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Robert J. Barro
José F. Ursúa

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ABSTRACT

Long-term data for 25 countries up to 2006 reveal 195 stock-market crashes (multi-year real returns of -25% or less) and 84 depressions (multi-year macroeconomic declines of 10% or more), with 58 of the cases matched by timing. The United States has two of the matched events—the Great Depression 1929-33 and the post-WWI years 1917-21, likely driven by the Great Influenza Epidemic. 45% of the matched cases are associated with war, and the two world wars are prominent. Conditional on a stock-market crash, the probability of a minor depression (macroeconomic decline of at least 10%) is 30% and of a major depression (at least 25%) is 11%. In a non-war environment, these probabilities are lower but still substantial—20% for a minor depression and 3% for a major depression. Thus, the stock-market crashes of 2008-09 in the United States and other countries provide ample reason for concern about depression. In reverse, the probability of a stock-market crash is 69%, conditional on a depression of 10% or more, and 91% for 25% or more. Thus, the largest depressions are particularly likely to be accompanied by stock-market crashes, and this finding applies equally to non-war and war events. We allow for flexible timing between stock-market crashes and depressions for the 58 matched cases to compute the covariance between stock returns and an asset-pricing factor, which depends on the proportionate decline of consumption during a depression. If we assume a coefficient of relative risk aversion around 3.5, this covariance is large enough to account in a familiar looking asset-pricing formula for the observed average (levered) equity premium of 7% per year. This finding complements previous analyses that were based on the probability and size distribution of macroeconomic disasters but did not consider explicitly the covariance between macroeconomic declines and stock returns.

Robert J. Barro
Department of Economics
Littauer Center 218
Harvard University
Cambridge, MA 02138
and NBER
rbarro@harvard.edu

José F. Ursúa
Department of Economics
Littauer Center 218
Harvard University
Cambridge, MA 02138
jfursua@fas.harvard.edu

“The stock market has predicted nine of the last five recessions,” Samuelson (1966).

The Samuelson quote is remarkable because it is simultaneously extremely clever and extremely misleading. We find, for 25 countries with long-term data, that stock-market crashes (cumulated multi-year real returns of -25% or less) go along with minor depressions (multi-year declines of consumption or GDP by 10% or more) 30% of the time and major depressions (declines by 25% or more) 11% of the time. In reverse, minor depressions feature stock-market crashes 69% of the time, whereas major depressions feature these crashes 91% of the time. Thus, as the Samuelson quote suggests, stock-market crashes are far more frequent than depressions. Nevertheless, a stock-market crash provides good reason for concern about the macro economy—because the conditional 30% chance of a minor depression and 11% chance of a major depression are far above the typical probabilities. In reverse, the absence of a stock-market crash is reassuring in the sense that a depression is highly unlikely.

The overall probability of moving from a “normal state” into a minor depression turns out to be 3.7% per year (3 per century). But knowing that there is no stock-market crash lowers the odds to 1.0% per year (1 per century). For a major depression, the overall probability is 0.9% per year (1 per century), but conditioning on no stock-market crash reduces this chance to 0.08% per year (less than 1 per millennium). Hence, although Samuelson is right in some sense, stock returns still provide important guidance about the prospects for depression. This kind of information is particularly valuable in the financially turbulent environment of 2008-09.

I. Stock-Market Crashes and Depressions in the Long-Term International Data

This study uses an updated version of the macroeconomic and stock-return data described in Barro and Ursua (2008). For the macroeconomic aggregates, we have annual time series from before 1914 for real per capita consumer expenditure, C, for 24 countries and real per capita GDP for 36 countries. Our earlier study and the online information available at http://www.economics.harvard.edu/faculty/barro/data_sets_barro provide a detailed description of the methods and sources used to construct the data on C and GDP.[1]

For stock returns, the data come mainly from Global Financial Data (described in Taylor [2005]).[2] When available, we used nominal total return indexes, deflated by consumer price indexes, to compute annual, arithmetic real rates of return. In other cases, we used nominal stock-price composite indexes, deflated by consumer price indexes, and then added estimates (or sometimes actual values) of dividend yields to estimate the arithmetic real rates of return. The present study focuses on 25 countries (18 OECD) with annual stock-return data since at least the early 1930s. Our annual real rates of return apply from the end of the previous year to the end of the current year.[3]

As in Barro and Ursua (2008), we gauge "depressions" by peak-to-trough declines in real per capita consumer expenditure, C, or GDP. These declines can apply to multiple years, such as

[1] Barro and Ursua (2008) compare our GDP data with those in Maddison (2003). One problem with the Maddison data is his propensity to interpolate in poorly documented ways over periods with missing data.

[2] We use the data from Dimson, Marsh and Staunton (DMS), available through Morningstar, for Canada 1900-13, Denmark 1900-14, Italy 1900-05, Netherlands 1900-19, Sweden 1900-01, Switzerland 1900-10, and South Africa 1900-10. We use stock-price data for Japan 1893-1914 from Fujino and Akiyama (1977) and for Mexico 1902-29 (missing 1915-18) from Haber, Razo, and Maurer (2003). Care should be taken in using the DMS data for later periods, usually wars, with missing entries in Global Financial Data. These DMS data appear to be generated (for periods such as France 1940 and Portugal 1974-77 when stock-return data seem to be unavailable) by interpolation. We have not used any of this information.

[3] For cases of missing data, usually during wars and sometimes because of closed markets, we were able to compute cumulative multi-year real returns across the gaps. These cases are Belgium 1914-18 and 1944-46, France 1940-41, India 1926-27, Mexico 1915-18, Netherlands 1944-46, Spain 1936-40, Portugal 1974-77, and Switzerland 1914-16.

1912 to 1918 for Germany during World War I, 1929 to 1933 for the U.S. Great Depression, 1935 to 1937 during the Spanish Civil War, 1938 to 1943 for France in World War II, 1972 to 1976 covering the Pinochet coup in Chile, 1981 to 1988 in Mexico during the Latin American debt crisis, and 1989 to 1993 during the financial crisis in Finland.[4] In the main analysis, we follow our previous study in focusing on contractions in C or GDP of size 0.10 or more. However, we also consider higher thresholds for labeling an economic decline as a depression.

In terms of asset pricing, the analysis maps more closely to consumption than to GDP. However, our C measures refer, because of data availability, to personal consumer expenditure, rather than consumption. Moreover, in many cases, the measurement error in C is likely to be greater than that in GDP. The analysis in Barro and Ursua (2008, section V) found that major contractions in C and GDP were similar overall in terms of timing. The average proportionate size of contraction was also similar during non-war periods. However, because of the large expansion in military purchases during wars, the average proportionate contraction in C during wartime was, on average, five percentage points greater than that in GDP. For example, the United Kingdom had depressions gauged by C during the two world wars but not by GDP. Moreover, some non-war aftermaths, such as the United States from 1944 to 1947, featured substantial declines in GDP but not in C—because of the massive demobilization that featured sharp declines in military purchases. This kind of post-war case does not constitute a depression in an economic sense.

