2.58	0.55	0.90	1.16	1.76	2.71	4.33	6.71	8.49	12.75	0.067
30 years	6.27	5.88	0.67	1.20	1.61	2.67	4.60	7.78	12.66	17.04	29.22	0.032

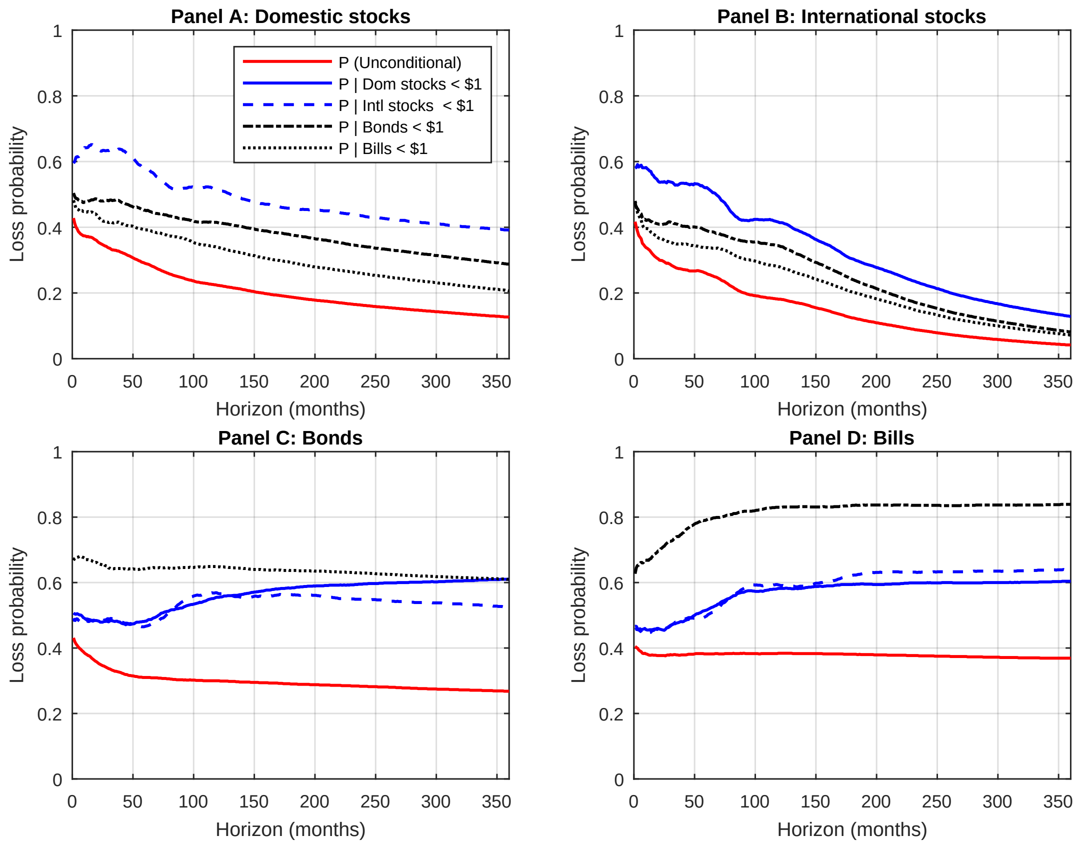

Figure B.1. Conditional loss probabilities for alternative investment horizons. The figure shows unconditional and conditional loss probabilities across 10,000,000 bootstrap simulations at various return horizons. The loss probability is the proportion of real payoffs that are less than the initial investment. Each panel corresponds to a specific asset class: domestic stocks (Panel A), international stocks (Panel B), bonds (Panel C), and bills (Panel D). In each panel, the solid red line corresponds to the unconditional loss probability. The other lines correspond to the loss probabilities conditional on a loss in one of the other asset classes.

