The Evolution of Corporate Cash*

John R. Graham

Fuqua School of Business, Duke University and NBER

Mark T. Leary

Olin School of Business, Washington University and NBER

First Draft: October 13, 2014
Current Version: March 19 2018

Abstract

We study time-series and cross-firm variation in corporate cash holdings over the past century. The recent increase in cash is not unique in magnitude. However, the recent divergence between average and aggregate cash is new and entirely driven by a shift in cash policies of new entrants, while within-firm changes are negative or flat since the 1940s. Cross-sectional relations between cash holdings and firm characteristics are stable from the 1920s to 2010s, though characteristics explain little of the trends in aggregate cash. Macroeconomic conditions, corporate profitability and investment, and (since 2000) repatriation taxes explain aggregate cash over the last century

JEL Codes: G32, E41, H32, N1

Keywords: Cash, Liquidity, IPO, Economic Growth

*We thank Alon Brav, Murillo Campello, Ian Dew-Becker, Amy Dittmar, Ran Duchin, Mike Faulkender, Michelle Hanlon, Andrew Karolyi (editor), Lil Mills, Michael Roberts, Rene Stulz, Shawn Thomas, two anonymous referees, and seminar participants at the AFA annual meeting, Amsterdam, BI Norwegian Business School, Colorado, Delaware, Duke, HBS, LBS, LSE, Maryland, Michigan, Michigan State, Missouri, South Florida, Temple, and Wharton / U. of Pennsylvania Law School for helpful comments. We also thank Song Ma and Steve Sims for excellent research assistance. Graham: (919) 660-7857, john.graham@duke.edu, Leary: (314) 935-6394, leary@wustl.edu

The large increase in corporate cash balances in recent years has garnered much attention in both the academic literature and popular press. Several explanations have been proposed to explain this apparent shift in corporate policies. Bates et al. (2009) suggest the riskiness of corporate cash flows has increased over time; Falato et al. (2013) suggest the nature of firms' assets has changed; Boileau and Moyen (2016) and Azar et al. (2016) argue that the opportunity cost of holding cash has declined; Nikolov and Whited (2014) suggest that agency conflicts stemming from low managerial stock ownership are responsible; Booth and Zhou (2013) and Begenau and Palazzo (2017) argue for a change in the nature of firms going public; and Faulkender, Hankins, and Petersen (2018) suggest that U.S. repatriation tax law led to trapped foreign cash. While these studies provide helpful insights, to fully understand what is different about modern cash policies and what drives time-series changes in corporate cash, one needs to put the recent trends in historical perspective. We gather data back to 1920 to provide this perspective.

There has been substantial variation in cash holdings over the past century. Today's high average cash balances were also experienced in the 1940s. These peaks were sandwiched between decades when mean cash-to-assets was less than half what it is today. In contrast, aggregate cash holdings today are similar to their 1920s levels, though they increased and fell dramatically in the middle of the century. This begs the question of whether these shifts in cash holdings are due to changing cash policies, changing characteristics of firms or sensitivity to these characteristics, or macroeconomic conditions.

To understand these changing patterns in cash holdings, we perform separate cross-sectional and aggregate time-series analyses, leading to several new insights: First, cross-sectional patterns in cash holdings have been stable over the past 90 years: holding sample composition constant, the types of firms that have high (low) cash holdings in recent years have had high (low) cash in nearly every decade over the last century. Second, even with stable cross-sectional sensitivities, changing sample composition led to changes in the distribution of cash holdings. In particular, small growth (newly

public Nasdaq) firms entered the sample with large cash holdings (relative to assets or sales), increasing equally-weighted average cash starting in 1980.[2] This is in sharp contrast to the distribution of cash policies over much of the century, which was marked by a stable cross-sectional dispersion, similar cash levels between the largest and smallest firms, and parallel changes in average and aggregate cash ratios. Third, these recent changes in characteristics of publicly traded firms are *not* the primary force behind changes in aggregate cash holdings. Contrary to the average, aggregate cash has been relatively stable in recent decades. Changes in aggregate corporate cash over the century are primarily driven by macroeconomic variables, corporate profitability and investment, and since 2000, repatriation taxes.[3]

To explore in more detail these conclusions about why corporate cash holdings have fluctuated, we start by examining cross-sectional determinants of cash holdings over the past century. The development of financial markets over the century has arguably impacted the relative importance of financial frictions relevant for cash policies, such as transaction costs and informational frictions.[4] One might expect that this would lead to a shift in the determinants of cash policies over time, which could also drive time-series variation in cash holdings. Perhaps surprisingly, controlling for sample composition (by focusing on NYSE firms), we find that many of the cross-sectional relations that have been identified in modern data are stable over the century. Ours is the first paper to show this over an extended horizon.

When we allow changes in sample composition, however, we find notable changes in both cash sensitivities and firm characteristics since 1980. Recent research has documented high cash balances post-1980 among firms with low profits, sales, current assets, and debt access. We show that the

[2] Doidge, Karolyi, and Stulz (2013) show that US IPOs waned starting around 2000, which coincides with the plateau and small reduction in average cash that we document below.
[3] Regarding repatriation, see also Foley et al. (2007) and Faulkender et al. (2018)
[4] Baumol (1952) and Miller and Orr (1966) explore the impact of transaction costs on cash policy; Kim et al. (1998) and Bolton et al. (2011) study optimal cash policy in the presence of costly external finance.

increase in average cash ratios between 1980 and 2000 is entirely driven by these new entrants. Within-firm changes in cash are flat to negative over this period. This again contrasts with the previous 50 years, in which large shifts in aggregate and average cash were associated with within-firm variation. Thus, while many of the factors that determined cash policies in the 1920s are still relevant today, changes in the composition of publicly traded firms, as well as sensitivities to factors that affect cash holdings, have dramatically affected the cross-sectional distribution of cash holdings in recent decades. This supports the views that the nature of a firm's assets is an important driver of cash policies (e.g., Falato et al., 2013), and different types of firms have gone public in recent decades.[5]

We next examine time-series patterns in economy-wide cash holdings. Much of the recent concern over high cash balances focuses on the amount of capital sitting "idle" on corporate balance sheets. To the extent that corporate cash management decisions impact money demand and economic growth, it is important to understand the drivers of aggregate cash holdings by the corporate sector. This requires many years of data in order to provide enough power to reliably estimate time-series relations. To our knowledge, ours is the first study to examine this issue over a nearly 90-year horizon.

We first explore whether cross-sectional firm characteristic patterns aggregate up to explain time-series patterns in economy-wide cash holdings – and find for the most part that they do not. While differences in cash holdings across firm types within a given cross-section are fairly stable, the entire distribution shifts over time in a way that is largely unrelated to aggregate characteristics. As a result, firm characteristics do not explain much of the time-series.

If not firm characteristics, what drives the observed shifts in aggregate corporate cash? Macroeconomic conditions may influence aggregate cash holdings by affecting the opportunity cost of

[5] See Booth and Zhou (2013), Begenau and Palazzo (2017), Denis and McKeon)2017). Doidge, Karolyi, and Stulz (2013) and Gao, Ritter, and Zhu (2013) document changes in the number and type of firms going public in recent years.

holding cash (e.g. through interest rates and inflation) or by influencing investment opportunities and uncertainty in ways not captured by firm characteristics. We find that cost of carry is negatively related to aggregate cash, but over the full sample horizon this relation is statistically weak and explains very little of the time series variation. Instead, we find evidence that firms hold more cash when aggregate investment opportunities (as proxied by productivity and GDP growth) are greater. Adding these macro variables to the model helps explain aggregate cash movements, but still leaves much of the time-series variation unexplained.

The factors that provide the most explanatory power for time-series changes in aggregate corporate cash are simply contemporaneous cash flows and investment expenditures. Combined with productivity, these variables explain nearly half of the variation in aggregate cash. Thus, while we find some evidence that firms have cash level targets, much of the year-to-year fluctuations in cash holdings stem from accumulation of profits, and the use of those profits to fund investment. These results are consistent with firms adhering loosely to cash targets, perhaps allowing cash to vary within upper and lower boundaries due to adjustment costs (Miller and Orr, 1966; Bolton, Chen and Wang, 2011).

Finally, we explore in depth the increase in aggregate cash that started in 2000, which we (and Faulkender et al., 2018) show is mostly due to foreign cash holdings. We use public data to document a strong correlation between cash holdings and the tax incentive to keep cash in overseas subsidiaries that Foley et al. (2007) and Faulkender et al. (2018) find in BEA data. In addition, we are the first to perform aggregate regressions that directly connect increased post-2000 aggregate cash holdings to repatriation taxes. Moreover, by examining this issue in a historic context that contains flat aggregate cash from 1970 to 2000, we note that repatriation taxes are unlikely to explain aggregate trends before 2000 (or after 2017, given the recent elimination of repatriation taxes), and therefore it is valuable to know which non-tax factors help explain aggregate cash. For example, we contrast the post-2000 increase with the

even larger rise in aggregate cash in the 1930s and 1940s. Our evidence suggests the run-up in cash over this time was associated with increased precautionary savings by firms that faced high costs of external funds (i.e., paid high undistributed profits taxes on retained profits). Over the century, macro factors, contemporaneous cash flow and investment, and firm characteristics together explain a great deal of time-series variation of the broad trends in aggregate corporate cash.

While a large literature studies the determinants of cash holdings, we are the first to comprehensively study how cash policies have evolved, both in the cross-section and in aggregate, over nearly a century. For example, Bates et al. (2009) argue that cross-sectional coefficients did not change much between the 1980s and 1990s. We show that this is not just a recent phenomenon, but extends back many decades despite substantial changes in financial markets over time. While Bates et al. attribute the recent cash run-up to changing firm characteristics, we show that this is not due to within firms changes in cash and characteristics but rather is driven purely by changing sample composition. We show that within-firm changes in cash have been negative since World War II.

Booth and Zhou (2013) and contemporaneous work by Begenau and Palazzo (2017) argue that the modern run-up in cash is related to the type of firms going public. We broaden our understanding of this finding in several ways. First, we use our expanded cross-section to show that this is only a recent phenomenon. For at least 60 years prior to 1980, non-NYSE and NYSE firms had similar cash ratios, as did new entrants and existing firms, and small and large firms. Thus, it is not the addition of more small firms or new entrants per se, but rather the changing nature of these new entrants that has impacted the distribution of cash ratios. Second, we show that a shift in the relative sensitivities to firm characteristics accompanies the increase in cash levels. Thus, the higher cash holdings among IPO firms post-1980 reflects not only a difference in firm characteristics, but also differences in how these firms manage their cash policies.

Opler et al. (1999) and Azar et al. (2016) also document decreasing cash ratios since 1950. We confirm this after correcting for the back-fill bias in Compustat and also show that this was a reversal of an equally large increase in cash holdings from 1920 through World War II. Azar et al. (2016), Curtis et al. (2017), and Boileau and Moyen (2016) argue that the time-series of corporate cash is related to the cost of carry. Using a longer time series, and both first difference and level specifications, we show that cost of carry has little explanatory power for aggregate cash over the whole century.

The longer perspective we take has several other advantages. First, we are able to describe how cash policies of today are similar to, and depart from, those in the past. This provides a deeper understanding of the nature of the modern cash "puzzle." Second, having nearly a century of data uniquely positions us to study the determinants of changes in aggregate corporate cash holdings through time. We document an important contrast: firm characteristics are stable with respect to cross-sectional differences in cash holdings, but have little explanatory power for aggregate cash. Macroeconomic conditions and contemporaneous cash flow and investment capture much of the century-long time-series variation, while repatriation tax incentives help explain recent aggregate trends. These findings highlight the importance of business cycle fluctuations on money supply and corporate asset allocation. Finally, we provide a rich set of empirical facts to guide development of cash theories. For example, our evidence suggests the frictions relevant for determining cash targets, at least among NYSE firms, are similar throughout the century. At the same time, our evidence suggests firms are unconcerned about modest deviations from cash targets. Dynamic cash theories should allow for this passive short-run behavior. Lastly, explanations for the increase in average cash in recent decades should be consistent with declining within-firm cash balances and increasing cash ratios among new, primarily Nasdaq-like firms in the tech and health sectors.

1. Sample selection and summary statistics

To form our sample, we begin with all firms in the Center for Research in Security Prices (CRSP) monthly stock files. This includes New York Stock Exchange (NYSE) firms since December 1925, firms listed on the American Stock Exchange (Amex) since 1962, and firms listed on Nasdaq since 1972. For these firms, stock market data are from CRSP. Accounting data are obtained from two sources: Standard and Poor's (S&P) Compustat, and, for CRSP firms not on Compustat, data hand-collected from Moody's Industrial Manuals.[6] The end result is an unbalanced firm-year panel beginning in 1920 and ending in 2014.[7] In a few cases, we replace missing Compustat data with Moody's data. In the analyses below, we refer to this sample as the "CRSP sample."

Because of differing institutional environments, we exclude regulated (utilities, railroads, and telecommunications) and financial firms and focus on unregulated industrial firms (all other industries). These exclusions allow us to avoid the effects of industry-specific regulatory environments affecting our analyses, and of course align us with the vast majority of empirical corporate finance research.

Once per decade (in years ending in "8"), we also gather company-specific stock market and financial statement data for every public, unregulated nonfinancial firm covered in the Moody's Industrial Manual. This "extended sample" includes data from regional exchanges, which to some extent played the role of Amex and Nasdaq in the early part of the 20th century. These data allow us to examine very small firms throughout the century and, as shown in Appendix C, allow for relatively homogenous across-decade comparisons with respect to firm size. In addition, we gather data from

[6] All firm-specific data before 1950 are from Moody's. In the 1950s, Compustat suffers from a back-fill problem (Opler et al., 1999), namely that Compustat initially started with a list of public companies that existed in the early 1960s, and data from the 1950s were back-filled for these firms. We address this issue by collecting Moody's data for CRSP firms that existed in the 1950s that are excluded by Compustat. Our data entry process also adds data to supplement the Compustat sample in the 1960s and later, though the number of added observations gradually declines.

[7] For all firms in CRSP as of December 1925, we gather data for 1920-1924 and include these years in some of the graphs that follow. However, due to lack of market value data and potential back-fill bias, we exclude these observations from our regression analyses.

Statistics of Income (SOI), which reports aggregated domestic tax return data for US-domiciled firms, including private and regulated companies.

Table 1 presents summary statistics for the main CRSP sample (unregulated, non-financial CRSP firms).[8] Panel A presents statistics for the firm-year panel. Panel B presents average firm characteristics by decade for the main (CRSP) sample, and Panel C does the same for the extended sample. In addition to their descriptive value, these results provide context for subsequent analyses.

2. Trends in cash holdings

2.1 Time series trends

Panel A of Figure 1 presents the aggregate (dashed line) and average (solid line) cash-to-assets ratios from 1920 to 2014. The rise in average cash that started around 1980 and has garnered much recent attention is evident in the figure, as are several other important trends. First, the level of average cash holdings were as high in the 1940s as they are in modern times – about 25% of assets (see also Graham, Leary, and Roberts, 2015). Moreover, average cash ratios increased by as much from 1920 to the mid-1940s as they have in recent decades, and fell by a similar magnitude in the two decades after World War II (WWII). In this sense, the recent experience is not unique by historical standards.

Second, the recent growth in aggregate cash is much less pronounced than in the average, and aggregate cash today remains below its mid-century levels. The difference between average and aggregate trends indicates that the recent growth in the average is driven by large cash balances (relative to book assets) in small firms (see also Bates et al., 2009). The increase in average cash holdings peaked in 2000, while larger firms accumulated moderately more cash but not starting until about 2000. In contrast to these differing recent trends, aggregate and average cash holdings were very similar (both in

[8] See Appendix A for variable definitions.

level and trend) prior to 1980. This implies that while the magnitude of the recent change in cash holdings is not unprecedented, the nature of cash trends differ in the first versus the second half of the sample. We explore this implication in detail below.