Putting these results together, we decided to measure macroeconomic contractions during non-war years as the average of those found in C and GDP. (If only one of the variables was

[4] In Barro and Ursua (2008) and in our main analysis here, we sometimes have intermediate years with small increases in C or GDP. However, the results do not change a lot if we constrain multi-year contractions to have declines in C or GDP for every year included in the multi-year interval.

available—in practice, GDP but not C—we gauged the contraction by the available variable.) In war aftermaths, we used only the information on C (and left the data as missing when only GDP was available). In war periods, we typically used only the data on C. However, we used an average of C and GDP when the contraction indicated by GDP was larger or when only the GDP data were available and the indicated contraction size was at least 0.10. For the 25 countries in the present study (2652 annual observations), this procedure yields 84 cases of macroeconomic contraction of size 0.10 or more.

We now apply an analogous peak-to-trough procedure to gauge stock-market crashes. In our main analysis, we focus on cumulative, multi-year real returns that were -0.250 or less. For the 25 countries, this procedure yields 195 cases of stock-market crashes.

Table 1 illustrates our methodology for U.S. data since 1869. We found 7 stock-market crashes (not including 2008, since our main sample goes to 2006), using the definition of cumulative real returns of -0.250 or less.[5] The worst is -0.55 for 1929-31 (Great Depression), followed by -0.49 for 1973-74, -0.47 for 1916-20, and -0.42 for 2000-02. The value -0.37 for 2008 (using data only through 2008) would be worth fifth place if it were included in the sample. The others are -0.37 for 1937-38, -0.32 for 1906-08, and -0.29 for 1939-41.

We matched stock-market crashes with depressions (macroeconomic contractions of size 0.10 or more) by finding periods that were coincident or adjacent. Table 1 illustrates our general procedure by providing the details for the United States from 1869 to 2006. The first two columns refer to the stock-market crashes, of which there were seven up to 2006 (and one more for 2008). The "macro contraction" in columns 7 and 8 is calculated by the method described

[5] The October 1987 U.S. stock-market crash does not show up as a decline for the full year. However, 1987 does appear as a sharp fall in the annual data for many other countries, including France, Germany, Italy, Denmark, Norway, Switzerland, and India.

earlier from the C and GDP declines shown in columns 3-6. The United States from 1869 to 2006 experienced only two periods with macro contractions of size 0.10 or more—the Great Depression of 1929-33, with a contraction of 0.25, and 1917-21, with a decline by 0.16. As discussed in Barro and Ursua (2008, section III), the 1917-21 contraction likely reflects the Great Influenza Epidemic, rather than World War I, per se. The other five periods with stock-market crashes were not associated with depressions, although 1906-08 comes close, 1937-38, 1973-74, and 2000-01 are all recession periods, and 1941-42 shows a decline in C but not in GDP. Of course, we do not yet know what will happen in the years following 2008. Note also that, unlike many other countries, the United States from 1869 to 2006 had no depressions that were not associated with stock-market crashes.

We applied the same methodology to all 25 countries (18 OECD) with long-term data on stock returns and the macroeconomic variables (at least GDP).[6] The matching of periods of stock-market crashes with those of macroeconomic declines were sometimes less clear cut than for the United States, but these considerations appear to be minor overall. Table 2, Panel A lists the 58 cases of stock-market crashes (returns of -0.250 or less) that paired up with depressions (macro contractions of 0.10 or more)—as already noted, two of these are for the United States. In this sample, the average stock return was -0.53, with an average duration of 3.9 years, and the average depression size was 0.23, with an average duration of 4.3 years.

Panel B lists the 26 cases of depressions that were not associated with stock-market crashes—of which there were none for the United States. In this sample, the average stock return was -0.09, with an average duration of 1.7 years, and the average depression size was

[6] We included two countries, New Zealand and South Africa, that have long-term data on GDP but not C. Also, in many cases, the GDP data start before the C data.

0.17, with an average duration of 4.0 years. There are another 137 cases (5 for the United States) of stock-market crashes not associated with depressions, but these are not shown in the table. The average stock return in this group was -0.41, with an average duration of 2.9 years, and the average depression size was 0.01, with an average duration of 1.5 years.

Among the 58 cases of paired stock-market crashes and depressions shown in Table 2, panel A, 14 are associated with World War II (including the neutral countries Spain, Sweden, and Switzerland), 10 with the Great Depression of the early 1930s, and 9 with World War I (including Sweden and Switzerland). There are 6 pairings associated with the Latin American debt crisis of the 1980s, 7 other post-World War II cases in Latin America, and 5 events with troughs in 1920-21, likely reflecting the Great Influenza Epidemic. The other cases involve Japan during the Russo-Japanese War (1904-05), the Mexican Revolution and Civil War (1910-20), the culmination of the German hyperinflation (1922-23), the Spanish Civil War (1936-39), India during the post-WWII conflict with Pakistan (1947-48), the peaceful ("Carnation") revolution in Portugal (1974-75), and the early 1990s financial crisis in Finland.

In Table 2, a bold entry for the macroeconomic period indicates a time of war (defined to include only active combatants).[7] Overall, 45% of the cases in Panel A (26 of 58) are associated with war.

Table 2, panel A misses a number of paired stock-market crashes and depressions associated with the Asian financial crisis of the late 1990s because the countries involved lack the long-term stock-return data needed to qualify for our sample. For example, Indonesia has a

[7]We used *Correlates of War*, inter- and intra-state conflicts (Sarkees [2000]), and other sources to designate times of "major" war. In Table 2, the conflicts designated as war for active combatants are Franco-Prussian War 1870-71, Russo-Japanese War 1904-05, World War I 1914-18, Mexican Revolution and Civil War 1909-18, Mexican War of the Cristeros 1926-29, Spanish Civil War 1936-39, World War II 1939-45, India-Pakistan War 1947-48, Pinochet coup in Chile 1973, Portugal Carnation Revolution 1974-75, and Peru's guerrilla conflicts 1987-92.

stock return of -0.69 for 1997-98 and a macro contraction of 0.11 for 1997-98, South Korea has a stock return of -0.63 for 1995-97 and a macro contraction of 0.11 for 1997-98, Malaysia has a stock return of -0.54 for 1997-98 and a macro contraction of 0.11 for 1997-98, and Thailand has a stock return of -0.81 for 1995-98 and a macro contraction of 0.14 for 1996-98. Our sample also excludes recent cases in Russia and other former Communist countries that lack long-term data.

In Table 2, panel B, for the 26 cases of depression unaccompanied by stock-market crashes, 7 are related to World War II (including the neutral country Portugal), 5 with the Great Depression, 4 with World War I (including the neutral country Chile), and 1 probably with the Great Influenza Epidemic. Other cases were the depression in Australia in the early 1890s, Canada in 1906-08 (likely related to the U.S. financial panic of 1907), Mexico in the early 1920s, Denmark in 1946-48, France around 1871 (Franco-Prussian War), France in the 1880s, Portugal at the time of the Spanish Civil War in 1934-36, Spain in the 1890s, and South Africa in the mid 1980s (possibly related to international sanctions against Apartheid). Overall, 31% of these cases (8 of 26) are associated with war. In contrast, for the 137 cases of stock-market crashes not associated with depressions, only 11 (8%) are associated with war.