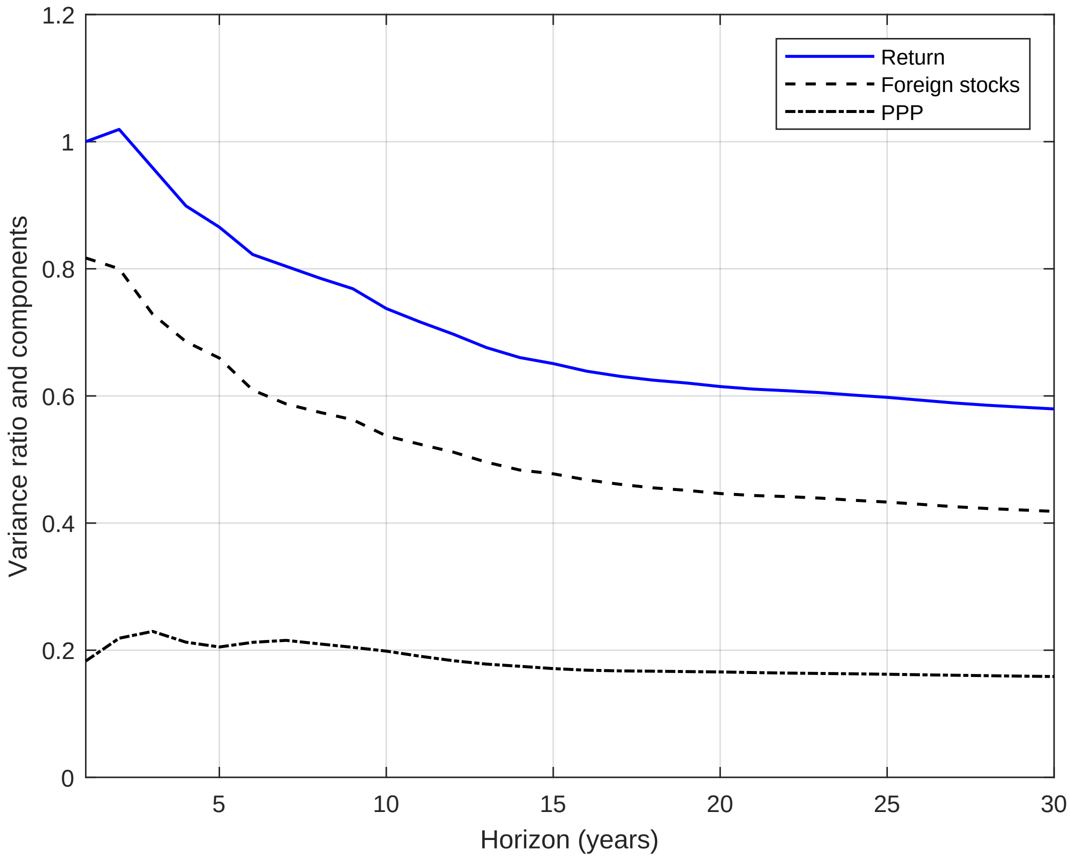

Figure B.2. Variance ratios for international stocks in the post-Bretton Woods period. The figure shows variance ratios and components of variance ratios for international stocks across 10,000,000 bootstrap simulations at various return horizons. The simulations exclude all data prior to September 1971.