Azar et al. (2016) point out that a portion of the high cash levels in the 1940s was due to corporate purchases of war bonds during WWII, which may represent a departure from normal cash management policies. However, in Panel B, we report the aggregate cash ratio excluding all short term investments (such as Treasuries), using data from *Statistics of Income*. Even excluding Treasuries, the plot shows a time series pattern very similar to that in Panel A: i) cash holdings increased about two-and-a-half fold from the early 1930s to the mid-1940s, and then gradually declined back to the 1930 level by 1970, and ii) while aggregate cash increased somewhat since 1990, it remains well below mid-century levels. As an alternative approach to control for WWII effects, we use regressions to estimate and remove the effects of war-related Treasury holdings, with the resulting time-series retaining the key patterns shown in Panels A and B.[9] See Appendix B for graphical analysis. Therefore, accounting for holdings of war bonds does not alter the key data patterns, nor our Section 4 conclusions about aggregate cash.

In sum, there appear to be four eras in cash holdings over the past century. Cash-to-assets 1) increased dramatically from the 1920s until the mid-1940s, then 2) gradually declined through 1970. 3) From 1980 to 2000, average cash holdings increased dramatically but aggregate cash was flat. Finally, 4) average cash plateaued starting in about 2000 while aggregate cash increased between 2000 and 2010.

[9] Specifically, we first estimate a time-series regression of the aggregate ratio of corporate Treasury holdings to assets on federal defense spending as a share of GDP, along with a collection of firm characteristics and macroeconomic control variables. We define war-related Treasury holdings as the portion of the fitted value accounted for by defense spending, and subtract this from the aggregate cash and short-term investments from Panel A. While this removes a portion of the peak in the early 1940s, the time series is otherwise similar to that in Panel A. The aggregate cash ratio increases steadily from about 8% of assets in 1920 to over 18% by 1950, before falling to around 6% in the 1970s and 1980s. See Appendix B for details.

2.2 Sample composition and heterogeneity in cash trends

Recent research has shown that much of the cash run-up in recent decades is the result of a change in the composition of publicly traded firms (see, for example, Bates et al. (2009), Begenau and Palazzo (2017) and Denis and McKeon (2017)). In this section, we document that while the time series changes in cash holdings prior to 1980 were of similar magnitude to the modern experience, the nature of these changes was markedly different.

Bates et al. (2009) show that since the 1980s, successive IPO cohorts enter the sample with higher cash ratios, though they conclude that the increase in average cash holdings is not driven fully by the IPO firms. They also show that the increase in cash in recent decades is more pronounced among smaller firms and in industries with more volatile cash flows. Denis and McKeon (2017) show that the increase in average cash ratios is concentrated among unprofitable firms. Begenau and Palazzo (2017) and Falato et al. (2013) argue that it is concentrated among firms that invest heavily in R&D and intangible assets. In this section, we ask whether these composition effects were also behind the earlier large time series changes or are unique to the modern era.

First, in Figure 2, we use two alternative samples to clarify the roles of sample coverage and sample composition in the trends in Figure 1. The sample in Figure 1, Panel A, is taken from the CRSP universe, which includes only NYSE firms prior to 1962 but adds Amex firms in 1962 and Nasdaq firms in 1972. In Panel A of Figure 2, we maintain consistent sample coverage by using our extended once-per-decade sample, which adds to the CRSP sample many small non-NYSE firms. Trends are similar to those in Figure 1, suggesting it is a change in the nature of public firms, not merely an expansion of sample coverage that led to changes in cash policies in recent years.[10] In Panel B we control for sample

[10] Note the extended sample shows a more modest increase in cash in the 1940s because by jumping from 1938 to 1948, the extended sample misses the early-to-mid 1940s.

composition by including only those firms with at least 80 years of data. The average and aggregate cash ratios in this constant-firm sample are very similar to the aggregate ratio from Figure 1. While there is substantial variation in the average cash ratio over the first fifty years of our sample, cash holdings for these long-lived firms have been stable since 1970, again with a slight increase only after 2000. In Appendix D, we present time series plots of cash-to-assets for each of the 66 long-lived firms in Panel B. The implications from Panel B also apply to many of the individual long-lived firms: There is substantial within-firm variation in cash holdings, especially in the first half of the sample. The cash ratios of the majority of the long-lived firms approach historic lows in the late-1990s, and post-2000 increases return cash ratios to near their long-run averages.

Second, we show that the cross-sectional heterogeneity in cash levels and trends found in modern data is largely absent in the first 60 years of our sample. Figure 3 documents how cross-sectional variation in cash holdings has evolved through time. Panel A plots the cross-sectional standard deviation of the cash/assets ratio by year. We use the extended sample for this analysis, in order to maintain consistent breadth of coverage through the century. The standard deviation was fairly stable at about 10% for the first sixty years of the sample, but more than doubled between 1980 and 2000. This is also reflected in Panel B, which plots the quartile breakpoints of the distribution of cash ratios each year. While the increase in average cash ratios since 1980 is associated with a dramatic widening of the distribution of cash holdings, the time-series changes prior to that time represent "parallel" shifts in the entire distribution. Panel C plots the full distribution of cash ratios once each decade and shows that while average cash ratios mid-century were at similar levels to today, the frequency of very high cash ratios (in excess of 80 percent of book assets) was much smaller.

Third, we examine how cash ratios have evolved across different types of firms. In panel A of Figure 4, we sort extended sample firms by size once each decade and report the average cash ratio in each size

quintile.[11] The last few decades in the plot show evidence consistent with Bates et al. (2009), in that we see a much larger increase in the average cash ratio among small firms than for large firms. However, the contrast with earlier periods is striking. While cash ratios today are on average three times as large among the smallest firms relative to the largest, prior to 1980 differences in average cash across size quintiles was very small. Further, consistent with panel B of Figure 3, time-series trends in cash holdings were very similar between the smallest and largest firms in first two-thirds of our sample.

A similar contrast is evident in panel B of Figure 4, which shows the average cash ratio over time by exchange. While the recent cash run-up has been driven by non-NYSE (primarily Nasdaq) firms, prior to 1980 average cash for NYSE and non-NYSE firms moved largely together. Prior to 1960, average cash ratios were actually lower among non-NYSE firms relative to NYSE firms.

Panel C sorts firms by both exchange and industry sector, grouping tech and health care versus all other sectors, as defined by the Fama-French 12-industry categorization.[12] While Bates et al. (2009) argue that the modern cash run-up cannot be attributed solely to technology firms, our evidence shows that the increase in average cash since 1980 is concentrated among Nasdaq firms in the health and technology sectors. Non-NYSE firms in sectors other than health and tech show a moderate increase after 1980 but it is concentrated after 2000.[13] Non-health/tech NYSE average cash holdings do not increase until after 2000, and then relatively modestly. Looking back in time, however, we again see a very different picture. Cash ratios were very similar between health/tech and other sectors from 1940 to 1980, though health/tech cash was also higher in the 1920s and 1930s.

[11] Appendix C shows that in the extended sample the average size of firms in the low end of the size distribution is fairly stable (in real dollar terms) over the century, and hence across-decade extended sample comparisons roughly hold size constant.
[12] Due to missing industry classification for many of our extended sample firms, panel C presents the CRSP sample.
[13] Pinkowitz, Stulz, and Williamson (2016) note that R&D-intensive U.S. firms hold more cash than similar foreign firms during 1998 to 2011, while U.S. firms that are not R&D intensive hold about the same amount of cash as foreign twins.

Finally, panel D compares cash ratios of existing firms to new entrants. The solid line displays the average cash/assets ratio in each year *t* for all firms in the database (same solid line as in Figure 1). The long-dash line plots the average cash ratio for firms that entered the sample prior to 1980, while the short-dashed and dotted lines show the average cash/assets of NYSE and Nasdaq firms new to the sample in each year *t*.[14] Consistent with Bates et al. (2009),[15] after 1980 new entrants come into the sample with increasingly higher cash ratios than incumbent firms, though this is only true of new Nasdaq firms. Interestingly, though, this is a relatively new phenomenon. For the first six decades of our sample, the average cash ratio of new entrants was very similar to that of existing firms.

In Table 2, we explore more formally the role of new firms relative to within-firm changes, in driving time-series trends in cash holdings. In the first four columns, we estimate panel regressions of cash-to-assets on a time trend, separately over each of four eras discussed above: 1920 – 1945, 1946 – 1980, 1981 – 2000, and 2001 – 2014. Consistent with Figure 1, the coefficients indicate a significantly positive trend over the first and third eras and a negative trend in the second period. Interestingly, despite the focus on increasing cash balances in recent years, the average 2000-2014 time trend in cash is negative, though not significantly so. In columns (5) through (8) we add firm fixed effects, so the time-trend variables measure the average within-firm changes in cash over each period. For the first two periods, the within-firm trends are very similar in both sign and magnitude to those in columns (1) and (2). In contrast, columns (7) and (8) show that during 1981 – 2000 and 2001 – 2014, the average within-firm change in cash is significantly negative, suggesting that the increase in the level of average cash from 1980-2000 is due entirely to firms *entering* the sample with higher cash to asset ratios.

[14] We define new entrants based on the first year they appear in the CRSP universe, which allows a consistent definition throughout our sample period. While this definition is likely to be somewhat broader than the set of IPO firms, we find very similar results for IPO firms in unreported analysis in which we link IPO dates from SDC's New Issues database to our sample from 1970 on.

[15] McLean (2011), Bouwman and Lowry (2012), Booth and Zhou (2013) and Begenau and Palazzo (2017) also study IPO effects.

In columns (9) and (10), we follow Bates et al. (2009) and remove the first 4 years of data for each firm. The coefficient in column (9) is still negative, though smaller in magnitude (relative to column (7)) and the coefficient for the post-2000 period turns slightly, though insignificantly, positive. These results indicate that much of the within-firm decline in cash balances since 1980 occurs among new firms during their first 4 years as public entities.[16] Still, even after removing the first 4 cash-burn years, within-firm cash is negative or at most indistinguishable from zero.

The overall message from Table 2 and Figure 4 (Panel B) is that while other research suggests that changing sample composition accounts for a substantial part of the recent increase in cash, our results show that new entrants account for *all* of the apparent increase. The average firm has not been increasing its cash holdings.[17] Therefore, explanations for changes in cash policies in recent decades should be consistent with negative (or at best, flat) within-firm average cash holdings since 1945. By contrast, we document very different cash patterns earlier in the century, including that the large pre-1980 changes represent within-firm changes in cash holdings.

2.3 Alternate scalers

In Figure 5, we explore trends in cash relative to other scalers besides book assets. The motivation is twofold. First, early theories (Baumol, 1952; Miller and Orr, 1966) envision cash holdings as a buffer to absorb fluctuations in expenditures and receipts. As a result, the amount of cash needed is tied to a firm's transaction volume. In Panel A of Figure 5, we use sales revenue as a proxy for transaction volume and examine the trends in average and aggregate cash / sales ratios. Several features of the plot are instructive. One, while cash/sales is volatile from 1920 – 1950, there is no overall trend. This implies that the increase in cash/assets in the 1930s and 1940s was associated with an increase in

[16] In light of this difference and to be consistent with prior research, in our subsequent regression analyses, we remove the first four years of data for each firm.
[17] Among NYSE firms, untabulated analysis shows a modest increase in cash after 2000, both on average and within firm.

asset productivity (sales/assets). (Later, in our time-series analysis of aggregate cash, in the first half of the sample we link increased cash holdings to macroeconomic productivity and GDP growth.) Two, there was a long, downward trend in cash/sales from about 1950 to 1980, consistent with improvements in the efficiency of cash management over this time period. Three, average cash/sales spikes sharply after 1980, indicating high cash balances among firms with low sales, suggesting other motives for holding cash beyond supporting corporate transactions. This is consistent with recent evidence in Denis and McKeon (2017) that the recent cash increase is concentrated in operating loss firms.

Second, the evidence in the previous section suggests that the broadening of the distribution of cash holdings after 1980 relates to a break in the nature of firms going public (e.g., Fama and French (2001), Begenau and Palazzo (2017)). One implication is that as the nature of corporate assets shifts, accounting (book) assets may not provide the most appropriate scaling to measure cash policies. Therefore, in panel B of Figure 5 we examine the evolution of the ratio of cash to the market value of assets, defined as equity market capitalization plus total book liabilities. Not surprisingly, cash-to-value spikes during the early 1930s, due to the Great Depression market crash. With the exception of that brief period, from 1926 through 1980 cash-to-value behaves very similarly to cash-to-assets. In contrast, after 1980, average cash scaled by market value is fairly stable except for two abrupt market downturns (following the "dot-com bubble bursting" in the early 2000s and the 2008-9 financial crisis) and a modest rise in the last 15 years. Aggregate cash-to-market peaks at 21% in 1944, while over the last 50 years it remains within a fairly narrow range of about 4% to 8%. Thus, relative to the *value* of assets, firms may not be holding substantially more cash now than they did 30 (or even 90) years ago.[18] Rather, financial statement book assets may simply understate the value of these assets. Alternatively, the shift

[18] While scaling by market value may for some firms provide a useful measure of cash holdings relative to the size of the firm, in the analysis that follows we follow the literature and scale by book assets. In unreported analysis we repeat our main tests scaling by market values and find that doing so does not change the economic conclusions we draw.

toward intangible assets reflected in rising market values relative to book values may increase firms' optimal cash holdings, as suggested by Falato et al. (2013). Overall, while the characterization of recent cash trends is quite sensitive to the choice of scalar, trends prior to 1980 are robust to this choice.

Summary of cash trends: Our descriptive evidence on cash holdings through the century can be summarized as follows. We explore these trends further in the sections below:

1. Average cash holdings have increased recently, but we have seen equally large shifts in average cash historically, such as the run up in 1930s-40s and decline in 1950s-60s.
2. Aggregate cash has also increased recently – but much less than the average and only since 2000. Aggregate cash is about where it was in the 1920s and is lower today than in the 1940s.
3. The cross-sectional dispersion in cash ratios was remarkably stable over the first 60 years of our sample period, but has widened dramatically since 1980.
4. In the first half of the century, levels and time trends in cash holdings were similar across firms of different sizes, industries and exchanges. Since 1980, though, there have been very different trends among small Nasdaq firms versus large NYSE firms. The increase in average cash is a sample composition effect, not a within-firm increase in cash among small firms.

What factors underlie these changes in corporate cash holdings through time? Can the same forces that have been associated with recent changes in cash holdings also account for the large increase and then decrease in cash holdings in the first half of the century? Or has there been a shift in the nature of cash policies? Do the same forces drive both average and aggregate cash holdings? To what extent are long-term trends in cash related to firm characteristics or economy-wide factors? We attempt to answer these and related questions below.

3. Cross-sectional variation in cash holdings

To understand whether the trends documented in the previous section represent a change in firms' cash policies, we begin by exploring the evolution of the relation between cash ratios and firm characteristics over the century. We first review the literature that relates firm characteristics to cash holdings. Then, we investigate which of these relations are unique to the modern era and which stand the test of time.

3.1 Review of Literature Related to our Cross-Sectional Analysis

If capital markets were perfect, cash policy would be irrelevant for firm value. Investing excess cash in liquid assets would earn zero NPV and firms could costlessly meet any cash shortfalls by raising external finance, converting illiquid financial or real assets into cash, or reducing payout. In the presence of market frictions, though, these activities are not costless. Therefore, a firm will manage cash so that the marginal benefit of holding the last dollar of cash just equals the marginal cost.

The benefits of holding cash typically result from financing frictions. Under a transactions motive (Keynes, 1936; Miller and Orr, 1966), firms hold sufficiently high cash balances to avoid the costs of selling non-cash assets if faced with an unexpected mismatch between cash inflows and outflows. This view predicts that there are economies of scale in cash management, such that larger firms will have lower cash targets. Under a precautionary motive (Opler et al. 1999), a benefit of cash is avoiding external finance costs when investment opportunities may unexpectedly exceed internal resources. Under this view, cash holdings should be optimally higher for firms with more valuable investment opportunities, lower expected cash flows, and greater uncertainty, as well as for more financially constrained firms.