II. Frequencies of Stock-Market Crashes and Depressions

Table 3 shows the overall frequency of stock-market crashes, defined as cumulative multi-year returns of -0.250 or less—or, as an alternative, -0.300 or less. The table also shows the frequency of macroeconomic contractions, defined as cumulative multi-year declines by at least 0.10, 0.15, 0.20, 0.25, or 0.30. Part A of the table combines non-war and war observations, and Part B distinguishes non-war from war events.

Begin with Part A of Table 3 and consider the pairing (-0.250, 0.10), which was used before. By this definition, the overall sample (25 countries, 2652 annual observations) has 195 stock-market crashes and 84 macro contractions. The average durations were 3.2 years for the stock-market crashes and 4.2 years for the macro contractions. When expressed as a probability per year of moving from "normalcy" into each state, the values are 0.100 for the stock-market crashes and 0.037 for the macro contractions. Thus, as Samuelson suggested, stock-market crashes are far more frequent than depressions—reflecting the much greater volatility of stock returns than of consumption or GDP growth rates.

Among the 195 stock-market crashes and 84 macro contractions, Table 3, part A shows that 58 were matched events—occurring over overlapping or adjacent years. Thus, 30% and 69%, respectively, of the stock-market crashes and macro contractions are paired with the other decline. To put it another way, if one knows that a stock-market crash (return of -0.250 or less) occurred, it is 30% probable that a depression (of size 0.10 or more) also occurred. Conversely, it one knows that a depression (of size 0.10 or more) occurred, it is 69% probable that a stock-market crash (of size -0.250 or worse) also occurred.

Not surprisingly, the probability of depression, conditional on observing a stock-market crash, declines as one raises the standard for declaring a depression. Table 3, part A indicates that, conditional on a stock-market crash (-0.250 or worse), the probability of depression is 0.30 for size 0.10 or more, 0.18 for size 0.15 or more, 0.13 for size 0.20 or more, 0.11 for size 0.25 or more, and 0.07 for size 0.30 or more.

In the reverse direction, the probability of a stock-market crash, conditional on seeing a depression, becomes larger the higher the standard for labeling a macro contraction as a depression. Table 3, part A shows that the conditional probability of a stock-market crash (-0.250 or less) goes from 0.69 when depressions are of size 0.10 or more to 0.71 at 0.15, 0.74 at 0.20, 0.91 at 0.25, and 0.93 at 0.30. Thus, the largest depressions are almost surely accompanied by stock-market crashes. (Table 2, panel B shows that the two largest depressions not accompanied by stock-market crashes were in Australia—in the early 1890s and during World War II.) Another way to view the result is that, if one knows that there is no stock-market crash, it is extremely unlikely that a major depression exists.

The last result can be expressed by calculating probabilities per year of entering into various states. Without knowing whether there is a stock-market crash, the unconditional probability per year of moving from "normalcy" into a major depression (0.25 or more) is 0.0091 per year, a little less than 1 per century. Knowing that there is no stock-market crash lowers these odds by a factor of 10 to 0.0008 per year, less than 1 per millennium. The change is less dramatic if one considers depressions of size 0.10 or more. In this case, the unconditional probability per year of entering into a depression is 0.037 per year (3-4 per century), whereas conditioning on no stock-market crash lowers the chance to 0.010 per year (1 per century). In other words, the conditioning reduces the depression odds by a factor of roughly four.

Table 3, part A also considers the breakpoint of -0.300 or less for declaring a stock-market crash. The number of these larger crashes is 159, corresponding to a probability of 0.078 per year of entering into this state. Among the 84 macro contractions of size 0.10 or more, 48 (57%) are paired with a stock-market crash of -0.300 or worse. Conditional on observing a stock-market crash of this larger magnitude, the probability of seeing a depression (0.10 or more) is roughly the same as before, 0.30.

Table 3, part A also has results for samples limited to the 18 OECD countries. The patterns are similar to those for the group of 25 countries. Thus, in the sample that combines non-war and war events, the predictive element of a stock-market crash is about the same in developed countries as in a set of middle-income countries from Latin America and Asia (although stock returns and growth rates of macroeconomic aggregates are more volatile in the middle-income countries).

Table 3, part B shows the results that separate non-war from war events. In the non-war sample, considered in columns 3-5 of the table, the biggest change from before is the decrease in depression probability, conditional on seeing a stock-market crash. For all 25 countries, for a stock-market crash of -0.250 or worse, the conditional probability of a minor depression (0.10 or more) is now 0.20, compared to 0.30 in the combined sample, and of a major depression (0.25 or more) is 0.03, rather than 0.11. For the OECD, the change is more pronounced—the conditional probability of a minor depression is now 0.17, rather than 0.28, and of a major depression is 0.02, rather than 0.10. The sample of OECD non-war events has only three major depressions—Australia in the 1890s (which did not have a stock-market crash) and the Great Depression in Canada and the United States (which had stock-market crashes).

We can apply the last set of findings to the 2008-09 environment, in which many countries experienced stock-market crashes (returns of -0.250 or worse) but not major wars. In this context, the upper portion of Table 3, part B implies a probability of minor depression (0.10 or more) of 20% and a probability of major depression (0.25 or more) of 3%.

The war sample is considered in columns 6-8 of Table 3, part B. The main change from the sample that combines all events is the much higher probability of depression, conditional on observing a stock-market crash. For all 25 countries, for a stock-market crash of -0.250 or worse, the conditional probability of a minor depression (0.10 or more) is now 0.70, compared to 0.30 in the combined sample, and of a major depression (0.25 or more) is 0.43, rather than 0.11. These results are similar for the OECD group. Thus, in a wartime context, a stock-market crash is highly predictive of depression.

In contrast, the probability of a stock-market crash, contingent on seeing a depression, is similar for the war and non-war samples. For example, for a minor depression (0.10 or more), the conditional probability of a stock-market crash (-0.250 or less) in the sample of 25 countries is 0.76 for the war sample, 0.64 for the non-war sample, and 0.69 for the combined sample. For a major depression (0.25 or more), the conditional probability of a stock-market crash is 0.94 for the war sample, 0.83 for the non-war sample, and 0.91 for the combined sample. Thus, in peace and war, depressions—especially the larger ones—are highly likely to be accompanied by stock-market crashes.

III. Rare Disasters and the Equity Premium

The analysis in Barro and Ursua (2008) followed the approach of Mehra and Prescott (1985), Rietz (1988), and Barro (2006) in asking whether a model calibrated to include rare disasters gets into the right ballpark for explaining observed equity premia. Based on long-term data on real returns on stocks and government bills, the challenge is to explain an average levered equity premium of around 7% per year. Correspondingly, with a debt-equity ratio of about one-half, the challenge is to explain an unlevered equity premium of around 5%.

a. Asset-Pricing Formulas

Barro (2009) and Barro and Ursua (2008) showed that equivalent results for the equity premium arose within two tractable models: a Lucas (1978)-tree model with i.i.d. shocks to productivity growth and an AK model with i.i.d. shocks to the depreciation rate (corresponding to destruction of "trees"). In both models, the economy was closed, and government consumption was not considered explicitly. In the former model, the number of trees was fixed, GDP and consumption coincided, and the expected growth rate was exogenous. The latter model allowed for endogenous investment (and saving) and growth but had a fixed price of equity shares (corresponding to Tobin's q equaling one).