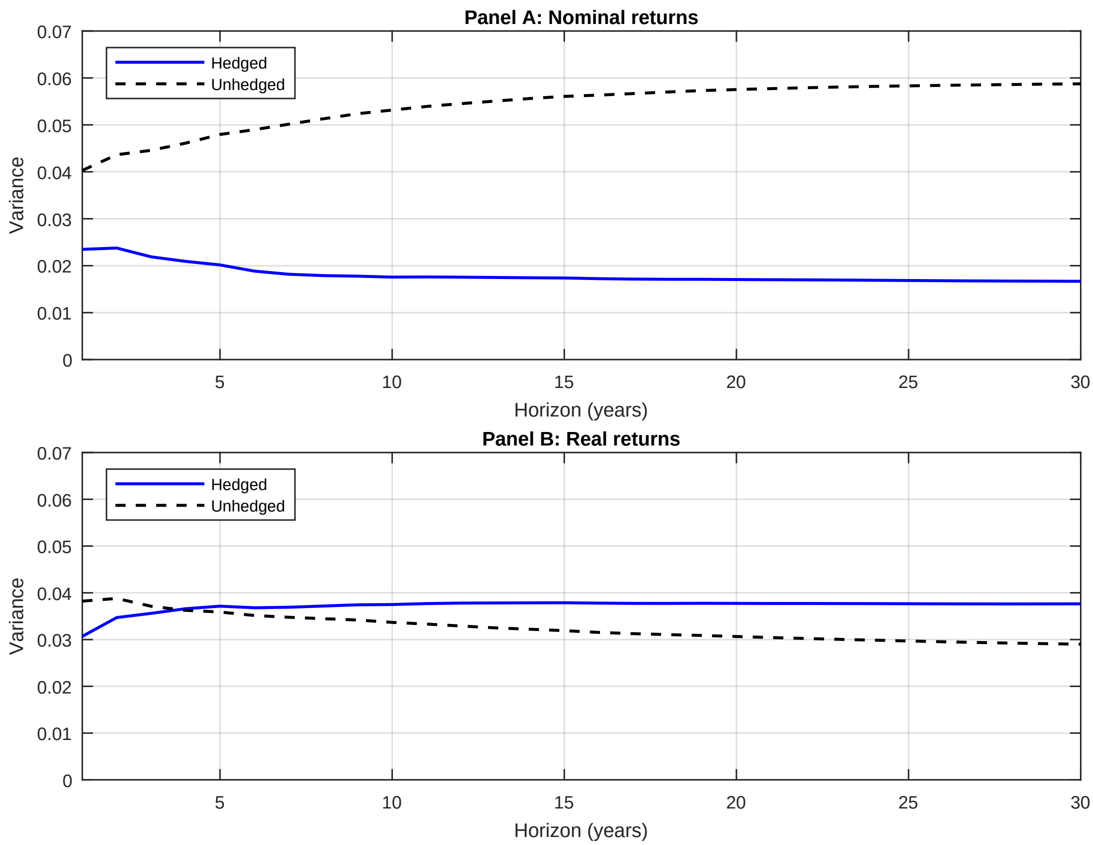

Figure B.3. Variance of log payoffs for international stocks. The figure shows the annualized variance of log wealth from investing in international stocks across 10,000,000 bootstrap simulations at various return horizons. The results in Panel A (Panel B) correspond to nominal (real) payoffs, and each panel plots variance for strategies that are hedged and unhedged to exchange rate risk.