Theories point to three main costs of holding cash and liquid assets. First, lower returns are earned on liquid assets (relative to more productive but less liquid assets) because of the ease with which

liquid assets can be converted into cash.[19] Second, there may be a tax cost to holding cash, as interest earned on liquid assets is taxed at both the corporate level (Riddick and Whited, 2009) and potentially again at the personal level. Third, there may be an agency cost of managerial discretion (Jensen, 1986). If managerial incentives are not aligned with those of shareholders, managers may use excess cash to increase their private benefits at the expense of shareholder wealth. These costs lead to predictions that cash holdings are optimally lower when the liquidity premium increases, for firms facing higher corporate tax rates (relative to their investors' tax rates), and for firms with weaker governance, respectively.

Prior literature has found some degree of support for many of these theoretical predictions. While earlier studies find mixed support for the expected negative relation between firm size and cash ratios, Opler et al. (1999) and Bates et al. (2009) confirm this relation in modern data. Several studies find a positive relation between cash holdings and proxies for investment opportunities and/or external finance costs.[20] On the cost side, Kim et al. (1998), Boileau and Moyen (2016) and Azar, Kagy, and Schmalz (2016) provide evidence that cash holdings are negatively related to measures of the liquidity premium and the cost of carry. Several studies provide evidence consistent with the agency costs of cash holdings. Harford (1999) and Harford, Mansi and Maxwell (2008) show that firms with more anti-takeover provisions hold less cash and make value-destroying acquisitions. Dittmar, Mahrt-Smith, and Servaes (2003) find that corporate cash holdings are greater in countries with weaker investor protections. Gao, Harford, and Li (2013) provide evidence that private firms (which are thought to be subject to fewer agency costs) hold half as much cash as public firms, and that poorly governed public firms quickly spend excess cash on excess investment. Nikolov and Whited (2014) argue that cash

[19] At the extreme, (as emphasized by Azar et al., 2016) firms forgo any return if they hold some portion of their cash in non-interest bearing checking accounts.

[20] See for example Kim, Mauer and Sherman, 1998; Opler et al., 1999; Bates et al., 2009; Riddick and Whited, 2009; Falato, Kadyrzhanova, and Sim, 2013; and Begenau and Palazzo, 2017.

holdings can be explained by agency costs such as managers' private benefits from excess perquisite consumption and attribute the recent increase in cash to insufficient managerial shareholdings.

3.2 Determinants of cash through the century

Table 3 documents how the cross-sectional relations between cash holdings and firm characteristics have evolved through time. We partition the CRSP sample into 10-year windows, centered on each year ending in "8", estimate annual regressions (within each decade window) of cash holdings on firm characteristics, and present Fama-MacBeth mean coefficients within each decade. In Panel A, we limit the sample to NYSE firms to (broadly) isolate away from changing sample composition. Panel B presents results using the full CRSP sample. The included independent variables largely follow the extant literature (e.g., Opler et al., 1999; Bates et al., 2009).

Focusing first on the right-most column (the 10 years centered on 2008), we confirm many of the relationships documented by papers that study modern data. Cash ratios are higher for smaller firms and non-dividend payers (often cited as measures of external financing costs), for firms with higher market-to-book ratios (expected investment opportunities), and firms with more volatile cash flows (uncertainty about future financing needs), which many studies interpret as being consistent with a precautionary motive to hold cash. The negative relation with firm size and positive relation with cash flow volatility can also be interpreted as consistent with transaction cost models. We also find evidence consistent with substitution between cash holdings and other current assets, as well as firms holding cash to offset current liabilities. Cash holdings are lower for firms with higher recent investment spending and (weakly) higher for NYSE firms with higher cash flow, consistent with use of internal funds for investment and accumulation of current cash flows. Finally, cash ratios are negatively correlated with

corporate debt. While this relation is hard to interpret theoretically, it is potentially consistent with firms with better access to debt markets having lower precautionary motives to hold cash.

Looking across the columns in Panel A of Table 3, many of the cross-sectional relations documented for the 2004 – 2013 column are steady through time, despite dramatic changes in capital markets and the severity of financial frictions over the past century. While some magnitudes vary, with only one notable exception, each of the cross-sectional relationships just discussed retains the same sign in every decade in our sample period, and is statistically significant in at least 7 of the 9 decades. Overall, this suggests consistency in cash policies, as the types of firms that maintain high (low) cash balances today are the same types that have done so throughout the century.

The exception is that early in the century, dividend-paying firms held more cash than non-payers, but less cash than non-payers since the 1960s. This dividend flip is surprising, given that the negative relation is typically interpreted as consistent with the relevance of external finance costs for cash policy and one would expect financing costs to be more severe when capital markets were less well developed. However, this easing of capital market frictions may be offset by the changing nature of new listings (Fama and French, 2004) as well as the concentration of dividends among the largest and most profitable firms (DeAngelo et al., 2004). These forces suggest that the pool of non-dividend payers (dividend payers) in our sample become relatively more (less) financially constrained in recent decades. We also note that the intercept increases substantially across the first three decades. This gives an initial indication that firm characteristics do not fully account for the increase in cash holdings over this period. We return to this issue in our analysis of aggregate cash holdings in the next section.

Panel B repeats the analysis on the full CRSP sample (which adds non-NYSE CRSP firms to Panel A). Prior to 1980, the sign and significance of most cross-sectional relations are fairly stable through the

century (again with the exception of the dividend variable). Panel B allows us to consider modern non-NYSE results in the broader context of history. In particular, the results highlight the impact of the influx of new Nasdaq firms on the cross-sectional relations. First, consistent with Bates et al. (2009) and Denis and McKeon (2017), the relation between cash holdings and earnings becomes negative in the two most recent decades. By contrast, the coefficient is positive and significant for each decade between 1920 and 1980. This suggests that the influx of unprofitable, high cash Nasdaq firms shifted the relation between cash ratios and profitability from its historical norm. Second, the positive relation between cash holdings and cash flow volatility noted by recent authors is much smaller in magnitude and less statistically significant for most of the century prior to the most recent two decades. This is consistent with especially high cash holdings among new Nasdaq firms in volatile industries (see Figure 3, Panel C). Finally, the coefficient on the Non-NYSE indicator shows that, controlling for firm characteristics, it is only since 1980 that non-NYSE (i.e., Nasdaq) firms hold more cash than NYSE firms.

3.3 Differing cash sensitivities for NYSE versus non-NYSE firms

In Section 2 we document that cash holdings evolved differently for NYSE and Nasdaq firms. Results in Section 3.2 suggest this may be in part due to differences in determinants of cash policies across these groups of firms. In Table 4, we explore this implication in more depth by estimating cross-sectional regressions similar to those in Table 3, except we allow for different sensitivities for NYSE and non-NYSE firms. We use the extended sample in Panel A so we can study how the difference in cash policies between NYSE and non-NYSE firms evolves over the century. Recall that the extended sample contains just a single year in each decade (1928, 1938, etc.), so these are pure cross-sectional regressions. Because of data limitations, we drop volatility, investment, and market/book from this specification. Offsetting this, we have credit rating information for the extended sample, and Panel A includes a variable indicating whether a firm is rated.

First, we note a dramatic shift in the intercept over time. In the 1920s and 1930s, non-NYSE listed firms held significantly less cash than NYSE firms, controlling for firm characteristics. However, the relative cash holdings of non-NYSE firms increased monotonically through the century, turning positive in the 1950s, though they are economically large and statistically significant only since the 1980s. These patterns suggest that while the higher cash holdings among non-NYSE firms in recent decades is related to the characteristics of these firms, it is not fully captured by the included firm characteristics.

Second, Panel A shows that NYSE and non-NYSE firms differ in their sensitivities of cash holdings to firm characteristics, and these differences are more pronounced today than they have been historically. From the 1920s through the 1960s, only nine out of forty coefficients are statistically different between NYSE and non-NYSE firms, compared to 22 out of 32 since the 1970s. Several of these differences have grown in magnitude over time. Thus, relative to the past, cash holdings are managed differently by non-NYSE firms in the modern era, both in the level of holdings and in sensitivities to firm characteristics. For example, for most of the century the coefficients are very similar for NYSE and non-NYSE firms for current assets, short-term- and long-term-debt, but become significantly and increasingly smaller for non-NYSE firms after the 1970s. Also, while the relation between earnings and cash is always smaller for non-NYSE firms, the relation becomes negative for non-NYSE firms, and statistically lower than that of NYSE firms, only since the 1980s. (This is most easily seen in Figure 6, which presents time series of estimated coefficients.) These results indicate that cash holdings are particularly high for unprofitable, low-current-asset Nasdaq firms with little debt financing. Thus, elements of financial constraint appear to be associated with the high cash holdings of Nasdaq firms.[21] Notably, the effect of firm size does not vary by exchange. Within both NYSE and

[21] Begenau and Palazzo (2017) attribute increased cash holdings in part to greater growth options among recent IPO firms, which is consistent with the positive sign on M/B in Panel B of our Table 4.

Nasdaq firms, the negative size coefficient is potentially consistent with both precautionary and transaction cost motives to hold cash.

Panel B of Table 4 reports results of similar analysis of the sample of CRSP firms. Panel B largely confirms the implications of Panel A and adds that, relative to NYSE firms, cash holdings by non-NYSE companies are more positively related to volatility and investment opportunities (market-book), and more negatively associated with investment spending, starting in the 1990s but not before.

To summarize so far, a primary objective of our paper is to determine whether the substantial shifts in cash holdings over the past century are due to changing cash policies, changing characteristics of firms, or something beyond firm characteristics. In Section 2 we showed that while time series variation in cash holdings through much of the century has been broad-based and driven by within-firm changes, the modern increase in average cash ratios is tied to changing sample composition (namely, newly public Nasdaq firms entering the sample with substantial cash holdings). The regression coefficients in this section highlight which firm characteristics and policies might be associated with this increase. The evidence in Table 4 suggests that the well-known modern increase in average cash holdings is tied to specific investment and liquidity characteristics of these non-NYSE firms. Their holding more cash in anticipation of future investment is consistent with a precautionary motive to hold cash: high cash ratios among non-NYSE firms are pronounced among firms with high investment opportunities (market-to-book) and limited sources of funds (low profits, few current assets, little debt capacity). The use of cash to invest is consistent with the realization of this precautionary need.

This combination of changing sample composition and characteristic sensitivity offers a plausible explanation for the 1980-2000 era increase in mean cash. However, we do not observe significant changes in composition or sensitivities during the increase in average and aggregate cash from 1920 to

1945, the reversal through 1970, nor the increase in aggregate cash since 2000. This suggests other factors are necessary to broadly explain the time-series variation in corporate cash holdings. We explore these implications in the next section.

4. Time series variation in aggregate cash

In this section, we explore the substantial variation over the past century in aggregate corporate cash holdings. This variation could be driven by several factors. The first is changing characteristics of publicly traded firms. The previous section documented stable relations between several firm characteristics and cash policies in the cross-section, especially for NYSE firms. This suggests that changes over time in aggregate firm characteristics could lead to changes in optimal cash holdings and result in shifts in aggregate corporate cash.

Second, macroeconomic conditions can affect the costs and benefits of holding cash in ways not fully captured by firm characteristics. For example, as real interest rates or expected inflation increase, the opportunity cost of holding cash in non-interest bearing accounts or fixed income instruments increases. Likewise, variation in the demand for (or supply of) liquid assets may impact the returns forgone by holding more of a firm's assets in cash and marketable securities. Further, the precautionary motive to hold cash may be influenced by business cycle fluctuations, which influence the value of growth opportunities, and the level of uncertainty about economic conditions. Finally, variation in tax rates over time may affect the tax cost of holding cash inside the firm.

Third, shocks to cash flow and investment opportunities can impact the time path of cash holdings. Several theoretical models (Baumol, 1952; Miller and Orr, 1966; Bolton, Chen and Wang, 2011) imply that when facing costs to adjusting cash balances, firms will allow their cash ratios to vary within an optimal range. While the costs and benefits of holding cash determine the width of the optimal

range in these models, until the cash ratio hits an upper or lower boundary, cash balances will increase (decrease) as current cash inflows exceed (fall short of) current investment opportunities. In this case, much of the time series variation in cash holdings may be driven by contemporaneous cash flow and investment realizations, consistent with the pecking order of Myers and Majluf (1984).[22] These firm-specific behaviors can affect aggregate cash holdings, for example in times of high aggregate profits.

4.1. Aggregate time series regressions

To explore the determinants of aggregate corporate cash holdings, we estimate aggregate time-series regressions of the form:

$$C_t = \alpha + \beta X_t + \gamma M_t + \varepsilon_t, \quad (1)$$

where C_t is the aggregate ratio of corporate cash holdings to assets, X_t is a set of aggregate firm characteristics, and M_t is a set of macroeconomic variables. We estimate equation (1) in both levels (with the addition of cubic time trend controls) and first differences.[23] All explanatory variables are scaled by their time-series standard deviation to ease comparison of economic magnitudes. Coefficient estimates are shown in Table 5. In Figure 7 we plot the fitted and actual aggregate cash ratio based on the first difference specification; that is, we cumulate the fitted values for changes in the aggregate cash ratio and compare that series to the cumulated changes in the actual aggregate cash ratio.

The first and fourth columns of Table 5, along with Panel A of Figure 7, present results using only firm characteristics as independent variables. These include aggregate versions of the same set of variables used in Table 3, with one exception. For the time series analysis, we attempt to distinguish

[22] Riddick and Whited (2009) show that cash holdings can be negatively related to cash flow in a dynamic model. For example, a positive productivity shock may lead to increased cash flows as well as more investment (the latter potentially reducing cash holdings).

[23] The use of first differences is motivated by the fact that many of the aggregate series are highly persistent, raising the possibility of a spurious regression. To mitigate this possibility in the level specification, we include linear, quadratic, and cubic trend terms, as in Azar et al. (2016).

between firms' expected levels of cash flow and investment and their contemporaneous realizations. That is, target cash holdings should be lower for firms expecting greater cash flows and higher for firms with greater anticipated investment needs. On the other hand, as mentioned above, for firms facing adjustment costs and therefore allowing cash holdings to vary within bounds (e.g., Miller and Orr, 1966), the relation between end-of-period cash holdings and the current-year realization of earnings and investment are likely to be the opposite. We proxy for expected cash flow and investment with a trailing 3-year moving average of each variable. We then construct an aggregate version of each variable by calculating an asset-weighted average across firms each year.

Panel A of Figure 7 shows that very little of the large time series variation in aggregate cash holdings can be explained by changes in aggregate firm characteristics alone. Table 5 indicates few robust significant relations between aggregate characteristics and aggregate cash. The only variable in the first difference specification with a significant coefficient in the expected direction is Current Assets. While before we showed that there are systematic differences in cash holdings across firms with different characteristics, and that these cross-sectional relations are fairly stable over time, the estimated coefficients and Figure 7 indicate that little of the time series variation in aggregate cash holdings is attributable to changes in these aggregate characteristics over time.

To understand which non-characteristic factors explain the large variation in aggregate cash, we next explore the role of macroeconomic conditions. We include two variables to proxy for the opportunity cost of holding cash: the cost of carry as defined by Azar, et al. (2016), which is the nominal 3-month T-bill rate multiplied by the fraction of corporate liquid assets held in non-interest bearing accounts[24]; and the spread between rates on AAA-rated corporate debt and the 10-year Treasury yield as

[24] Since the fraction of liquid assets held in non-interest bearing accounts is measured using U.S. Flow of Funds data, it is not available prior to 1945. Therefore, for years between 1925 and 1945, we assume it stays at the average level of 1945-49. This assumption is reasonable, given that the fraction is very stable and close to 1 prior to 1960 (see Azar et al., 2016).

a measure of the liquidity premium. In addition, we include the standard deviation of market returns and the Economic Policy Uncertainty index of Baker et al. (2016) to capture aggregate uncertainty. We further include two measures of aggregate investment opportunities: real GDP growth and aggregate productivity (output to capital ratio). Finally, we include the domestic corporate tax rate to capture variation in the tax cost of holding cash. (Due to data requirements, we explore repatriation tax incentives separately, in Section 4.2.)