For present purposes, it is sufficient to provide a brief sketch of the Lucas-tree setting. The log of GDP and consumption, C_t, follow the stochastic process:

(1) $$\log(C_{t+1}) = \log(C_t) + g + u_{t+1} + v_{t+1} \ .$$

The random term u_{t+1} is i.i.d. normal with mean 0 and variance σ^2. This term reflects "normal" economic fluctuations. The parameter $g \geq 0$ is a constant that reflects exogenous productivity growth. The random term v_{t+1} picks up rare disasters, which occur with a constant probability $p \geq 0$ per unit of time. In a disaster, output contracts instantaneously by the fraction b, where $0 < b < 1$. Thus, the distribution of v_{t+1} is given by

$$\text{probability } 1-p: \quad v_{t+1} = 0,$$

$$\text{probability } p: \quad v_{t+1} = \log(1-b).$$

The disaster size, b, follows some probability distribution, gauged by the empirical distribution of these sizes. (In ongoing research, we find that this size distribution is well described, above some cutoff value, by a power-law distribution.)

The representative household has preferences given by an Epstein-Zin-Weil utility function, as developed by Epstein and Zin (1989) and Weil (1990). This specification separates the coefficient of relative risk aversion, denoted γ, from the reciprocal of the intertemporal-elasticity-of-substitution (IES) for consumption, denoted θ. Hence, the framework allows for values of γ that are large enough (in the range of 3-4) to accord with observed equity premia. In addition (unlike with the usual power-utility formulation when $\gamma > 1$), $\text{IES} > 1$ is possible. This condition is important because it is required to generate some plausible properties of equity prices—in particular, if $\text{IES} > 1$, a once-and-for-all increase in uncertainty (a rise in p or σ or an outward shift in the distribution of b) reduces the price-dividend ratio for unlevered equity, whereas a once-and-for-all rise in the expected growth rate (reflecting an increase in g) raises this ratio. The condition $\text{IES} < 1$, although often assumed, generates the reverse, implausible properties for the price-dividend ratio. For further analysis, including discussion of empirical evidence on the IES, see Bansal and Yaron (2004) and Barro (2009).

Because the growth-rate shocks are i.i.d. (equation [1]), the model with Epstein-Zin-Weil utility satisfies an asset-pricing condition of familiar form (see Barro [2009] for a derivation):

$$(2) \qquad C_t^{-\gamma} = \left(\frac{1}{1+\rho^*}\right) \cdot E_t(R_t \cdot C_{t+1}^{-\gamma}),$$

where R_t is the gross, one-period return on any asset. Two key points are, first, the negative exponent on C_t and C_{t+1} is γ, the coefficient of relative risk aversion, not θ, the reciprocal of the IES, and, second, the effective rate of time preference, denoted ρ*, differs from the usual rate, denoted ρ, when γ and θ diverge.[8]

Equation (2) can be used to derive the equity premium in the model. As the length of the (arbitrary) period approaches zero, the formula becomes

(3) $$r^e - r^f = \gamma\sigma^2 + p \cdot E\left\{b \cdot \left[(1-b)^{-\gamma} - 1\right]\right\} ,$$

where r^e is the (constant) expected rate of return on unlevered equity, and r^f is the (constant) risk-free rate. The first term on the right-hand side, $\gamma\sigma^2$, corresponds to the equity premium in Mehra and Prescott (1985) and is trivial for reasonable values of γ and σ. Barro (2006) and Barro and Ursua (2008) show that, if γ is 3-4, the second term can explain an unlevered equity premium of around 5% when p and the distribution of b are calibrated from the sample of observed macroeconomic disasters, analogous to those shown in Table 2.

In the model, unlevered equity prices have the same volatility as GDP and consumption. Levered equity prices have more volatility but not enough more to explain the observed variance of stock prices. Explaining this "excess volatility" requires some underlying parameter involving uncertainty or expected growth to move around. For example, Gabaix (2008) relies on movements in *p*, whereas Bansal and Yaron (2004) rely on shifts in long-run growth rates, *g*. If

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[8] The formula is, if $\gamma \neq 1$, $\rho^* = \rho - (\gamma - \theta) \cdot \left\{ g - (1/2)\sigma^2(\gamma - 1) - \left(\frac{p}{\gamma - 1}\right) \cdot \left[E(1-b)^{1-\gamma} - 1\right] \right\}$, where *E* is the expectations operator.

these shifts are temporary and orthogonal to contemporaneous consumption, the model's implications for the average equity premium do not change a lot from the formula in equation (3). Thus, this extended framework may explain the average equity premium along with the high volatility of stock prices.

Another issue is that the empirical applications of the model in Mehra and Prescott (1985), Rietz (1988), Barro (2006), and Barro and Ursua (2008) do not consider the observed time series of stock returns, except to gauge the average equity premium. In equation (3), in the last term on the right-hand side, the first "*b*" represents the proportionate negative effect of a disaster on real stock prices (occurring at an instant of time when the period length approaches zero). The term $(1-b)^{-\gamma}$ can be viewed heuristically (not literally in an Epstein-Zin-Weil setup) as the marginal utility of consumption in a disaster state expressed as a ratio to the marginal utility in a normal state. The "*b*" that appears here represents the proportional loss of consumption during a disaster. The previous applications assume that the two *b*'s are the same—because, in the model, a disaster causes unlevered stock prices to decrease in the same proportion as consumption and GDP. Actually, the two *b*'s do not have to be identical, because they can differ by orthogonal, temporary noise.

A different, complementary approach uses the observed time series of stock returns during crises (and, perhaps, also at other times) to calibrate an analog to the last term on the right-hand side of equation (3). More formally, the equation can be replaced by a familiar looking formula that involves the covariance between stock returns and an asset-pricing factor, which depends on $(1-b)^{-\gamma}$, where b is the proportionate fall of consumption during a disaster.