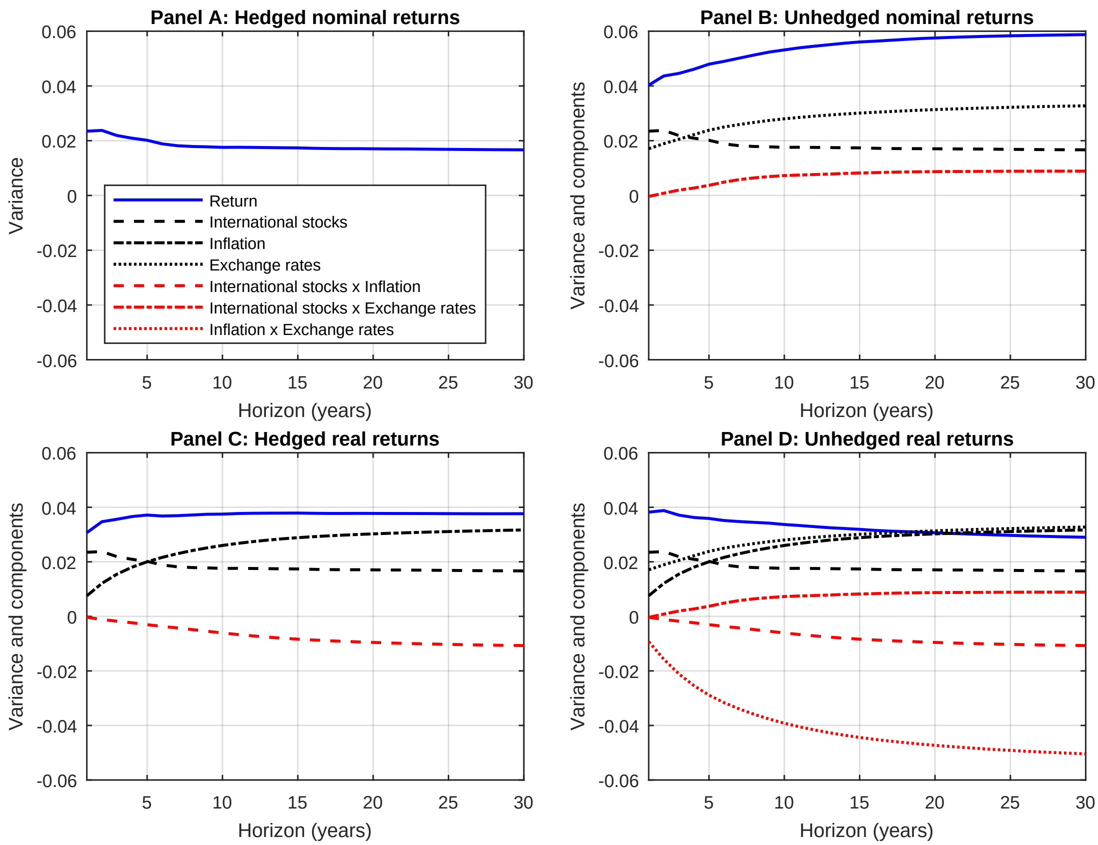

Figure B.4. Variance decompositions for international stocks. The figure shows the annualized variance and components of annualized variance of log wealth from investing in international stocks across 10,000,000 bootstrap simulations at various return horizons. The results correspond to the nominal returns of a currency-hedged strategy (Panel A), the nominal returns of an unhedged strategy (Panel B), the real returns of a currency-hedged strategy (Panel C), and the real returns of an unhedged strategy (Panel D). The variance decompositions follow from equation (B3) and include components related to the variances and pairwise covariances for international stock returns, inflation, and exchange rate changes.

C Derivations appendix

This appendix presents additional details on the return decompositions for stocks and bonds presented in Section 4.2.2.

C.1 Domestic stocks decomposition

The real stock return can be written

$$R_{t+1}^{Stocks} = \frac{P_{t+1} + D_{t+1}}{P_t \Pi_{t+1}}. \tag{C1}$$

The log stock return is

$$\begin{aligned} r_{t+1}^{Stocks} &= \log(P_{t+1} + D_{t+1}) - \log(P_t) - \log(\Pi_{t+1}) && \text{(C2)} \\ &= p_{t+1} + \log(1 + \exp(d_{t+1} - p_{t+1})) - p_t - \pi_{t+1}. && \text{(C3)} \end{aligned}$$

Using a loglinear approximation around the long-run mean of $d_{t+1} - p_{t+1}$,

$$\log(1 + \exp(d_{t+1} - p_{t+1})) \approx q_s + (1 - \rho_s)(d_{t+1} - p_{t+1}), \tag{C4}$$

where q_s and ρ_s are loglinearization constants.[10] Substituting back,

$$\begin{aligned} r_{t+1}^{Stocks} &= p_{t+1} + \log(1 + \exp(d_{t+1} - p_{t+1})) - p_t - \pi_{t+1} && \text{(C7)} \\ &\approx p_{t+1} + (1 - \rho_s)(d_{t+1} - p_{t+1}) - p_t - \pi_{t+1} + q_s && \text{(C8)} \\ &= \rho_s p_{t+1} + (1 - \rho_s) d_{t+1} - p_t - \pi_{t+1} + q_s && \text{(C9)} \\ &= \rho_s (p_{t+1} - p_t) + (1 - \rho_s)(d_{t+1} - p_t) - \pi_{t+1} + q_s && \text{(C10)} \\ &= \rho_s((p_{t+1} - d_{t+1}) - (p_t - d_t)) + \rho_s(d_{t+1} - d_t) + (1 - \rho_s)(d_{t+1} - p_t) - \pi_{t+1} + q_s. && \text{(C11)} \end{aligned}$$

As such, a single-period log real stock return can be decomposed into components that capture valuation changes as reflected by a change in the price-dividend ratio, dividend growth, the dividend yield, and inflation. The valuation term contains two ratios, such that it is not directly affected by inflation. Inflation can be distributed into the dividend growth and dividend income terms. Rearranging,

$$r_{t+1}^{Stocks} \approx \rho_s((p_{t+1} - d_{t+1}) - (p_t - d_t)) + \rho_s(d_{t+1} - d_t - \pi_{t+1}) + (1 - \rho_s)(d_{t+1} - p_t - \pi_{t+1}) + q_s. \tag{C12}$$

[10]The loglinearization constants are

$$q_s = -\log \rho_s - (1 - \rho_s) \log\left(\frac{1}{\rho_s} - 1\right) \tag{C5}$$

and

$$\rho_s = \frac{1}{1 + \exp(\overline{d_{t+1} - p_{t+1}})}. \tag{C6}$$

We use annual data to decompose stock returns because of the periodicity of our dividend observations. We calculate $\overline{d_{t+1} - p_{t+1}}$ from the data and use $\rho_s = 0.965909$ and $q_s = 0.148687$.