Columns (2) and (6) of Table 5 suggest these macro factors help explain some of the time-series variation in aggregate cash, although only a few coefficients are statistically significant. The cost of carry is negatively correlated with aggregate cash, consistent with Azar et al. (2016), but over the century this relation is at best marginally statistically significant in the levels specification and insignificant in first differences.[25] Aggregate productivity and GDP growth are each positive in both specifications and statistically significant in first differences.[26] Their economic magnitudes are also reasonably large. For example, from the levels specification (2), a one standard deviation change in aggregate productivity is associated with a 1.7 percentage point (roughly 0.4 standard deviations) change in aggregate cash.[27] This suggests that the value of growth opportunities or the expected volume of transactions is relevant for aggregate cash holdings, beyond anything captured by firm-level variables such as market-to-book and firm size. Finally, the corporate tax rate has a significant coefficient in the level specification, but is positive in both levels and first differences, inconsistent with a tax cost incentive. Therefore, we drop this variable in the other columns.

[25] In untabulated analysis, we find a statistically stronger relation between aggregate cash and cost of carry in the second half of our sample than the first half. Separately, we add one and two-year lags of the cost of carry to the first difference specification, to allow cash holdings to respond to changes in carry cost with a delay. The coefficient on the one-year lag is negative and significant in column 5; once we control for corporate cash flow and investment (column 8), though, it loses significance and the coefficient on the two-year lag turns positive.

[26] As anticipated in our discussion of Figure 5, aggregate cash is positively and significantly associated with real GDP growth and productivity in the first half of the sample, but not in the second half. Results available upon request.

[27] Magnitudes are similar in the first difference specification. There, a one-standard deviation change in the first difference of productivity corresponds to a 0.7 standard deviation change in the first difference of the aggregate cash ratio.

Adding macro variables to Table 5 increases the adjusted r-squared by a few percentage points in levels and by nearly 30 points in first differences. The improved fit is also reflected in Panel B of Figure 7. While much of the time-series variation remains unexplained in the middle of the sample, adding macro variables to the model captures some of the increase in cash holdings in the 1940s and the decline that follows.[28]

In Columns (4) and (8) of Table 5, we add contemporaneous earnings and investment to our set of firm characteristics. While the previously discussed firm characteristics represent proxies for target cash levels, these can be viewed as cash flow and investment realizations that may push a firm away from its target. The estimated coefficients are highly statistically significant and robust across both level and first difference specifications. Their marginal effects are also among the largest of any of the included variables. From the level specification, a one-standard deviation change in either aggregate investment or earnings is associated with about a quarter standard deviation change in aggregate cash holdings. We also see a marked increase in the adjusted r-square in the first difference specification, increasing from 0.36 to 0.53. This is further reflected in Panel C of Figure 7. This last panel demonstrates that a model that incorporates all three elements – characteristic-based proxies for target cash holdings, macroeconomic indicators, and current cash flow and investment realizations – is able to capture much of the time series patterns in aggregate corporate cash holdings over the past century.

In Table 6, we compare more formally the explanatory power of each macroeconomic variable and the aggregate cash flow and investment variables. In Panel A, we measure contribution to in-sample fit for each variable in two ways. First, we estimate a series of univariate regressions in first differences; second, we start with our full specification (column 8 in Table 5) and remove each variable one at a

[28] In unreported analysis we create a version of Figure 7, Panel B that adds cost of carry (but none of the other macro variables) to the firm characteristics. This graph is nearly identical to that shown for just firm characteristics in Panel A. Thus, while cost of carry is negatively correlated with aggregate cash holdings , its incremental explanatory power in the time-series is small.

time. We report the adjusted R-squared and RMSE from each specification. From the univariate regressions, productivity and aggregate cash flow and investment have by far the largest explanatory power. These three variables together account for 48% of the variation in aggregate cash, and account for 74% of the explained variation of the full model.[29] Similarly, removing productivity, cash flow and investment from the full specification has the biggest impact on in-sample fit.

In Panel B, we evaluate the contribution of each variable to the model's ability to predict out of sample. Here, we use a variant of the cross-validation approach. Specifically, we start by removing the first decade (1926 – 1935) from the estimation sample and use the estimated coefficients to predict out of sample for the excluded decade. We then repeat this for each decade and report the RMSE over all decades for each model specification. Results are consistent with those in Panel A. Productivity and cash flow and investment are the only variables whose inclusion (exclusion) substantially reduce (increase) the out of sample mean squared error.

We note that the importance of current cash flow and investment realizations indicates that a significant portion of the time series variation in aggregate cash appears to reflect straight-forward accumulation of profits and use of internal funds. While such behavior may appear "passive" in the short-run, it is also consistent with several theoretical models of cash policy (e.g., Bolton et al., 2011).

4.2 Contrasting historic and modern increases in aggregate cash

The analysis above helps to identify which factors are (or are not) associated with time series variation in a near-century of aggregate cash holdings. In this section we attempt to understand more deeply the drivers of the two episodes of increasing aggregate cash – one in the 1930s and early 1940s and the

[29] In untabulated analysis of covariance, we calculate the fraction of explained variation attributable to each variable by scaling the type III partial sum of squares for that variable by the total type III sums of squares across all variables. The resulting values for productivity, cash flow and investment are 29%, 13%, and 32%, respectively.

recent increase that starts in 2000. Contrasting these episodes helps clarify the forces behind changes in aggregate cash, while simultaneously evaluating the modern event in historical perspective.

The recent literature focuses on two explanations for rising cash balances: precautionary savings motives (Bates et al., 2009; Falato et al., 2013; Begenau and Palazzo, 2017) and repatriation tax incentives (Foley et al., 2007, Faulkender et al., 2018). Our evidence in sections 2 and 3, in combination with those from recent studies, suggests that precautionary motives help explain the cross-section of cash holdings as well as the 1980-2000 increase in average cash ratios. However, our evidence from section 2 shows the increase in aggregate cash since 2000 is driven by increases in cash among large firms, for which precautionary motives are likely less important. Indeed, a contemporaneous working paper by Faulkender et al. (2018) argues that proxies for precautionary motives are unrelated to holdings of cash in foreign subsidiaries, which account for most of the increase in aggregate cash since 2000. Rather, foreign held cash is associated with repatriation tax incentives, consistent with cross-sectional evidence in Foley et al. (2007). In the analysis below, we first confirm the role of tax incentives in the modern cash increase in panel regressions and in aggregate regressions. We then examine which factors are associated with the increase in aggregate cash seen in the 1930s and 1940s. Unlike in modern times, repatriation tax motives were likely absent in the first part of the century, so we explore the role of precautionary and transaction cost motives in driving the earlier trends.

4.2.1. Repatriation taxes and the post-2000 increase

To begin our examination of the post-2000 rise in aggregate cash, we first note in Panel A of Figure 8 that this increase is much less apparent in data from US Flow of Funds than in Compustat data. The key difference between these two data sources is that Compustat measures worldwide cash holdings (which for multinational firms include cash held in foreign affiliates), while the Flow of Funds balance sheet

data are based on the *Statistics of Income*, which is collected from US corporate tax returns (and thus more closely represent domestic cash holdings). This suggests that the difference between the two series reflects cash held in foreign affiliates.[30] This interpretation is supported by Panel B which plots the difference between the two series in Panel A versus the aggregate ratio of "permanently reinvested earnings" (PRE) from Harford, Wang and Zhang (2017)[31] and in Panel C which plots an aggregate measure of the repatriation tax cost used by Foley et al. (2007).[32] The high correlation between the series is consistent with a large portion of the increase in aggregate Compustat cash since 2000 being due to trapped foreign cash. This corresponds to the timing of when the US corporate income tax rate became greater than the tax rates of the US's main trading partners, as shown in Panel D.[33]

In Table 7, we explore whether avoidance of repatriation taxes helps explain variation in cash holdings since 1981. We first estimate panel regressions (columns 1 and 2) of the cash to assets ratio on the firm-specific repatriation tax incentive variable along with the set of firm characteristic and macro controls used above.[34] Consistent with analysis of BEA data in Foley et al. (2007) and Faulkender et al. (2018), we find that higher US taxes owed on foreign profits are associated with higher cash holdings.

We next perform, to our knowledge for the first time in the literature, aggregate regressions that attempt to explain cash holdings with repatriation tax incentives. We estimate time series regressions in which the dependent variable is either the aggregate cash ratio (columns 5 and 6) or the difference between aggregate cash as reported in Compustat and Flow of Funds (columns 3 and 4). The

[30] Additionally, the Flow of Funds series includes private firms, which are excluded from the CRSP/Compustat sample. However, this difference has little effect on the aggregate ratio due to the small relative size of private firms.
[31] PRE are foreign profits that US-domiciled companies have declared will be held permanently overseas (i.e., "trapped foreign cash"). We thank Jarrad Harford for kindly providing the PRE data.
[32] We first calculate the repatriation tax cost variable separately for each firm using information on foreign sales and taxes from Compustat, then aggregate this tax variable across all firms.
[33] Data from (http://www.oecd.org/tax/tax-policy/tax-database.htm). Faulkender, Hankins, and Petersen (2018) show that much of the increase in aggregate cash of U.S. firms since 2000 is held in foreign affiliates.
[34] Since we are relating the flow of taxes owed on foreign profits to the stock of cash balances, we use a 3-year moving average of the repatriation tax incentive variable.

independent variables include the aggregate repatriation tax cost variable along with aggregate firm characteristic and macro controls. Since the availability of the tax cost variable (and indeed the incentive for and practice of leaving cash overseas) is relatively recent, we use only 34 annual observations in this regression (1981 through 2014). Nonetheless, we find a significant positive relation between the repatriation tax cost and aggregate cash holdings, even after controlling for a time trend and other determinants of cash policy.

4.2.2 The pre-war cash increase

While repatriation tax incentives were unlikely an important driver of cash policies in the 1930s and 1940s, the transactions cost and precautionary savings models offer two potential explanations for the increase in corporate cash holdings leading up to WWII. Transaction cost models (Baumal, 1952; Miller and Orr, 1966) suggest the average level of cash holdings increases in the volume of receipts and expenditures flowing through the firm. This implies a positive relation between the cash to assets ratio and sales to assets, which we find to be true: sales to assets increased on average in the years leading up to WWII, averaging roughly 90% from 1926 to 1935, then increasing to 160% by 1945.

In addition, there are reasons to believe that precautionary motives may have increased cash holdings in the late 1930s and early 1940s. First, this period was associated with a heightened level of uncertainty. The Economic Policy Uncertainty index of Baker et al. (2016) was less than 100 between 1925 and 1931, but subsequently increased and remained over 150 from 1932 until the end of the war. At the same time, the booming war-time economy increased the value of investment opportunities and the limited access to funding during the early 1930s was likely fresh on corporate managers' minds.

To test the relevance of these two explanations for the pre-war cash increase, in Table 8 we examine cross-sectional differences in the change in cash ratios over the 1936 to 1945 period. We first

sort firms by several proxies for the severity of financing constraints using data from 1936. If precautionary motives were relevant, we would expect firms facing more severe constraints to increase cash balances more rapidly. We then sort firms based on their growth in sales to assets over the 1936 to 1945 period. If growth in transaction volume was a primary driver of the increasing cash balances over this time, we expect that those firms with larger increases in sales would see larger increases in cash.

We appeal to the prior literature for guidance on ex-ante proxies for financing constraints. Several authors have used credit ratings (Almeida and Campello, 2007), firm size (Hadlock and Pierce, 2010) and dividend status (Fazzari et al., 1988) to proxy for financing constraints (with small firms and non-payers assumed to be more constrained). In addition, Calomiris and Hubbard (1995) (CH) point out that a firm's response to the Undistributed Profits Tax (UPT) of 1936-37 reveals the firm's assessment of its cost of external (relative to internal) finance.

Beginning in 1936, but lasting only two years, firms faced a UPT surtax on any earnings that were not paid out to shareholders. CH argue the imposition of this tax was largely unexpected. The tax rate was progressive, based on the fraction of earnings retained by the firm. Given that firms could avoid the tax (or reduce the tax rate) by paying more dividends, CH argue that the marginal rate paid by a firm indicates its desire to reduce the probability of needing to raise external funding. We follow CH and classify firms into three groups based on the marginal UPT rate they faced in 1936. Type A firms, considered the least constrained, had retention rates below 20% and faced marginal UPT rates of 12% or less. Type B firms retained between 20% and 40% of their earnings, faced a 17% tax rate, and are considered moderately constrained. Type C firms are the most financially constrained, retaining more than 40% of earnings, which increased their marginal UPT rate to 17% or 22%.

In the first 8 columns of Table 8, we report results of panel regressions over 1936-1945 of the cash to asset ratio on a time trend and the trend interacted with proxies for financing constraints. All specifications include firm fixed effects; columns (5) through (8) add the firm characteristic variables used in Table 3. Across all specifications, we find a) a positive and significant time trend and b) a positive and significant coefficient on the interaction between the time trend and the ex-ante measure of financing constraints. The latter result is consistent with precautionary savings demand playing a role in the pre-war run-up in cash holdings. That is, firms for which we would expect precautionary savings motives to be more pronounced added cash at a faster rate during this period. Comparing the magnitudes of the coefficients on the time trend and interaction variables suggest that constrained firms added cash 35% – 73% faster than unconstrained firms.[35] The results also show that even relatively unconstrained firms increased their cash balances significantly, suggesting that precautionary demand was unlikely to be the only driver of the rise in cash.

In columns (9) and (10), we sort firms by the change in sales to assets over this time period. In particular, we first calculate for each firm the difference between the average sales-to-assets ratio from 1943-45 and the average ratio from 1934-36.[36] We then sort firms into tertiles based on the change in sales-to-assets and estimate regressions similar to those in the earlier columns, but now we interact the time trend with an indicator for firms in the high sales growth group. Interestingly, we find no evidence that firms that experienced higher sales growth increased their cash ratio more than firms with lower sales growth. The coefficient on the interaction is negative and insignificant. This evidence is inconsistent with a transactions demand explanation for the pre-war cash run-up. We note that this is not an artifact of a lack of heterogeneity in sales growth rates: from 1936 to 1945, average sales to assets

[35] From column (2), 0.507/1.45 = 0.35 and from column (4), 0.809/1.102 = 0.73.

[36] Results are robust to other measures of sales growth, such as the percentage difference in total sales between 1936 and 1945 and the average annual sales growth between 1936 and 1945.

was essentially flat for firms in the lowest tertile, while for firms in the highest tertile, average sales to assets increased from 130% in 1936 to over 250% by 1943. Yet, despite these large differences in sales growth, these two groups showed roughly the same change in average cash ratios.

In sum, our analysis of cash trends in Figures 1 and 2 shows that the recent increase in aggregate cash is not unique in its magnitude when viewed in historical context. However, the results in this section highlight a sharp contrast in the forces behind the two episodes of rising aggregate cash over the past century. While the recent increase in aggregate cash appears to be driven by tax incentives, the earlier episode was driven by precautionary motives. Combining the results in Tables 5 through 8, aggregate corporate profits and investment, precautionary motives, and macroeconomic effects (such as productivity increases and repatriation tax costs) appear to explain a large part the evolution of aggregate cash over the last century. However, the importance of each of these factors varies substantially across time.

5. Conclusions and directions for future research

While the near-tripling of average cash ratios since 1980 has received much attention, this is only one aspect of the rich evolution of corporate cash policies over the last century. From 1920 to 1945 corporate cash holdings for small and large firms tripled, and then returned to below their starting points by 1970. More recently, cash ratios among new entrants increased sharply from 1980 to 2000, while cash holdings among large and established firms were relatively stable until 2000. We explore these large and (in modern times) divergent cash trends using a hand-collected database for all public, unregulated U.S. firms.

Over our near-century of data, two of the most important drivers of average and aggregate cash are that firms build up cash when they realize current-period profitability and use it to fund current

investment. One explanation for this finding could be that, due to adjustment costs, firms allow cash holdings to vary within boundaries as profits and investment change. For this to explain the large movements in aggregate cash in the first half of the sample, either the boundaries must have been extremely wide or they shifted through time as conditions changed. Empirically modeling dynamic trends in the upper and lower boundaries is an interesting task for future research.