Consider the asset-pricing condition in equation (2) when applied over a period of length T years. Let R_T be the gross return on any asset from the time t to $t+T$. Equation (2) implies

$$(4) \qquad (1+\rho^*)^T = COV\left[R_T, \left(\frac{C_{t+T}}{C_t}\right)^{-\gamma}\right] + ER_T \cdot E\left(\frac{C_{t+T}}{C_t}\right)^{-\gamma} ,$$

where COV is the covariance operator.[9] When applied to the gross risk-free return, R_T^f, the result is

$$(5) \qquad (1+\rho^*)^T = R_T^f \cdot E\left(\frac{C_{t+T}}{C_t}\right)^{-\gamma} .$$

Substituting for $E\left(\frac{C_{t+T}}{C_t}\right)^{-\gamma}$ from equation (5) into equation (4) yields

$$(6) \qquad \frac{ER_T}{R_T^f} = 1 - \frac{1}{(1+\rho^*)^T} \cdot COV\left[R_T, \left(\frac{C_{t+T}}{C_t}\right)^{-\gamma}\right] .$$

We can verify that equation (6) implies equation (3) as the period length, T, approaches zero, when R_T is the gross return on Lucas-tree equity (a perpetual consumption claim) and C_t is generated from equation (1). The derivation of equation (3) from equation (6) relies on the condition (implied by equation [1]) that the proportionate change in unlevered equity prices always equals the proportionate change in consumption.[10] Instead of imposing this condition, we can implement equation (6) directly by computing the covariance between gross stock returns

[9] Equation (2) applies in the Epstein-Zin-Weil setting only when the shocks to consumption growth are i.i.d. In this case, the covariance and the expectations shown in equation (4) and subsequent expressions will be time invariant; that is, they do not have to be conditioned on t.
[10] However, the results would not change if we added temporary, independent noise to stock returns and the asset-pricing factor $(C_{t+T}/C_t)^{-\gamma}$.

and the asset-pricing factor, $\left(\frac{C_{t+T}}{C_t}\right)^{-\gamma}$. Since this approach uses observed returns on levered equity, the left-hand side of equation (6) will refer to the levered equity premium, empirically averaging around 7% per year (see Barro and Ursua [2008, section II]). That is, the model has to generate a higher equity premium than before, where the target was the 5% value corresponding to the estimated average unlevered equity premium.

b. Covariance Calculations

Our first approach implements equation (6) with all of the available long-term data for 25 countries on gross real stock returns, R_T, and consumption ratios, C_{t+T}/C_t. These calculations use various period lengths, T (in years), and coefficients of relative risk aversion, γ.[11] This analysis measures consumption changes from the data on real per capita consumer expenditure; that is, we use no GDP data. In the main analysis, we interact the consumption ratio, C_{t+T}/C_t, computed from annual data for years t and $t+T$, with returns, R_T, calculated from the end of year $t-1$ to the end of year $t+T-1$.[12] To implement equation (6), we use ρ^*=0.029 per year (from Barro and Ursua [2008, Table 9]). However, for small values of T (such as $T=1$ year), the results depend little on ρ^*.

The bottom line is that these calculations yield equity premia that are too low by a factor of around 10, compared with the target of 0.07 per year for the levered equity premium. For example, with $T=1$ and $\gamma=3.5$, there are 2401 observations, the covariance is -0.006, and the

[11] For cases of missing stock-return data, as described in n.3, we use the interpolated values.
[12] We could get a better match in the timing between consumption changes and stock returns if we used the monthly data on stock returns that are available for some countries and time periods. This extension is worth pursuing, but we doubt that the results will change a lot.

equity premium is 0.006 per year. For $T = 2$ and $\gamma = 3.5$, there are 2381 (overlapping) observations, the covariance is -0.011, and the equity premium is 0.005 per year. If we shift the timing to measure returns from the end of year t to the end of year $t+T$ or from the end of year $t-2$ to the end of year $t+T-2$, the computed equity premia are even smaller.

We know from Barro and Ursua (2008, Tables 9 and 10) that the calibrated results for the equity premium depend mostly on the cases of extreme macroeconomic contraction. These events, with contractions of size 0.10 or more, are the ones shown in Table 2 (for the 25 countries that also have long-term data on stock returns). Examination of panel A, which has the 58 cases of paired stock-market crashes and depressions, suggests two key properties. First, crashes and depressions usually arise as multi-year events—but this feature was already captured in the covariance analysis by allowing for period lengths, T, that exceeded one year. Second, the timing between the stock-market crashes and the depressions is irregular. That is, unlike our covariance calculations, the matches do not always refer to the same timing, such as relating consumption changes between year t and year $t+T$ to gross stock returns from the end of year $t-1$ to the end of year $t+T-1$.

A prototypical case is the United States during the Great Depression—the stock return is -0.55 for 1929-31 (gross return of 0.45), and the macroeconomic contraction is 0.25 for 1929-33. This pattern—with the strongly negative stock return applying slightly prior to or coincident with the macro contraction—also applies to other cases in Table 2, panel A. Examples include Denmark, Sweden, Switzerland, and the United Kingdom in World War II; Chile, France, Germany, Mexico, and Spain during the Great Depression; Canada over the period of World War I and the Great Influenza Epidemic; Norway, Sweden, and the United States during this epidemic; Germany at the end of the hyperinflation in 1922-23; India during its 1947-48 conflict with Pakistan; Chile in the 1970s; Chile, Mexico, and Peru in the 1980s; and Finland in the early 1990s.

Some cases that deviate from this prototypical pattern can be explained by measurement issues. For example, the need to interpolate stock-return data for Mexico 1915-18, Belgium in World Wars I and II, Portugal 1974-77, and Spain 1936-40 may explain the patterns in which the negative stock returns appear to lag the macroeconomic declines.

Other cases are likely to be affected strongly by wartime controls on prices and other variables. An extreme example is Germany during World War II, where the controls—on consumer prices starting in 1936 and on stock prices starting in 1943—lapsed only in 1948. Clearly, the measured real stock return for 1948, -0.89, is way too low, especially because the controls prevented the posted nominal stock prices from falling earlier. Correspondingly, during the war and through 1947, the underestimation of true inflation and the propping up of reported stock prices must have led to a substantial overstatement of real returns. These considerations likely explain why the real stock return of -0.91 shown for 1944-48 in Table 2, panel A appears to lag the macro decline of 0.41 for 1939-45. Moreover, an important point is that longer-term real returns that bridge the controls are likely to be satisfactory. For example, the measured, cumulative real stock return in Germany for 1939-48 of -0.85 is probably an accurate long-term indicator.

Analogous effects from price controls likely arise for France and other countries during World War II and, perhaps also, World War I.[13] For France (also affected by missing data for

[13] For the United States, in a case not included in Table 2, the measured real stock return of -0.25 for 1946-47 is likely to be far below the "true" value because of the unwinding of price controls from 1945 to 1948. Barro (1978, Table 2) estimates that the "true" price level was 53% above the reported value in 1945, 21% above in 1946, and 8%

1940-41), the cumulative real return for 1939-47 is -0.41. This long-term return, which bridges the missing data and the likely price controls, is probably reliable. In contrast, there is an apparent mismatch in timing between the reported real stock return of -0.69 shown for 1943-45 in Table 2, panel A and the macro contraction of 0.58 for 1938-43. Again, measurement problems may explain the mismatch.

These considerations suggest that an alternative way to evaluate the formula for the equity premium in equation (6) is to focus on the 58 cases of paired stock-market crashes and depressions (Table 2, panel A) and to calculate the covariance in a flexible way that allows for different timing for each case. Essentially, we compute the cross product between the demeaned values of the stock returns shown in column 3 and the macro contractions shown in column 5.[14] Then, in applying the result to equation (6), we measure the period length, T, as the average duration (5.2 years) for the 58 paired cases. Subsequently, we go further by bringing into the calculation the additional 163 cases that had either a stock-market crash or a depression but not both (of which 137 had a stock-market crash and 26—those shown in Table 2, panel B—had a depression).