Denoting the real wealth from investing in stocks with a horizon of H months as W_H^{Stocks}, ending log real wealth is determined by

$$w_H^{Stocks} = \sum_{t=1}^{H} r_t^{Stocks} \tag{C13}$$

$$\approx \rho_s[(p_H - d_H) - (p_0 - d_0)] + \rho_s \sum_{t=1}^{H}(\Delta d_t - \pi_t) + (1 - \rho_s)\sum_{t=1}^{H}(d_t - p_{t-1} - \pi_t) + Hq_s, \tag{C14}$$

where $\Delta d_t = d_t - d_{t-1}$. The three terms represent the cumulative effects of valuation changes, real dividend growth, and real dividend income (inclusive of Hq_s). We validate the quality of this approximation (i.e., we compare 30-year log domestic stock returns with the sum of the 30-year calculations for the three components), and we find the correlation to be 0.982 across bootstrap draws.

C.2 International stocks decomposition

The real international stock return can be written

$$R_{i,t}^{International\ stocks} = \sum_{j \neq i} w_{j,t-1} \frac{R_{j,t}^{Nominal\ stocks}}{\Pi_{i,t}} \left(\frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right). \tag{C15}$$

As described in the paper, we approximate the cumulative wealth from investing in international stocks as the product of two terms

$$W_H^{International\ stocks} = \prod_{t=1}^{H} R_{i,t}^{International\ stocks}$$

$$\approx \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Stocks} \right) \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} \frac{\Pi_{j,t}}{\Pi_{i,t}} \frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right), \tag{C16}$$

such that ending log real wealth is given by

$$w_H^{International\ stocks} \approx \log \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} R_{j,t}^{Stocks} \right) + \log \left(\prod_{t=1}^{H} \sum_{j \neq i} w_{j,t-1} \frac{\Pi_{j,t}}{\Pi_{i,t}} \frac{E_t^{i,j}}{E_{t-1}^{i,j}} \right). \tag{C17}$$

We validate the quality of this approximation (i.e., we compare 30-year log international stock returns with the sum of the 30-year calculations for the two components), and we find the correlation to be 0.999 across bootstrap draws.

C.3 Bonds decomposition

Let P_t be the clean bond price of a new 10-year government bond and $\tilde{P}_{t+1}$ be the clean bond price at time $t+1$ of a 10-year government bond issued at time t. Also let C_{t+1} be the (accrued or paid) coupon payment in month $t+1$ and L_{t+1} represent the percentage loss in period $t+1$ from government default. The real bond return can be written

$$R^{Bonds}_{t+1} = \frac{\tilde{P}_{t+1}(1 - L_{t+1}) + C_{t+1}}{P_t \Pi_{t+1}}. \tag{C18}$$

In the months in which $C_{t+1} > 0$ (i.e., c_{t+1} is defined), the log bond return is

$$\begin{aligned} r^{Bonds}_{t+1} &= \log(\tilde{P}_{t+1}(1 - L_{t+1}) + C_{t+1}) - \log(P_t) - \log(\Pi_{t+1}) && \text{(C19)} \\ &= \tilde{p}_{t+1} + \log(1 - L_{t+1}) + \log(1 + \exp(c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1}))) - p_t - \pi_{t+1}. && \text{(C20)} \end{aligned}$$