We find that productivity gains and precautionary motives help explain the increase in cash holdings from 1920 to 1945. The decrease in cash/assets and cash/sales from 1945 to 1970 is consistent with improving efficiency of cash management. Future research should measure cash management efficiency directly and explore this issue. The increase in aggregate cash holdings since 2000 is consistent with the direction and magnitude of increased holdings of cash trapped overseas due to repatriation taxes. Thus, without repatriation taxes, aggregate cash would likely have been relatively stable since 1970. Repatriation taxes likely played little role before 2000 (nor will they play a role after 2017 once the dust settles from recent tax law changes), highlighting the importance of documenting non-tax motivations.

Most of the recent papers that study cash examine the increase in average cash holdings from 1980 to 2000. Either explicitly or implicitly (because they study cash using equally-weighted regressions[37]) many results in these papers are primarily driven by increasing cash ratios among small firms. We attribute the increase in mean cash to changes in sample composition. We find that the sign and magnitude of the recent increase in average cash holdings is entirely consistent with a 'Nasdaq effect' in which Nasdaq firms went public with ever-increasing amounts of cash from 1980 to 2000. This Nasdaq effect is stronger for unprofitable, low sales, low current asset, low debt, high growth, high volatility, health and tech firms. We emphasize that this is not purely a firm size effect. Our extended

[37] One exception is Azar et al. (2016) who estimate size-weighted least squares regressions.

sample holds the proportion of small firms in the sample relatively constant, and yet we still observe a sharp increase in average cash holdings from 1980 to 2000. Thus, the sample-composition-driven increase in mean cash does not occur because more small firms enter the sample starting in 1980 but rather because non-size characteristics (and sensitivity to characteristics) of Nasdaq IPO firms changed.

Another take-away from our findings, as well as those of Booth and Zhou (2013) and Beganau and Palazzo (2017) is that characteristic-based explanations of increased average cash holdings need to be consistent not with individual firms increasing cash over time, but with the influence of Nasdaq-like firms as we have described. For example, while we do not explicitly examine agency explanations of cash holdings, an agency explanation of the mean increase in modern cash would need to manifest primarily in the changing nature of Nasdaq firms, and for the most part, be consistent with negative within-firm cash holdings. Likewise for volatility explanations, working capital hypotheses, etc.

Setting aside this sample composition effect, we find that for NYSE firms the sensitivities of firm-specific cash holdings to commonly studied variables are directionally stable over our near-century of data. One of the stronger findings throughout the firm-specific analysis is that debt, especially short-term debt, is negatively related to cash holdings. While we offer some tentative thoughts above, we find this correlation somewhat hard to interpret and look forward to future research that explores this relation in more depth.

Also noteworthy, even with the relative stability of firm-specific cash sensitivities, and changes in firm characteristics over time, we do not find that changes in firm characteristics explain time-series changes in aggregate cash holdings. One must also consider macroeconomic effects, aggregate corporate investment and profitability, and (in modern times) repatriation tax incentives to explain the long-term aggregate trends in corporate cash holdings.

References

Almeida, Heitor and Murillo Campello, 2007, Financial Constraints, Asset Tangibility, and Corporate Investment, *Review of Financial Studies* 20, no. 5 (2007), 1429-1460.

Azar, Jose, Jean-Francois Kagy, and Martin Schmalz, 2016. Can Changes in the Cost of Carry Explain the Dynamics of Corporate "Cash" Holdings? *Review of Financial Studies* 29, no. 8 (2016), 2194-2240.

Baker Scott R., Nicholas Bloom, and Steven J. Davis, 2016, Measuring Economic Policy Uncertainty, Quarterly Journal of Economics 131, No. 4 (2016): 1593-1636.

Bates, T., Kahle, K., Stulz, R., 2009. Why do US firms hold so much more cash than they used to? Journal of Finance 64, 1985–2021.

Baumol, William J., 1952. The Transactions Demand for Cash: An Inventory Theoretic Approach, Quarterly Journal of Economics 66, No. 4 (1952): 545-556

Begenau, Juliane, and Berardino Palazzo, 2017, Firm Selection and Corporate Cash Holdings, Harvard University Working Paper.

Boileau, Martin and Nathalie Moyen, 2016. Corporate Cash Holdings and Credit Line Usage, *International Economic Review*-57, no. 4 (2016), 1481-1506

Bolton, Patrick, Hui Chen, and Neng Wang, 2011, A Unified Theory of Tobin's q, Corporate Investment, Financing, and Risk Management, *Journal of Finance* 66, 1545-1578.

Booth, Laurence and Jun Zhou, 2013, Increase in Cash Holdings: Pervasive or Sector-Specific?, Frontiers in Finance and Economics 10 (2): 1 – 30.

Bouwman, Christa H.S., and Michelle Lowry, 2012, Cash Holdings and the Effects of Pre-IPO Financing in Newly Public Firms, Wharton Financial Institutions Center working paper

Calomiris, Charles W. and R. Glenn Hubbard, 1995, Internal Finance and Investment: Evidence from the Undistributed Profits Tax of 1936-37, *Journal of Business*, Vol. 68, No. 4 (Oct., 1995), pp. 443-482.

Curtis, Chadwick, Julio Garin and Saif Mehkari, 2017, Inflation and the evolution of firm-level liquid assets, *Journal of Banking and Finance* 81: 24 – 35.

Dittmar, Amy, Jan Mahrt-Smith, and Henri Servaes. International corporate governance and corporate cash holdings. Journal of Financial and Quantitative analysis 38, no. 01 (2003): 111-133.

Doidge, C.; Karolyi, G. A.; Stulz, R. M.. The U.S. Left Behind: The Rise of IPO Activity around the World, Journal of Financial Economics, 110, 546–573.

Falato, Antonio, Dalida Kadyrzhanova, and Jae Sim, 2013. Rising intangible capital, shrinking debt capacity, and the US corporate savings glut. Working paper, Federal Reserve Board.

Fama, Eugene F., and Kenneth R. French, 2001. Disappearing dividends: changing firm characteristics or lower propensity to pay? *Journal of Financial Economics* 60, No. 1 (2001): 3-43

Faulkender, Michael, Kristine Hankins and Mitchell Petersen, 2018, Understanding Precautionary Cash at Home and Abroad, working paper, University of Maryland.

Fazzarri, Steven, R. Glenn Hubbard and Bruce Petersen, 1988, Financing constraints and corporate investment, *Brookings Papers on Economic Activity* 1, 141-195.

Foley, Fritz C., Jay C. Hartzell, Sheridan Titman, and Garry Twite, 2007. Why do firms hold so much cash? A tax-based explanation. *Journal of Financial Economics* 86, no. 3 (2007): 579-607.

Gao, Huasheng, Jarrad Harford, and Kai Li, 2013. Determinants of corporate cash policy: insights from private firms. Journal of Financial Economics 109, 623 – 639.

Gao, Xiaohui, Jay R. Ritter, and Zhongyan Zhu, 2013. Journal of Financial and Quantitative Analysis 48, 1663-1692.

Graham, J., Leary, M., Roberts, M., 2015. A Century of capital structure: The leveraging of corporate America. Journal of Financial Economics 118, 658-683.

Hadlock, Charles J. and Joshua R. Pierce, 2010, New Evidence on Measuring Financial Constraints: Moving Beyond the KZ Index, *Review of Financial Studies* 23, no. 5 (2010), 1909-1940.

Harford, Jarrad, 1999, Corporate cash reserves and acquisitions. *Journal of Finance* 54, no. 6 (1999): 1969-1997.

Harford, Jarrad, Sattar A. Mansi, and William F. Maxwell, 2008. Corporate governance and firm cash holdings in the US. *Journal of Financial Economics* 87, no. 3 (2008): 535-555.

Harford, Jarrad, Cong Wang, and Kuo Zhang, 2017. Foreign Cash: Taxes, Internal Capital Markets, and Agency Problems, *The Review of Financial Studies* 30, no. 5 (2017): 1490-1538.

Jensen, Michael C, 1986. "Agency costs of free cash flow, corporate finance, and takeovers." *The American economic review* (1986): 323-329.

Keynes, J.M., 1936. "The General Theory of Employment, Interest, and Money." Palgrave Macmillan, UK.

Kim, Chang-Soo, David C. Mauer and Ann E. Sherman, 1998. The determinants of corporate liquidity: theory and evidence. *Journal of Financial and Quantitative Analysis*, 33, 335 – 359.

McLean, R. David, 2011, Share Issuance and Cash Savings, *Journal of Financial Economics* 99, 693-715.

Miller, Merton and Daniel Orr, 1966. A model of the demand for money by firms. *Quarterly Journal of Economics*, 413 – 435.

Myers, Stewart C., and Nicholas S. Majluf, 1984. Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics* 13, no. 2 (1984): 187-221.

Nikolov, Boris, and Toni M. Whited, 2014. Agency Conflicts and Cash: Estimates from a Dynamic Model. *Journal of Finance* 69, No. 5 (2014): 1883-1921

Opler, T., Pinkowitz, L., Stulz R., Williamson, R., 1999. The determinants and implications of corporate cash holdings. Journal of Financial Economics 52, 3-46.

Pinkowitz, Lee, Rene M. Stulz, and Rohan Williamson, 2016. Do U.S. firms hold more cash than foreign firms do?, *Review of Financial Studies* 29, 309-348.

Poterba, James, 2004, Taxation and Corporate Payout Policy, *American Economic Review*, 94 (2): 171 – 175.

Riddick, Leigh A., and Toni M. Whited, 2009, The Corporate Propensity to Save, *Journal of Finance* 66, 1729-1766.

Appendix A: Variable Definitions

Cash / Assets: Sum of cash and short-term investments, scaled by total book assets.

Cash flow: Income before extraordinary items minus expected dividends, where expected dividends is the product of dividends per share from the previous fiscal year (adjusted for any stock splits) times the number of shares outstanding at the end of the current fiscal year.

Industry cash flow volatility: For each firm-year, we calculate the standard deviation of *Cash flow* over the past 10 years. If fewer than 10 years of lagged data are available, the standard deviation is calculated over all available years, but is set to missing if there are fewer than three years available. We then calculate the average standard deviation across all firms in each industry-year, where industry is defined by 3-digit SIC code.

Real Assets: The natural logarithm of total book assets in 2004 dollars.

MA / BA: The ratio of the market value of assets to the book value of total assets. Market value of assets is defined as the product of shares outstanding and stock price as of end of fiscal year plus book value of total liabilities.

Investment: Annual change in net Property, Plant and Equipment, scaled by lagged total assets.

E[*Cash flow*]: The average of *Cash flow* (scaled by total assets each year) over years *t-1* through *t-3*. Set to missing if fewer than two past observations are available.

E[*Investment*]: The average of *Investment* over years *t-1* through *t-3*. Set to missing if fewer than two past observations are available.

Div. Payer: An indicator equal to one if common dividends exceed zero in year *t*.

Current Assets / A: Current assets (total) less cash and short-term investments, scaled by total book assets.

Current Liabilities / A: Current liabilities (total) less short-term debt, scaled by total book assets.

Repatriation Tax Cost: The maximum of zero and the difference between the U.S. tax burden on foreign profits and taxes paid to foreign governments, scaled by book assets. The U.S. tax burden on foreign profits is estimated as pre-tax income from foreign operations times the U.S. statutory tax rate of 35%.

3-month T-bill rate: End of year secondary market rate on 3-month treasury bills, minus inflation. (Source: Federal Reserve)

Inflation: Percent change (December to December) in the Al Urban CPI (Source: US Bureau of Labor Statistics)

AAA-Treasury spread: Difference between the year-end Moody's seasoned AAA bond yield and the 10-year Treasury constant maturity yield. (Source: Federal Reserve)

sd(Mkt Return): Standard deviation of the daily value-weighted market returns. (Source: CRSP)

Real GDP growth: Annual percent change in real US Gross Domestic Product (chained 2009 $). (Source: US Bureau of Economic Analysis)

Productivity: Nominal GDP scaled by prior year total nonresidential fixed assets. (Source: US Bureau of Economic Analysis)

Personal tax rate: Weighted average household marginal tax rate on dividends from Poterba (2004).

Corporate tax rate: Top statutory US federal corporate income tax rate.

Appendix B: World War II

This appendix discusses corporate holdings of cash and marketable securities in the years surrounding World War II. We focus particularly on the influence of US government securities issued to fund the war on corporate holdings of liquid assets. A large spike in the corporate cash ratio in the early 1940s is apparent in Figure 1. The solid line in Panel A of Figure A.1 shows the ratio of corporate holdings of government securities to total assets, taken from *Statistics of Income* data. The figure shows an increase in corporate holdings of Treasuries in the early 1940s. However, the figure also indicates that during non-war years, Treasuries were a significant portion of the non-cash liquid assets held by firms.

In Panel B of Figure A.1, we assess the impact of war-driven Treasury holdings on the time-series patterns in aggregate cash that we document in section 2. Specifically, we first regress aggregate corporate holdings of Treasury securities on the ratio of defense spending to GDP along with a series of firm-specific and macroeconomic control variables (PP&E/assets, net working capital, leverage, earnings, and all the macro variables included in Table 5). We then calculate war-related Treasury holdings as the annual defense spending to GDP times its estimated coefficient. The figure in Panel B plots the aggregate cash to assets ratio, including and excluding these war-related Treasury holdings. This adjustment reduces the magnitude of the spike in the early 1940s, but otherwise leaves the long time series patterns unchanged. In the series that filters out war-related Treasuries, aggregate cash more than doubles between 1920 and 1950, increasing from less than 10% of assets to almost 20% of assets. The adjusted 1950s level is still higher than the level in recent years. Further, in unreported analysis, we obtain very similar results when we repeat the analyses of Tables 5 and 6 using the filtered aggregate cash series.

Appendix C: Extended Sample

This appendix describes the cross-sectional distribution of firm sizes for our extended sample, which contains data on all firms covered by the Moody's manuals. We hand-enter these data once per decade: 1928, 1938, … 2008. Our main sample (or "CRSP sample") comprises all non-financial, unregulated firms covered by CRSP,

which limits the sample to NYSE firms prior to 1962. By contrast, the extended sample includes many small, regional stock exchange firms.

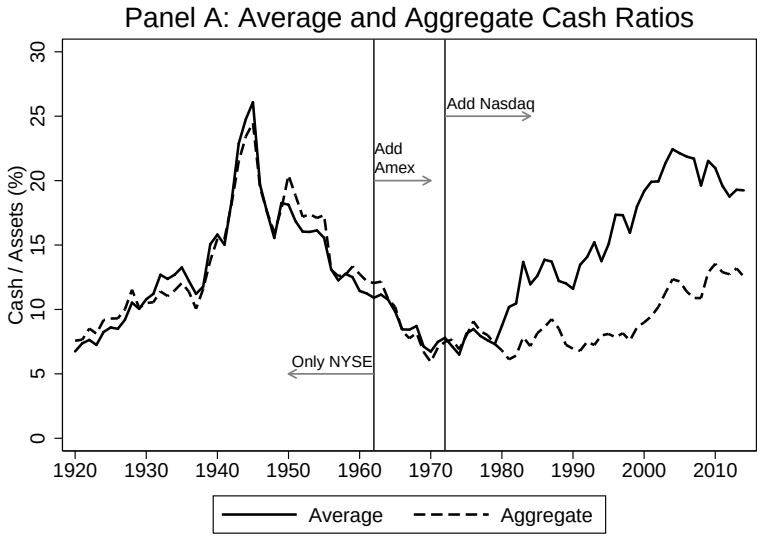
The first four panels in Figure A.2 plot the cumulative size (book assets) distribution in the extended sample and our main sample of CRSP firms for the first four decades of our sample period (1928, 1938, 1948 and 1958). As the plots indicate, this extended sample greatly broadens our coverage of small firms in these years, relative to the CRSP universe. The bottom two panels plot the 10^{th} and 25^{th} percentiles, respectively, of the distribution of real book assets in each year ending in "8." As the plots indicate, the CRSP sample has many fewer small firm proportionally, relative to the extended sample, before the 1980s. In contrast, in the extended sample, the size of "small" firms (in real dollar terms) is fairly consistent throughout the century. Thus, with respect to firm size, the extended sample provides a more stable comparison across decades than does the CRSP sample.