In the first application of the method, we begin by computing the covariance for the 58 paired cases shown in Table 2, panel A. To carry out this calculation, we use the values shown in columns 3 and 5 to express each gross stock return (one plus the rate of return) and transformed consumption ratio, $\left(\frac{C_{t+T}}{C_t}\right)^{-\gamma}$, as a deviation from the respective overall sample

above in 1947. Conversely, during the war, the controls led to an understatement of inflation and, hence, to an overestimate of real stock returns.

[14] In these calculations, we did not adjust for price controls, such as in Germany and France, by measuring real stock returns over even longer periods than those shown in Table 2, panel A. Such adjustments, in conjunction with a systematic analysis of price controls, might improve the results.

mean.[15] (We use values of γ equal to 3, 3.5, and 4.) Then we add up the cross terms and divide by the number of cases, 58, to compute the sample covariance. To get the contribution to the overall covariance, we multiply by the weight applicable to the matched sample. This weight is the ratio of the years in the 58-case sample (299, corresponding to an average duration of $T = 5.2$ years) to the total sample years (2652)—the result is $p_T = 0.113$, shown in the first line of Table 4. To calculate the term on the right-hand side of equation (6), we multiply 0.113 by the 58-case covariance and then divide by $(1+\rho^*)^T$, using $\rho^* = 0.029$ per year, as before, and $T = 5.2$ years. Using $T = 5.2$ again on the left-hand side of equation (6), we then compute the equity premium, expressed per year.

The results for the three assumed values of γ are shown on the first line of Table 4. The computed levered equity premium is 0.039 per year when $\gamma = 3$, 0.054 when $\gamma = 3.5$, and 0.074 when $\gamma = 4$. Thus, the model accords with the observed average levered equity premium of 0.07 if $\gamma = 4$. Note that this match relies only on the behavior during the 58 matched stock-market crashes and depressions. Implicitly, the contribution to the covariance from the other 2353 years in the sample is taken to be roughly zero.

The second line of Table 4 repeats the calculations for a sample limited to the 18 OECD countries (which have a total of 2006 observations). The computed equity premia are somewhat larger than those from the full sample—0.043 when $\gamma = 3$, 0.060 when $\gamma = 3.5$, and 0.085 when $\gamma = 4$. Although the weight, $p_T = 0.097$, is smaller for the OECD than for the overall sample, the OECD also has a higher frequency of very large macroeconomic contractions. This last consideration turns out to dominate and leads, thereby, to a higher equity premium for the OECD

[15] For example, for the United States 1929-31, the gross real stock return of 0.45 is taken as a deviation from the overall sample mean for all 25 countries of gross real stock returns over 3-year periods, which is 1.28.

than for the full sample. For the OECD, a value of γ close to 3.5 is adequate for roughly matching the observed average levered equity premium of 0.07.

Lines 3 and 4 of Table 4 carry out the analysis for the larger sample of events that includes stock-market crashes without depressions and depressions without stock-market crashes. Thus, there are now 221 events for 25 countries and 153 events for 18 OECD countries. The fraction, p_T, of the overall sample years contained in these sub-samples is much larger than before—0.31 for the 25 countries and 0.27 for the OECD. However, since the covariance between stock returns and macro contractions is not so high in the newly added group (because these events were selected not to have pairings of stock-market crashes with depressions), the incremental contribution to the computed equity premium is positive but modest in size. For the full group of countries, the equity premium is now 0.046 at $\gamma = 3$, 0.063 at $\gamma = 3.5$, and 0.086 at $\gamma = 4$. For the OECD, the results are 0.050 at $\gamma = 3$, 0.070 at $\gamma = 3.5$, and 0.098 at $\gamma = 4$. Thus, $\gamma = 3.5$ is now more clearly adequate to match the target value of 0.07.

Another 69% of the sample years for the 25 countries (73% for the OECD) are contained neither in a stock-market crash nor a depression. We have not studied in detail the contribution of this part of the sample to the computed equity premium. However, we can get an idea of the effect by calculating the covariance between the one-year stock returns and the asset-pricing factors, $(C_{t+1}/C_t)^{-\gamma}$. That is, we use our initial approach for computing the covariance but look here only at the years not contained within a stock-market crash or a depression. The result when $\gamma = 3.5$ is that the covariance is -0.005 for this sample when applied to 25 countries and -0.003 for the 18 OECD countries. Weighting by the fraction of the overall years in the sample (0.69 for the overall group and 0.73 for the OECD) implies that the incremental contribution to the equity premium is 0.003 for the overall group and 0.002 for the OECD. Thus, by these calculations, the inclusion of the rest of the sample years in the analysis has a slightly positive impact on the equity premia reported in Table 4.

The bottom line is that a "flexible covariance analysis" applied to the asset-pricing formula in equation (6) generates a reasonable levered equity premium if the coefficient of relative risk aversion, γ, is around 3.5. The main element in this computation is the flexible interpretation of the timing between stock-market crashes and depressions during the small number of paired, multi-year events (58 in our sample).

This conclusion accords with the one reached by Barro and Ursua (2008, Tables 9 and 10), who followed Mehra and Prescott (1985) by considering only the sizes of macroeconomic contractions and not the covariance with stock returns. This previous analysis looked at multi-year depressions but did not require measurement of the timing between depressions and stock-market crashes. In other words, the assumption that prices of unlevered equity claims move in the same proportion as consumption (aside from temporary orthogonal noise) substitutes for the complexities associated with matching the timing of stock returns and consumption changes.

A key point is that the covariance calculation that "works" for the equity premium relies almost entirely on the roughly 11% of the time-series observations that apply to matched stock-market crashes and depressions (Table 2, panel A). The inclusion of the additional 20% of the observations that feature unmatched stock-market crashes and depressions has a minor effect (Table 4), and the consideration of the remaining 69% of the data from "normal times" has essentially a zero effect. We think that further refinement of the results should focus even more on the 11% of the data that matters for the equity premium. In particular, we need to consider further how to carry out a covariance analysis that allows for flexible timing between stock returns and consumption changes. An important part of this analysis is to deal more satisfactorily with periods of missing annual data and with the price controls that characterize many of the wartime observations.

IV. Conclusions and Future Research

The long-term history for 25 countries indicates that stock-market crashes (cumulative real returns of -0.25 or worse) have substantial predictive power for depressions (cumulative macroeconomic declines by 10% or more). For example, in a non-war environment, the realization of a stock-market crash implies that the probability of a minor depression (fall in real per capita consumer expenditure and GDP by 10% or more) is 20%, and the probability of a major depression (decline by 25% or more) is 3%. Given the stock-market crashes for the United States and other countries in 2008, these probabilities apply to 2008-09 and subsequent years. In future research, we will consider whether the predictive content of stock-market crashes for depressions can be improved by bringing in additional variables, such as the state of the housing market.

The long-term data also show that the majority (64%) of minor, non-war depressions are accompanied by stock-market crashes, whereas most major, non-war depressions (83%) are accompanied by these crashes. Therefore, in the absence of a stock-market crash, the occurrence of a depression is highly unlikely.