Using a loglinear approximation around the long-run mean of $c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1})$,

$$\log(1 + \exp(c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1}))) \approx q_b + (1 - \rho_b)(c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1})), \tag{C21}$$

where q_b and ρ_b are loglinearization constants.[11] Substituting back,

$$\begin{aligned} r^{Bonds}_{t+1} &= \tilde{p}_{t+1} + \log(1 - L_{t+1}) + \log(1 + \exp(c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1}))) - p_t - \pi_{t+1} && \text{(C24)} \\ &\approx \tilde{p}_{t+1} + \log(1 - L_{t+1}) + (1 - \rho_b)(c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1})) - p_t - \pi_{t+1} + q_b && \text{(C25)} \\ &= \rho_b \tilde{p}_{t+1} + \rho_b \log(1 - L_{t+1}) + (1 - \rho_b) c_{t+1} - p_t - \pi_{t+1} + q_b && \text{(C26)} \\ &= \rho_b(\tilde{p}_{t+1} - p_t) + \rho_b \log(1 - L_{t+1}) + (1 - \rho_b)(c_{t+1} - p_t) - \pi_{t+1} + q_b. && \text{(C27)} \end{aligned}$$

As such, a single-period log real bond return can be decomposed into components that capture valuation changes that would be reflected by changes in yields, the valuation effect of default, the coupon income, and inflation. The inflation term can be distributed to the valuation and coupon income terms, which both reflect time-$(t + 1)$ outcomes from time-t investments of currency. As such,

$$r^{Bonds}_{t+1} \approx \rho_b(\tilde{p}_{t+1} - p_t - \pi_{t+1}) + \rho_b \log(1 - L_{t+1}) + (1 - \rho_b)(c_{t+1} - p_t - \pi_{t+1}) + q_b. \tag{C28}$$

Denoting the real wealth from investing in bonds with a horizon of H months as W^{Bonds}_H, ending log real wealth is determined by

$$\begin{aligned} w^{Bonds}_H &= \sum_{t=1}^{H} r^{Bonds}_t && \text{(C29)} \\ &\approx \rho_b \sum_{t=1}^{H} (\tilde{p}_t - p_{t-1} - \pi_t) + \rho_b \sum_{t=1}^{H} \log(1 - L_t) + (1 - \rho_b) \sum_{t=1}^{H} (c_t - p_{t-1} - \pi_t) + H q_b. && \text{(C30)} \end{aligned}$$

The three terms represent the cumulative effects of valuation changes, default losses, and real coupon income (inclusive of Hq_b).

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[11] The loglinearization constants are

$$q_b = -\log \rho_b - (1 - \rho_b) \log\left(\frac{1}{\rho_b} - 1\right) \tag{C22}$$

and

$$\rho_b = \frac{1}{1 + \exp(\overline{c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1})})}. \tag{C23}$$

We use monthly data to decompose bond returns because of our assumptions that maintain investments in new 10-year bonds in each month. We calculate $\overline{c_{t+1} - \tilde{p}_{t+1} - \log(1 - L_{t+1})}$ from the data and use $\rho_b = 0.996047$ and $q_b = 0.025819$.

In the months in which $C_{t+1} = 0$, the real bond return simplifies to

$$R_{t+1}^{Bonds} = \frac{\tilde{P}_{t+1}(1 - L_{t+1})}{P_t \Pi_{t+1}}. \tag{C31}$$

In these cases, no approximation is necessary, and the log bond return is

$$r_{t+1}^{Bonds} = \tilde{p}_{t+1} + \log(1 - L_{t+1}) - p_t - \pi_{t+1}. \tag{C32}$$

In situations with negative yields, our assumed zero coupon bond would trade at a premium, and price depreciation would be expected in the absence of changes in interest rates. This expected price depreciation is a negative analogue to the positive coupon income on bonds with positive coupon yields. As such, we introduce $\tilde{p}_{t+1}^*$, which is the clean price of a hypothetical bond under the assumption that the bond yield stays constant from month t to month $t+1$. We then decompose the log bond return as

$$r_{t+1}^{Bonds} = (\tilde{p}_{t+1} - \tilde{p}_{t+1}^*) + \log(1 - L_{t+1}) + (\tilde{p}_{t+1}^* - p_t - \pi_{t+1}), \tag{C33}$$

and we treat the three terms as the valuation component, the default loss component, and the coupon income component.

We validate the quality of these decompositions (i.e., we compare 30-year log bond returns with the sum of the 30-year calculations for the three components), and we find the correlation to be 0.984 across bootstrap draws.

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