Appendix D: Long-lived Sample

Figure A.3 presents cash-assets plots for each of the 66 firms for which we have 80+ years of data. Several patterns are notable. First, there is a good deal of variation in cash holdings within a given firm, especially in the first half of the sample. The average firm varies its cash holdings over a range (inter-quartile range) of 34 (12) percent of assets before 1970, but only 21 (7) percent of assets from 1970 on. Second, many long-lived firms follow a time-series pattern similar to the overall average displayed in Panel B of Figure 1. As a result, cash balances for most firms were near historic lows as recently as the late 1990s. For example, in 2000, almost 90 percent of these firms had cash ratios below their firm's time-series median, and over 60% had cash ratios in the bottom quartile of their historical values. This is surprising given that most of the increase in average cash ratios (Panel A of Figure 1) that has stimulated research on the modern run-up in cash holdings had already occurred by 2000. Cash balances tended to rise among long-lived firms only after 2000, but not to unprecedented levels. By 2014, the median firm had a cash ratio very close to its historical average.

Figure 1
Average and Aggregate Cash Ratios Through Time

In Panel A, the solid (dashed) line presents the annual average (aggregate) ratio of cash and short-term investments to total assets. Aggregate cash-to-assets is defined each year as the cross-sectional sum of total cash and short-term investments divided by the sum of total book assets. Panels A usea the "CRSP sample," which includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Panel B present the aggregate ratio of cash (excluding short-term investments) to assets using data from Statistics of Income. In both panels, financial firms, utilities and railroads are excluded.



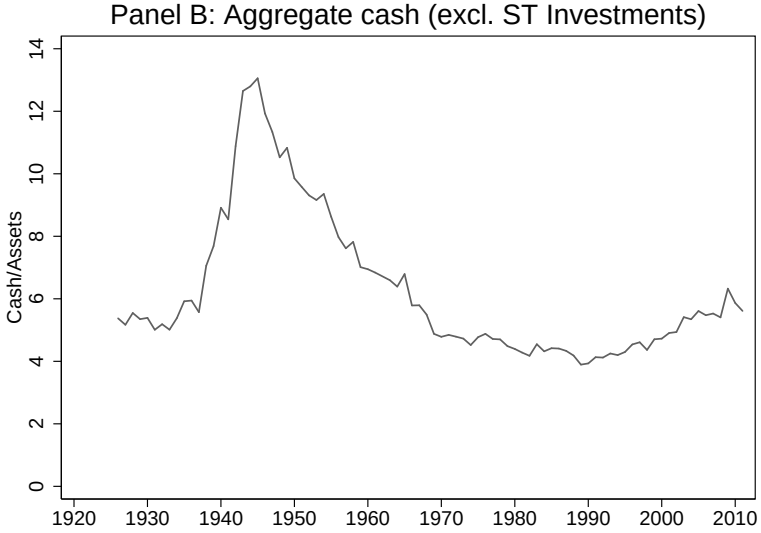
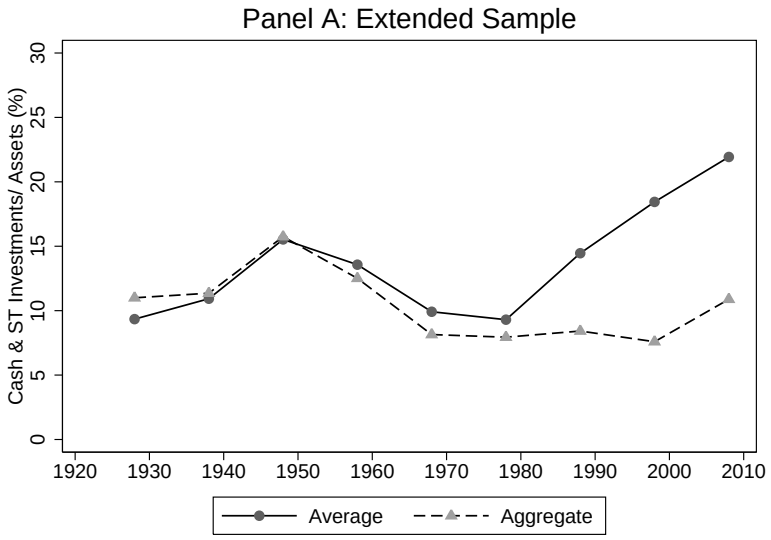


Figure 2
Alternate Samples

The solid (dashed) line presents the annual average (aggregate) ratio of cash and short-term investments to total assets. Panel A uses the "extended sample," which includes all firms in the Moody's Industrial Manual for years ending in "8" (e.g., 1938). Panel B is based on the sample of 66 firms for which we have at least 80 years of data.



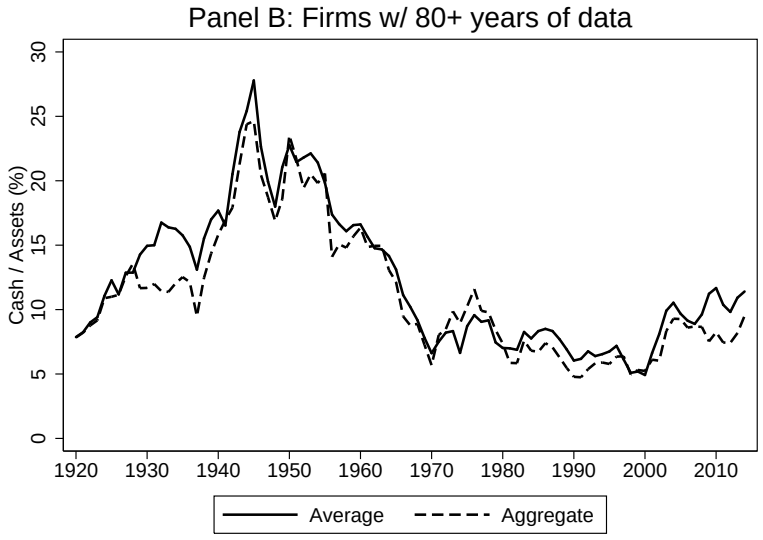


Figure 3
Cross-sectional Dispersion in Cash Ratios

Panels A presents the cross-sectional standard deviation of the cash ratio (ratio of cash and short-term investments to total book assets) for each year based on the "extended sample." Panel B plots the 25th percentile, median, and 75th percentile of each year's cross-sectional distribution from the CRSP sample. Panel C displays a scatter plot of the distribution of cash ratios each year for the extended sample.

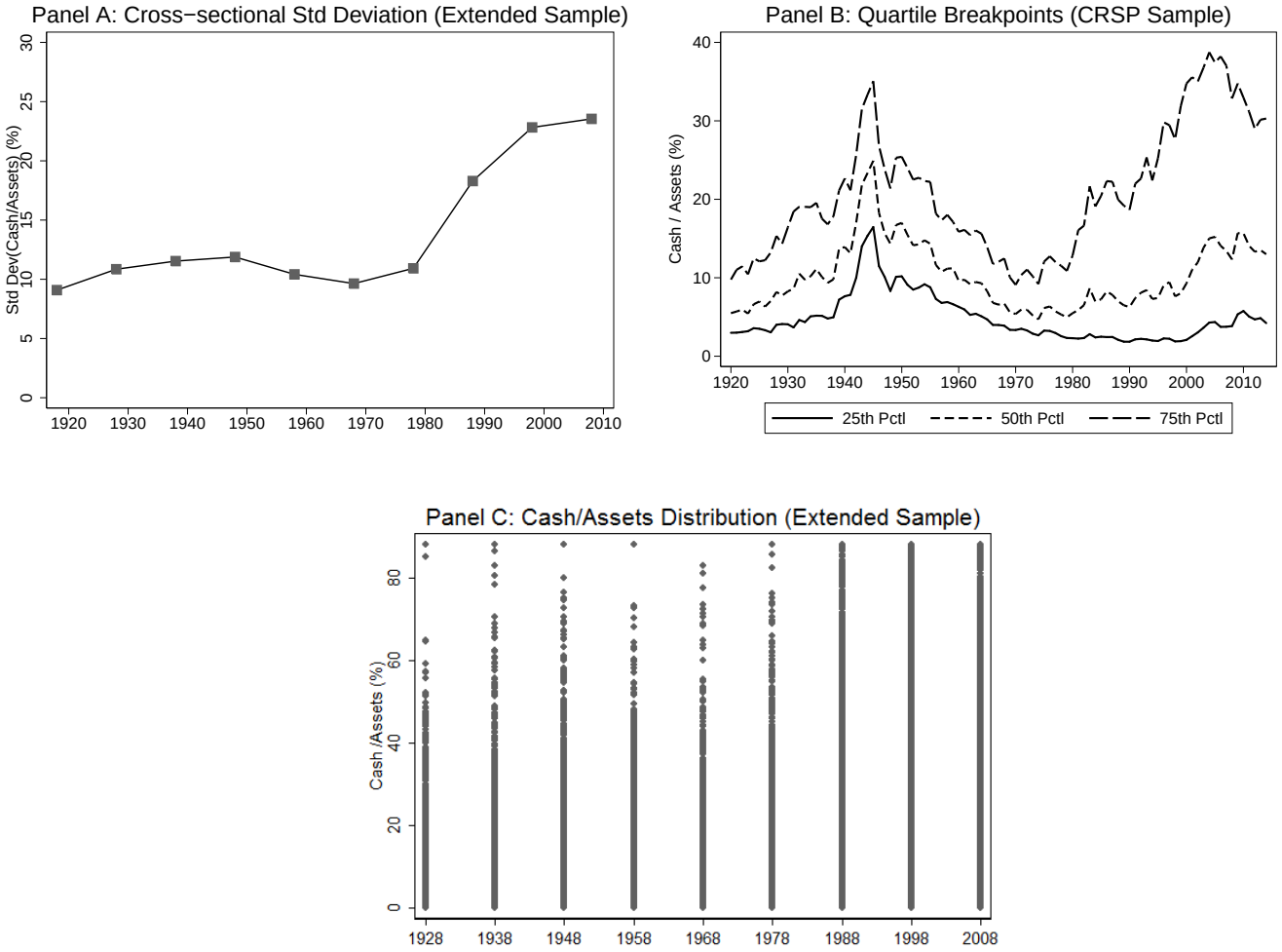
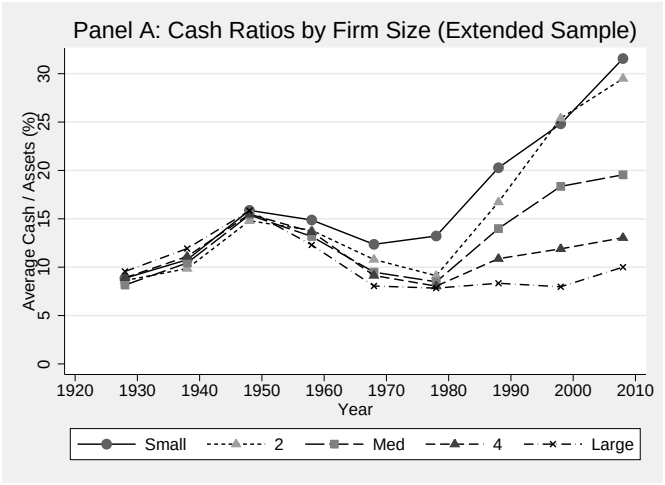
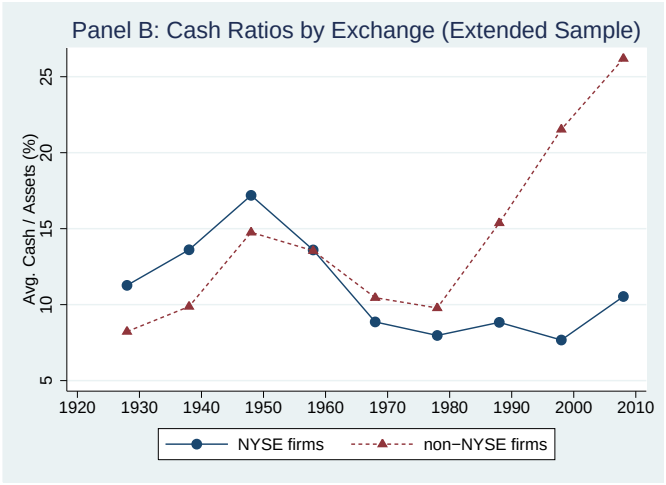
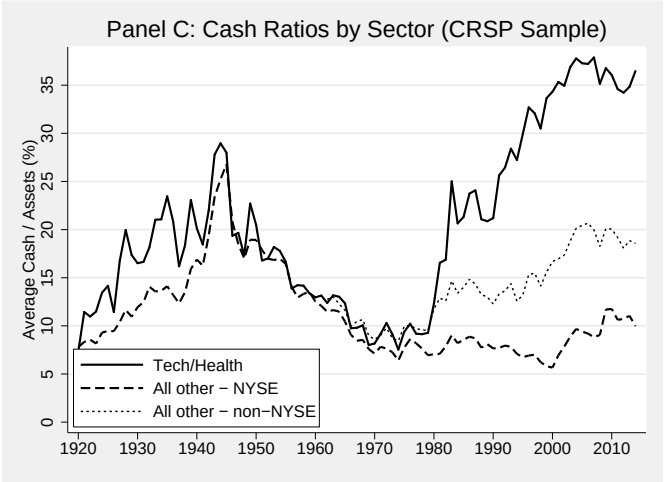


Figure 4
Cross-sectional Heterogeneity in Cash Trends

The extended sample in Panels A and B includes all firms in the Moody's Industrial Manuals for each fiscal year ending in "8". In Panels C and D, the sample includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Financial firms, utilities and railroads are excluded. Non-NYSE firms include Amex listed firms starting in 1962 and Nasdaq firms starting in 1972. Technology and healthcare firms are defined using the Fama and French 12-industry definitions and represent both NYSE and non-NYSE firms. In Panel D, new firms are those firms that appear in the sample for the first time in each year t. Each line represents the average ratio of cash and short-term investments to book assets. "All, pre-1980 entrants" is all unregulated non-financial firms on NYSE, Amex or Nasdaq that entered the CRSP sample before 1980.







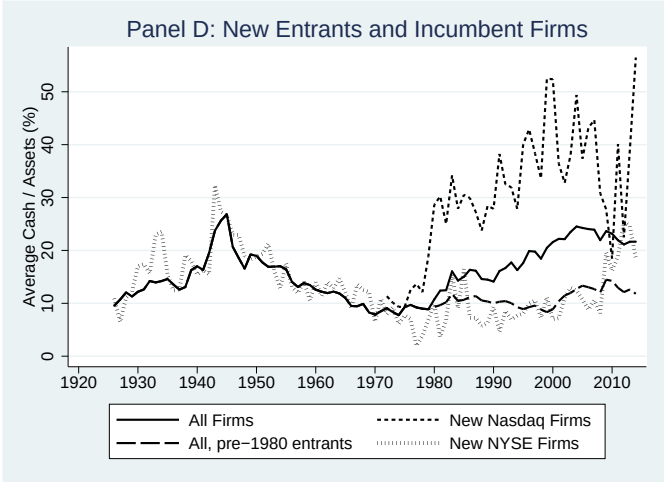
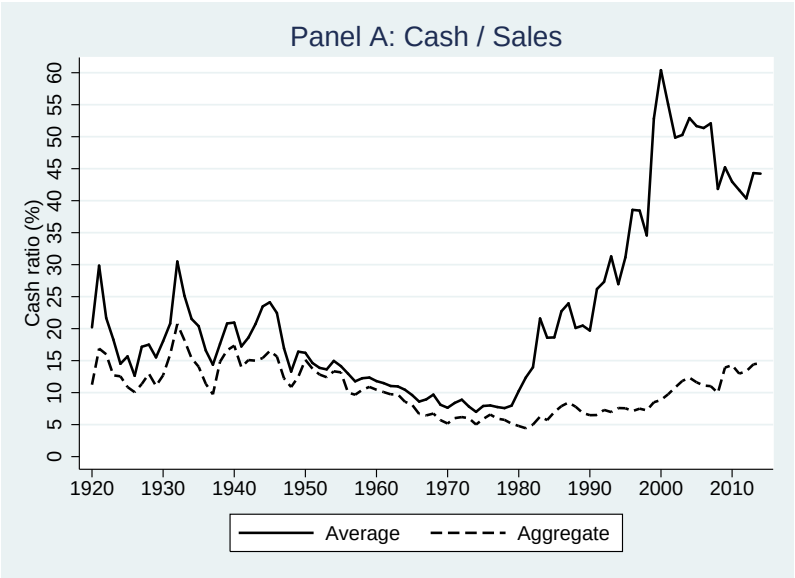


Figure 5
Alternate scalers

Figures are based on the CRSP sample, which includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Financial firms, utilities and railroads are excluded. Averages are equally weighted, with firm-level ratios trimmed at the 5th and 95th percentiles to minimize the impact of outliers. Aggregate ratios are formed by summing cash and marketable securities holdings across all firms each year and scaling by the cross-sectional sum of total sales (panel A) or market values (panel B). Market value is defined as the sum of the book value of total liabilities and the product of the fiscal year-end stock price and the number of common shares outstanding.