The full history of 2652 annual observations reveals 58 matched cases of stock-market crashes and depressions, of which 45% are associated with war. The years contained in the 58 cases constitute 11% of the overall sample (because the average duration of a crisis was 5.2 years). The co-movement between stock returns and macroeconomic changes for the 58 cases may be sufficient to explain the observed equity premium of 7%, assuming that the coefficient of relative risk aversion is around 4. The required coefficient falls to about 3.5 if we bring in the additional 20% of the sample that features a stock-market crash or depression but not both. A crucial aspect of this analysis is that the computed covariances use a flexible timing pattern between stock returns and macroeconomic changes. In future research, we plan to consider this flexible covariance analysis in more detail. Part of this research involves the roles of missing data and wartime price controls, which can distort the covariances calculated from a rigid timing structure.

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Table 1 U.S. Stock-Market Crashes since 1869							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stock period	**Stock return (-)**	**C period**	**C contraction**	**GDP period**	**GDP contraction**	**Macro period**	**Macro contraction**
1907-07	0.32	1906-08	0.04	1906-08	0.10	1906-08	0.07
1916-20	0.47	1917-21	0.16	1918-21	0.12	1917-21	0.16
1929-31	0.55	1929-33	0.21	1929-33	0.29	1929-33	0.25
1937-37	0.37	1937-38	0.02	1937-38	0.04	1937-38	0.03
1939-41	0.29	1941-42	0.03	1939-40	-0.08	1941-42	0.03
1973-74	0.49	1973-74	0.02	1973-75	0.03	1973-75	0.02
2000-02	0.42	2000-01	-0.01	2000-01	0.00	2000-01	-0.01
2008-08	0.37	?	?	?	?	?	?

Notes: Underlying stock returns are real rates of return (arithmetic) from end of previous year to end of current year. Stock return in column 2 is cumulated real return (all negative) over period shown in column 1. For example, 1929-31 refers to the cumulated return from the end of 1928 to the end of 1931. The cases selected are those with returns ≤ -0.250. C in columns 3 and 4 is real per capita consumer expenditure. Contraction in column 4 is cumulated fractional decline over period shown in column 3. For example, 1929-33 refers to the ratio of consumer expenditure in 1933 (annual average) to that in 1929 (annual average). GDP is real per capita GDP. Contraction in column 6 is cumulated fractional decline over period shown in column 5. Macro contraction in column 8 is the average for C and GDP for non-war cases and C value for wars and war aftermaths. The macro period in column 7 is the overlap for C and GDP when the macro contraction is the average for C and GDP. When only C is used, the macro period corresponds to that for C. For the United States, there are no other macroeconomic contractions of size 0.10 or more. (1913-14 has a GDP contraction of 0.10 but a C contraction of only 0.05—the stock return for 1913-14 is -0.16.)

Table 2 Depressions with and without Stock-Market Crashes (25 countries with long-term data on stock returns and macro aggregates)				
Panel A: Stock-Market Crashes and Depressions (58)				
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Country	**Stock-Market Period**	**Stock Return (negative)**	**Macro Period**	**Macro Contraction**
Australia	1929-30	0.25	1926-32	0.23
Belgium	1914-18*	0.76	**1913-18**	0.46
	1929-31	0.48	1930-34	0.10
	1937-39	0.26	**1937-42**	0.53
	1942-48*	0.74	**1942-46**	0.13
Canada	1916-20	0.27	1918-21	0.20
	1929-32	0.54	1928-33	0.29
Denmark	1917-17	0.27	**1914-18**	0.12
	1919-22	0.60	1919-21	0.24
	1937-40	0.27	**1939-41**	0.26
Finland	1989-91	0.47	1989-93	0.13
France	1913-20	0.62	**1912-18**	0.25
	1929-31	0.46	1929-35	0.12
	1943-45	0.69	**1938-43**	0.58
Germany	1914-20	0.91	**1912-18**	0.42
	1922-22	0.63	1922-23	0.13
	1929-31	0.52	1928-32	0.20
	1944-48	0.91	**1939-45**	0.41
Italy	1944-45	0.89	**1939-45**	0.35
Japan	1897-98	0.54	**1899-06**	0.12
	1943-47	0.97	**1937-45**	0.64
Netherlands	1918-22	0.47	**1912-18**	0.44
	1944-46*	0.42	**1939-44**	0.54
Norway	1917-18	0.36	**1916-18**	0.17
	1919-21	0.55	1919-21	0.16
Portugal	1974-78*	0.97	**1974-76**	0.10
Spain	1929-31	0.53	1929-33	0.10
	1935-40*	0.43	**1935-37**	0.46
	1935-40*	0.43	1940-45	0.14
Sweden	1917-18	0.60	1913-18	0.13
	1919-20	0.30	1920-21	0.13
	1939-40	0.26	1939-45	0.14
Switzerland	1914-20*	0.68	1912-18	0.15
	1939-40	0.28	1939-45	0.15
United Kingdom	1912-20	0.60	**1915-18**	0.17
	1937-40	0.41	**1938-43**	0.17

(1)	(2)	(3)	(4)	(5)
United States	1916-20	0.47	1917-21	0.16
	1929-31	0.55	1929-33	0.25
Chile	1929-31	0.40	1929-32	0.37
	1972-72	0.27	**1972-76**	0.40
	1981-84	0.56	1981-85	0.25
Colombia	1931-31	0.28	1929-32	0.11
India	1940-42	0.30	**1937-42**	0.13
	1940-42	0.30	**1943-46**	0.13
	1946-49	0.49	**1947-50**	0.18
Mexico	1909-18*	0.79	**1909-16**	0.25
	1924-31	0.55	**1926-32**	0.31
	1980-82	0.81	1981-88	0.14
	1994-96	0.38	1994-95	0.10
Peru	1967-76	0.66	1975-79	0.14
	1981-82	0.86	1981-83	0.11
	1987-88	0.76	**1987-92**	0.31
Venezuela	1946-47	0.28	1948-52	0.14
	1958-61	0.34	1957-64	0.19
	1977-81	0.65	1977-86	0.28
	1988-89	0.70	1988-89	0.10
	1992-95	0.55	1992-99	0.11
	1997-2001	0.60	2001-03	0.16

Panel B: Depressions without Stock-Market Crashes (26)				
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Country	**Stock-Market Period**	**Stock Return (negative)**	**Macro Period**	**Macro Contraction**
Australia	1889-89	0.02	1889-95	0.27
	1915-15	0.16	**1913-18**	0.24
	1940-41	0.09	**1938-44**	0.30
Canada	1907-07	0.09	1906-08	0.10
	1913-14	0.18	**1912-15**	0.13
Denmark	1947-48	0.07	1946-48	0.14
Finland	1928-29	0.12	1928-32	0.13
	1939-39	0.05	**1938-42**	0.24
France	1871-71	0.12	**1864-71**	0.16
	1882-85	0.13	1882-86	0.11
New Zealand	1930-31	0.13	1929-32	0.18
	1940-40	0.01	**1939-44**	0.22
Norway	1939-40	0.05	**1939-44**	0.15

(1)	(2)	(3)	(4)	(5)
Portugal	1936-36	-0.03	1934-36	0.13
	1937-40	0.22	1939-42	0.10
Spain	1896-96	0.07	1892-96	0.15
Chile	1913-15	0.08	1911-15	0.21
	1920-20	0.05	1918-22	0.15
Colombia	1940-41	0.03	1939-43	0.14
Mexico	1920-20	0.12	1921-24	0.12
Peru	1930-32	0.18	1929-32	0.20
South Africa	1914-15	0.08	**1912-17**	0.23
	1931-32	0.15	1928-32	0.12
	1981-81	0.12	1981-87	0.10
Venezuela	1932-32**	0.04	1930-33	0.24
	1942-42	0.03	1939-42	0.11

*These periods include interpolated stock returns.