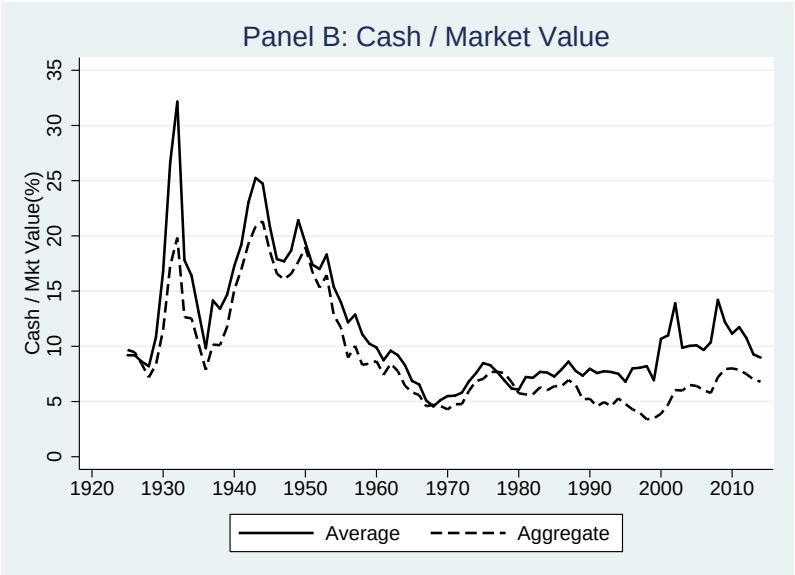


Figure 6
Cross-sectional Regressions: Coefficient Estimates Over Time

The figure plots coefficient estimates from cross-sectional regressions in Panel A of Table 4 using the extended sample. Values plotted for non-NYSE firms are calculated as the sum of the coefficient on the main effect of each variable plus the coefficient on the non-NYSE interaction variable.

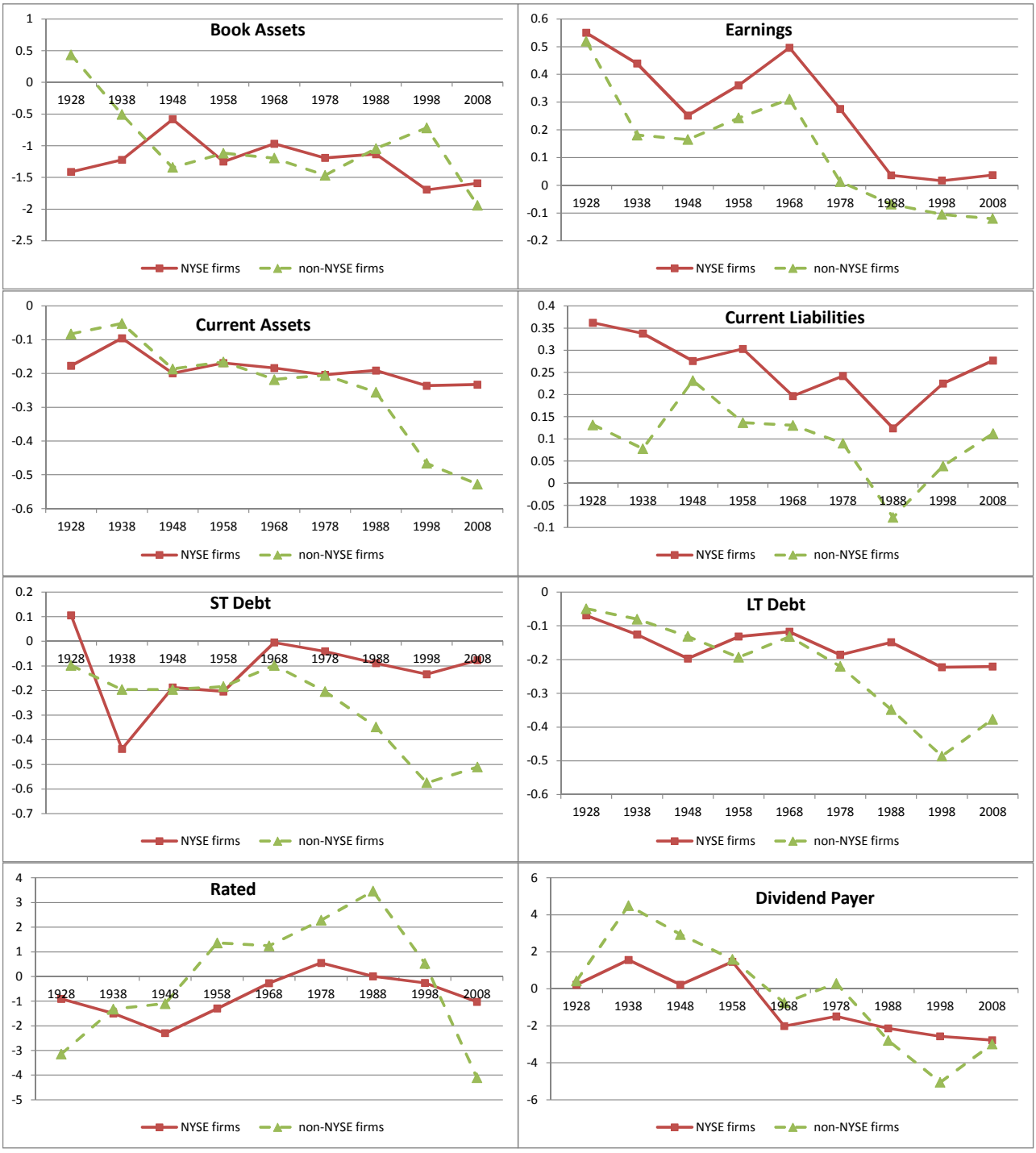


Figure 7
Cumulative Changes in Aggregate Cash Ratio: Fitted vs. Actual

The figure is based on the CRSP sample, which includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals from 1925 - 2014. Financial firms, utilities and railroads are excluded. The solid line presents cumulative annual changes in the aggregate ratio of cash and short-term investments to total assets. The dashed lines display cumulative predicted changes from estimating equation (1) in first difference form. In Panel A, the estimation includes only the firm-specific target determinants in column (5) of Table 5; in Panel B, we add the macroeconomic variables in column (7) of Table 5. Panel C is based on column (8) of Table 5, in which we add contemporaneous cash flow and investment.

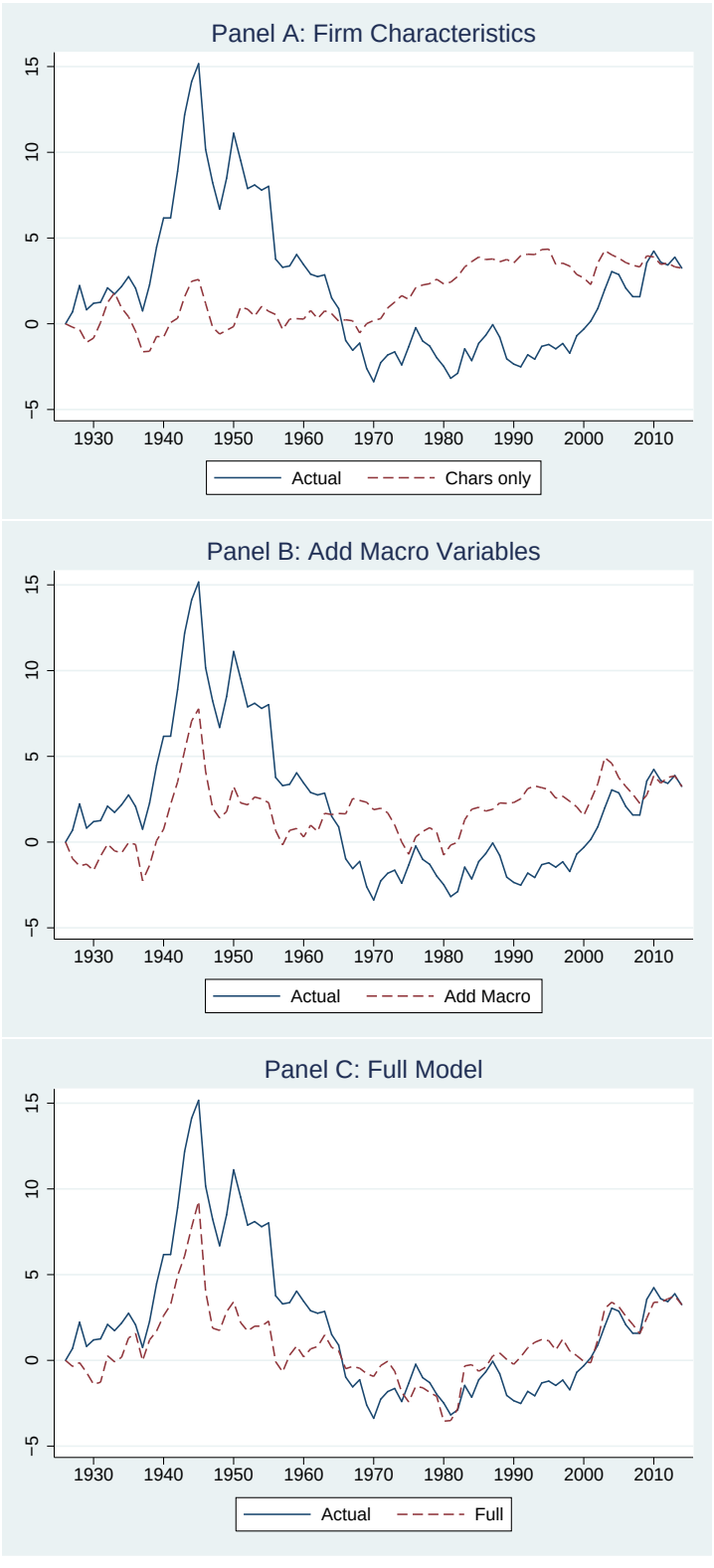
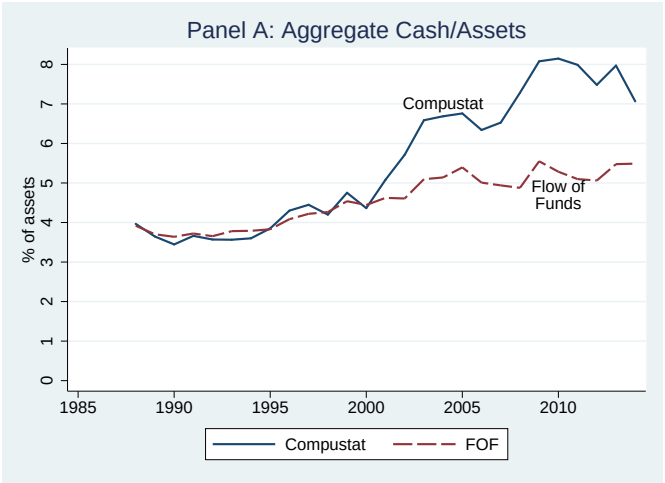
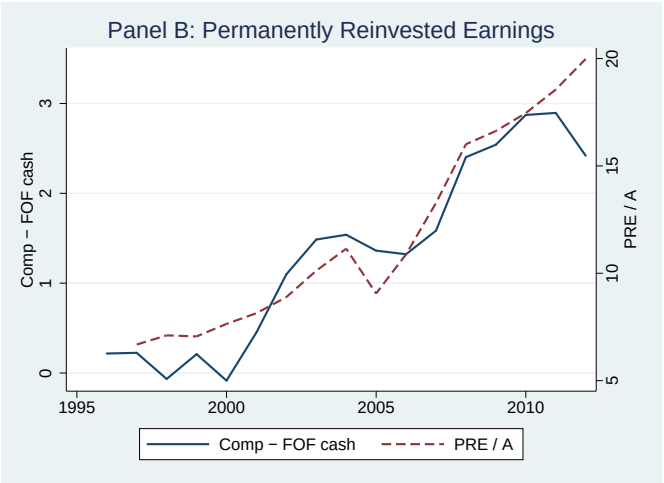
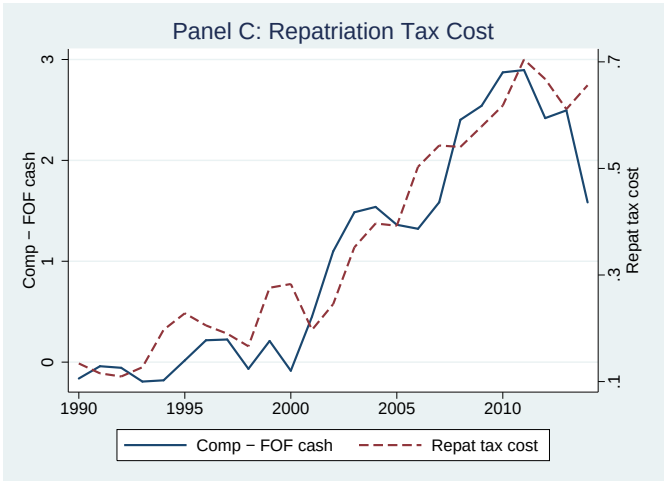


Figure 8
Cash Holdings and Repatriation Tax Incentives

In Panel A, the sample includes all firms in the intersection of the CRSP and Compustat databases, excluding financial firms, from 1985 - 2014. The Flow of Funds (FOF) data are aggregate balance sheet data for nonfinancial, non-farm businesses from US Flow of Funds. Cash excludes short-term investments. Panel B plots the aggregate ratio of permanently reinvested earnings (PRE) from Harford, Wang, and Zhang (2017) to assets versus the difference between the two lines in Panel A. In Panel C, repatriation tax cost is calculated as in Foley et al. (2007) as foreign income times the US tax rate minus taxes paid on foreign profits (or zero if this difference is negative). The time series plotted is the aggregate ratio of this estimated tax cost to total book assets. Panel D presents statutory income tax rates for the US versus OECD countries.