**Data missing before 1930.

Notes: See notes to Table 1 on measures of stock returns and macroeconomic contractions. Panel A shows the 58 paired cases with stock-market crashes (cumulative returns of -0.250 or less) and depressions (macroeconomic contractions of 0.10 or more). Panel B shows the 26 cases of macro contractions not accompanied by stock-market crashes. Not shown are 137 cases with stock-market crashes unaccompanied by depressions. Bold for macro period indicates wartime interval (limited to active combatants).

For cases of missing data on consumer expenditure, C, macro contractions were based on GDP except for war aftermaths (which were left as missing data) and during wars when the indicated GDP fall was less than 0.10 (also left as missing data). For wartime contractions, when C and GDP data were available, the macro contraction was based on C when this decline was greater than that in GDP. When the GDP decline was larger, the macro contraction was computed as the average of the C and GDP contractions. Annual data on stock returns were missing (typically because of closed markets) for Belgium 1914-18 and 1944-46, Mexico 1915-18, Netherlands 1944-46, Spain 1936-40, Portugal 1974-77, and Switzerland 1914-16. The stock returns that include these periods were based on cumulative, multi-year returns over periods that bridged the gaps in the annual data.

Table 3 Frequencies of Stock-Market Crashes and Depressions Part A: Non-War and War Observations Combined				
		Numbers of events		
Stock return ≤	**Macro Contraction ≥**	**Stock-Market Crashes**	**Depressions**	**Both**
All countries (25)				
-0.25	0.10	195	84	58 (.30, .69)
-0.25	0.15	195	49	35 (.18, .71)
-0.25	0.20	195	34	25 (.13, .74)
-0.25	0.25	195	23	21 (.11, .91)
-0.25	0.30	195	15	14 (.07, .93)
-0.30	0.10	159	84	48 (.30, .57)
-0.30	0.15	159	49	29 (.18, .59)
-0.30	0.20	159	34	20 (.13, .59)
-0.30	0.25	159	23	18 (.11, .78)
-0.30	0.30	159	15	12 (.08, .80)
OECD countries (18)				
-0.25	0.10	137	54	38 (.28, .70)
-0.25	0.15	137	34	25 (.18, .74)
-0.25	0.20	137	23	18 (.13, .78)
-0.25	0.25	137	16	14 (.10, .88)
-0.25	0.30	137	11	10 (.07, .91)
-0.30	0.10	111	54	31 (.28, .57)
-0.30	0.15	111	34	20 (.18, .59)
-0.30	0.20	111	23	14 (.13, .61)
-0.30	0.25	111	16	12 (.11, .75)
-0.30	0.30	111	11	9 (.08, .82)

Part B: Non-War and War Observations Compared							
		Numbers of Events					
		Non-war only			War only		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Stock ≤	Macro ≥	Stock	Depression	Both	Stock	Depression	Both
All countries (25)							
-0.25	0.10	158	50	32 (.20, .64)	37	34	26 (.70, .76)
-0.25	0.15	158	22	15 (.09, .68)	37	27	20 (.54, .74)
-0.25	0.20	158	13	9 (.06, .69)	37	21	16 (.43, .76)
-0.25	0.25	158	6	5 (.03, .83)	37	17	16 (.43, .94)
-0.25	0.30	158	1	1 (.01, 1.00)	37	14	13 (.35, .93)
-0.30	0.10	130	50	26 (.20, .52)	29	34	22 (.76, .65)
-0.30	0.15	130	22	12 (.09, .55)	29	27	17 (.59, .63)
-0.30	0.20	130	13	7 (.05, .54)	29	21	13 (.45, .62)
-0.30	0.25	130	6	5 (.04, .83)	29	17	13 (.45, .76)
-0.30	0.30	130	1	1 (.01, 1.00)	29	14	11 (.38, .79)
OECD countries (18)							
-0.25	0.10	109	28	19 (.17, .68)	28	26	19 (.68, .73)
-0.25	0.15	109	13	10 (.09, .77)	28	21	15 (.54, .71)
-0.25	0.20	109	7	6 (.06, .86)	28	16	12 (.43, .75)
-0.25	0.25	109	3	2 (.02, .67)	28	13	12 (.43, .92)
-0.25	0.30	109	0	0 (.00, --)	28	11	10 (.36, .91)
-0.30	0.10	90	28	15 (.17, .54)	21	26	16 (.76, .62)
-0.30	0.15	90	13	7 (.08, .54)	21	21	13 (.62, .62)
-0.30	0.20	90	7	4 (.04, .57)	21	16	10 (.48, .63)
-0.30	0.25	90	3	2 (.02, .67)	21	13	10 (.48, .77)
-0.30	0.30	90	0	0 (.00, --)	21	11	9 (.43, .82)

Part A combines non-war and war events. Part B considers non-war and war events separately (where "war" indicates that the period of macroeconomic contraction overlaps with active combat status in a major inter-state or intra-state conflict). The numbers of events refer to stock-market returns ≤ the amount shown or macro contractions ≥ the amount shown or both. In the last column of part A and columns 5 and 8 of part B, the fractions in parentheses are, first, the frequency of contractions ≥ the amount shown, given that the stock return is ≤ the amount shown, and, second, the frequency of stock returns ≤ the amount shown, given that the contraction is ≥ the amount shown.

Table 4 Stock-Market Crashes and Depressions, Implications for Equity Premium						
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Sample criterion	N	T	p_T	**Equity premium**		
				γ=3	**γ=3.5**	**γ=4**
All countries (25), stock ≤ -0.25 and contraction ≥ 0.10	58	5.2	0.113	0.039	0.054	0.074
OECD (18), stock ≤ -0.25 and contraction ≥ 0.10	38	5.1	0.097	0.043	0.060	0.085
All countries (25), stock ≤ -0.25 or contraction ≥ 0.10	221	3.7	0.308	0.046	0.063	0.086
OECD (18), stock ≤ -0.25 or contraction ≥ 0.10	153	3.5	0.268	0.050	0.070	0.098

Note: This table considers countries and multi-year time periods for which stock returns are -0.250 or less or macro contractions are 0.10 or more or both. N in column 2 is the number of occurrences of the state described by the sample criterion in column 1. T in column 3 is the average duration in years of these states. p_T in column 4 is the fraction of the total observations (2652 for all countries, 2006 for OECD) represented by this sample. The calibrated (levered) equity premium in columns 5-7 is calculated as discussed in the text. The results are for the coefficient of relative risk aversion, γ, set to 3, 3.5, or 4.