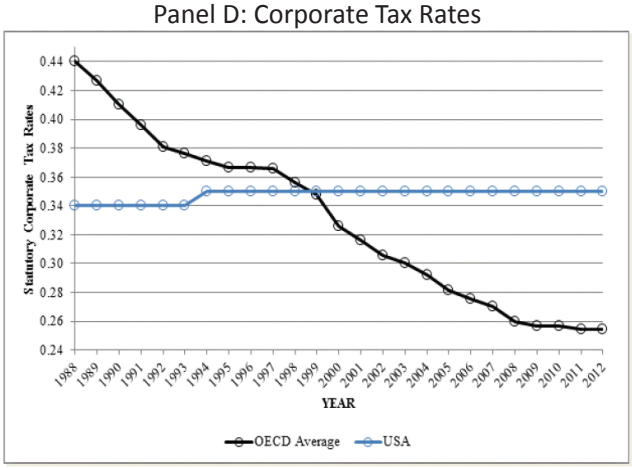


Table 1

Summary Statistics

The "CRSP sample" reported in Panels A and B covers the period 1920 - 2014 and includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. There are 176,853 firm-year observations. Financial firms, utilities and railroads are excluded. The "Extended sample" in Panel C includes all non-financial unregulated firms in the Moody's Variable Industrial Manual in each year ending in "8" (1928, 1938, etc.). In Panel B (C), averages are calculated as the equal-weighted mean of all firm-year observations within each decade (year). Variable definitions are provided in Appendix A.

Panel A: Panel Data Summary Statistics (CRSP Sample)

	mean	sd	min	max
Cash / Assets (%)	15.69	18.60	0.04	88.60
Cash / Sales (%)	25.63	71.38	0.03	587.10
Cash flow volatility	0.08	0.06	0.00	0.81
Mkt assets / Book assets	1.73	1.61	0.01	20.00
ln(Real book assets)	5.26	1.95	-1.85	12.55
(Curr. Assets - Cash) / A (%)	39.00	21.88	1.16	86.76
Curr. Liab. / A (%)	19.87	11.76	1.80	65.84
ST Debt / A (%)	5.23	8.78	0.00	50.26
LT Debt / A (%)	16.22	17.02	0.00	76.96
Dividend payer	0.45	0.50	0.00	1.00
Sales / A (%)	146.31	100.92	0.26	570.18
Earnings / A (%)	0.24	19.85	-105.56	33.36
Investment / A (%)	3.55	11.09	-23.23	64.98

Panel B: Averages by Decade (CRSP Sample)

	Obs.	Cash/ A	Cash/ S	CF vol	MA/ BA	ln(Real assets)	Curr. A/ A	Curr. Liab./A	ST D/ A	LT D/ A	Div. Pay.	Sales/ A	Earnings/ A	Invest./ A
1921–1930	1,938	11.37	18.10	0.05	1.21	5.84	29.28	6.48	2.27	8.16	0.75	95.83	7.79	3.09
1931–1940	4,994	14.18	20.67	0.06	1.00	5.68	29.24	7.61	1.84	7.99	0.62	98.50	4.91	-0.65
1941–1950	6,230	20.70	18.92	0.04	1.05	5.76	39.86	18.85	2.06	6.76	0.95	168.63	9.67	2.71
1951–1960	6,619	15.15	12.95	0.03	1.16	6.19	43.03	17.67	3.26	11.42	0.92	160.88	7.08	3.26
1961–1970	11,646	9.76	8.91	0.02	1.58	6.03	47.43	17.99	5.43	16.39	0.79	171.04	6.77	4.84
1971–1980	27,022	8.67	7.54	0.03	1.22	5.32	49.45	20.64	6.52	19.13	0.65	181.81	6.37	4.68
1981–1990	34,913	13.23	17.63	0.07	1.72	4.54	42.43	20.65	7.34	17.95	0.40	150.07	-0.63	4.21
1991–2000	41,952	16.73	31.06	0.11	2.11	4.84	37.46	21.13	5.63	16.59	0.26	142.88	-4.03	4.29
2001–2014	41,539	22.64	47.34	0.13	2.04	5.74	29.38	20.55	3.51	15.98	0.29	116.74	-3.96	1.85

Panel C: Cross-sectional Averages by Year (Extended Sample)

	Obs.	Cash/ A	Cash/ S	ln(Real assets)	Curr. A/ A	Curr. Liab./A	ST D/ A	LT D/ A	Div. Pay.	Sales/ A	Earnings/ A
1928	1,579	9.35	13.38	4.37	29.95	7.81	2.88	11.45	0.48	98.69	7.00
1938	2,213	10.93	15.29	4.05	29.29	8.63	3.26	9.58	0.46	104.47	2.62
1948	2,622	15.53	12.70	4.27	41.28	16.75	3.43	8.36	0.78	166.73	9.10
1958	2,536	13.60	12.33	4.83	43.44	15.63	4.27	11.22	0.77	151.04	4.57
1968	3,151	9.98	9.92	5.32	48.34	19.08	6.33	17.27	0.69	158.76	5.88
1978	4,638	9.37	7.90	4.76	49.83	22.06	7.23	19.58	0.60	164.13	4.95
1988	5,048	14.52	20.56	4.43	40.62	20.93	8.11	18.47	0.32	126.18	-5.05
1998	5,944	18.32	34.60	5.09	34.63	20.94	5.55	17.91	0.25	112.93	-7.88
2008	3,806	21.94	43.07	5.87	27.80	20.22	4.44	17.09	0.31	105.76	-10.63

Table 2

Time Trends in Cash Holdings

The presented CRSP sample includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. The dependent variable is the ratio of cash and short-term investments to total assets. The first four columns capture time trends in average cash holdings. Columns (5) - (8) include firm fixed effects and therefore measure average within-firm changes in cash ratios. Columns (9) and (10) measure within-firm changes in cash excluding the first four years after each firm's IPO, proxied by the first year the firm appears in our database. $t-$statistics are in parentheses. Statistical significance at the 1%, 5% and 10% levels is indicated by ***, **, and *, respectively. Standard errors are adjusted for clustering at the firm level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	1920-45	1945-80	1980-2000	2000-14	1920-45	1945-80	1980-2000	2000-14	1980-2000	2000-14
Time trend	0.636***	-0.316***	0.404***	-0.039	0.558***	-0.409***	-0.392***	-0.092***	-0.111***	0.046
	(23.93)	(-27.35)	(19.95)	(-1.01)	(18.40)	(-33.41)	(-20.37)	(-2.97)	(-5.95)	(1.42)
Firm FE					Yes	Yes	Yes	Yes	Yes	Yes
Remove 1st 4 yrs									Yes	Yes
Adj. R^2	.124	.082	.013	.000	.142	.134	.019	.001	.003	.000
N	13,529	59,803	94,968	50,217	13,529	59,803	94,968	50,217	57,135	38,858

Table 3

Relation Between Firm Characteristics and Cash Holdings

The sample includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals, excluding financial firms, utilities and railroads. The first four years of data for each firm are excluded. The dependent variable is the ratio of cash and short-term investments to total assets. Reported are the average coefficient estimates from ten cross-sectional regressions (Fama and MacBeth, 1973) over the years listed in each column heading. Column (1) includes only eight cross-sections, from 1926 through 1933 due to data limitations. $t-$statistics are in parentheses. Statistical significance at the 1%, 5% and 10% levels is indicated by ***, **, and *, respectively. Standard errors are adjusted for clustering at the firm level.

Panel A: NYSE Firms

	(1) 1926 - 1933	(2) 1934 - 1943	(3) 1944 - 1953	(4) 1954 - 1963	(5) 1964 - 1973	(6) 1974 - 1983	(7) 1984 - 1993	(8) 1994 - 2003	(9) 2004 - 2013
Ind. CF vol.	41.840*	16.678*	14.391	21.393	46.966***	28.264***	18.289***	23.197***	32.551***
	(3.36)	(2.32)	(1.22)	(2.11)	(6.75)	(12.05)	(8.15)	(9.64)	(19.30)
MA/BA	1.466	3.296***	2.309***	0.761*	1.385***	1.843***	1.595***	1.461***	1.800***
	(2.07)	(7.41)	(6.59)	(2.66)	(7.45)	(5.42)	(6.54)	(5.85)	(7.13)
Real Assets	-0.573**	-1.030***	-0.621**	-1.238***	-1.064***	-1.092***	-1.563***	-1.463***	-1.236***
	(-4.73)	(-10.21)	(-3.87)	(-28.77)	(-17.12)	(-10.34)	(-24.26)	(-20.20)	(-15.61)
Earnings/A	0.372***	0.305***	0.460***	0.448***	0.313***	0.261***	0.132***	0.028	0.093*
	(9.24)	(10.06)	(7.84)	(12.29)	(8.75)	(15.72)	(4.92)	(1.05)	(2.59)
Invest/A	-0.147***	-0.226***	-0.343***	-0.278***	-0.208***	-0.226***	-0.198***	-0.201***	-0.231***
	(-10.04)	(-6.78)	(-10.89)	(-13.42)	(-8.44)	(-16.42)	(-10.15)	(-15.16)	(-15.69)
STD / A	-0.207	-0.331***	-0.117*	-0.128***	-0.026	-0.071*	-0.102***	-0.160***	-0.162***
	(-2.30)	(-5.41)	(-3.14)	(-5.27)	(-1.84)	(-3.09)	(-8.44)	(-6.38)	(-7.36)
LTD / A	-0.106***	-0.204***	-0.175***	-0.109***	-0.091***	-0.127***	-0.154***	-0.178***	-0.200***
	(-10.41)	(-7.09)	(-15.62)	(-16.86)	(-20.43)	(-10.76)	(-17.09)	(-20.06)	(-21.63)
Curr. Assets / A	0.002	-0.102***	-0.206***	-0.175***	-0.159***	-0.147***	-0.176***	-0.151***	-0.118***
	(0.10)	(-5.05)	(-11.21)	(-21.98)	(-16.56)	(-15.73)	(-27.53)	(-19.38)	(-9.11)
Curr. Liab./ A	0.169	0.159**	0.288***	0.261***	0.128***	0.174***	0.113***	0.112***	0.136***
	(1.56)	(3.46)	(14.83)	(13.75)	(9.44)	(15.41)	(6.01)	(12.15)	(11.31)
Div. payer	2.954*	1.678	1.319	0.865*	-1.013***	-0.769*	-2.609***	-2.493***	-1.550***
	(3.20)	(1.78)	(2.23)	(2.36)	(-5.49)	(-3.17)	(-10.89)	(-10.28)	(-7.29)
Constant	8.202***	18.264***	20.746***	21.798***	18.790***	18.322***	26.196***	23.770***	20.891***
	(13.87)	(12.65)	(13.58)	(30.97)	(21.93)	(13.42)	(36.04)	(38.59)	(15.63)
Avg. R^2	0.314	0.324	0.330	0.355	0.340	0.293	0.222	0.244	0.291
N	2,439	4,407	6,097	6,459	7,641	9,805	7,820	8,497	8,094

Panel B: All Firms

	(1) 1926 - 1933	(2) 1934 - 1943	(3) 1944 - 1953	(4) 1954 - 1963	(5) 1964 - 1973	(6) 1974 - 1983	(7) 1984 - 1993	(8) 1994 - 2003	(9) 2004 - 2013
Ind. CF vol.	41.840*	16.678*	14.391	20.660	32.597***	24.768***	9.695*	50.359***	62.730***
	(3.36)	(2.32)	(1.22)	(2.08)	(5.04)	(4.95)	(2.67)	(11.36)	(43.49)
MA/BA	1.466	3.296***	2.309***	0.743*	1.175***	1.627***	1.673***	2.144***	2.615***
	(2.07)	(7.41)	(6.59)	(2.65)	(9.12)	(8.34)	(11.86)	(27.80)	(30.99)
Real Assets	-0.573**	-1.030***	-0.621**	-1.242***	-1.100***	-1.189***	-1.172***	-0.739***	-1.221***
	(-4.73)	(-10.21)	(-3.87)	(-28.12)	(-18.09)	(-10.75)	(-15.48)	(-11.62)	(-10.70)
Earnings/A	0.372***	0.305***	0.460***	0.454***	0.280***	0.221***	0.128***	-0.015	-0.100***
	(9.24)	(10.06)	(7.84)	(12.89)	(11.42)	(12.41)	(6.31)	(-0.92)	(-7.38)
Invest/A	-0.147***	-0.226***	-0.343***	-0.269***	-0.193***	-0.234***	-0.208***	-0.273***	-0.320***
	(-10.04)	(-6.78)	(-10.89)	(-13.99)	(-8.95)	(-20.86)	(-19.05)	(-20.08)	(-12.64)
STD / A	-0.207	-0.331***	-0.117*	-0.134***	-0.078**	-0.149***	-0.277***	-0.353***	-0.343***
	(-2.30)	(-5.41)	(-3.14)	(-5.25)	(-4.70)	(-8.87)	(-15.12)	(-18.79)	(-12.93)
LTD / A	-0.106***	-0.204***	-0.175***	-0.109***	-0.112***	-0.180***	-0.247***	-0.294***	-0.297***
	(-10.41)	(-7.09)	(-15.62)	(-16.73)	(-16.08)	(-17.18)	(-25.14)	(-37.99)	(-34.98)
Curr. Assets / A	0.002	-0.102***	-0.206***	-0.173***	-0.140***	-0.157***	-0.200***	-0.261***	-0.345***
	(0.10)	(-5.05)	(-11.21)	(-20.63)	(-15.47)	(-19.30)	(-38.28)	(-19.48)	(-46.03)
Curr. Liab./ A	0.169	0.159**	0.288***	0.257***	0.067***	0.094***	-0.008	0.039*	0.092***
	(1.56)	(3.46)	(14.83)	(12.33)	(8.27)	(6.82)	(-0.64)	(2.95)	(7.80)
Div. payer	2.954*	1.678	1.319	0.776	-0.420	-0.731**	-2.422***	-2.669***	-1.421***
	(3.20)	(1.78)	(2.23)	(1.93)	(-1.40)	(-3.36)	(-11.34)	(-11.10)	(-7.69)
Non-NYSE					-0.286	-0.255**	0.968**	3.367***	4.112***
					(-2.20)	(-4.25)	(3.44)	(11.30)	(22.62)
Constant	8.202***	18.264***	20.746***	21.865***	20.180***	23.273***	30.029***	24.182***	27.979***
	(13.87)	(12.65)	(13.58)	(30.05)	(27.27)	(16.35)	(50.20)	(52.52)	(26.01)
Avg. R^2	0.314	0.324	0.330	0.355	0.289	0.284	0.295	0.421	0.492
N	2,439	4,407	6,097	6,535	10,672	21,497	22,522	25,467	23,062

Table 4

Relation Between Firm Characteristics and Cash Holdings: NYSE vs. Non-NYSE firms

Panel A uses the extended sample, which includes all firms in the Moody's Industrial Manual for each year ending in "8" (e.g., 1938) from 1928 through 2008 and presents coefficient estimates from one cross-sectional regression for each of these years. The sample in Panel B covers the period 1926 - 2014 and includes all firms in the CRSP database (excluding financial firms, utilities and railroads) that are also covered either in Compustat or Moody's Industrial Manuals. Panel B presents average coefficient estimates from ten cross-sectional regressions (Fama and MacBeth, 1973). The dependent variable is the ratio of cash and short-term investments to total assets. $t-$statistics are in parentheses. Statistical significance at the 1%, 5% and 10% levels is indicated by ***, **, and *, respectively.

Panel A: Extended Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	1928	1938	1948	1958	1968	1978	1988	1998	2008
Book Assets	-1.413*	-1.224***	-0.583	-1.252***	-0.969***	-1.193***	-1.133***	-1.695***	-1.592***
	(-2.12)	(-3.87)	(-1.88)	(-5.23)	(-4.79)	(-5.92)	(-3.67)	(-5.33)	(-5.72)
x non-NYSE	1.848**	0.716	-0.761	0.132	-0.227	-0.273	0.089	0.977*	-0.350
	(2.59)	(1.77)	(-1.89)	(0.41)	(-0.83)	(-1.09)	(0.24)	(2.49)	(-0.86)
Earnings / A	0.550***	0.439***	0.252***	0.361***	0.496***	0.275**	0.036	0.017	0.037
	(3.63)	(5.14)	(3.80)	(4.40)	(5.38)	(2.93)	(0.98)	(0.61)	(1.49)
x non-NYSE	-0.030	-0.258**	-0.087	-0.118	-0.185	-0.262**	-0.104**	-0.122***	-0.157***
	(-0.18)	(-2.60)	(-1.16)	(-1.09)	(-1.81)	(-2.69)	(-2.66)	(-4.08)	(-5.46)
STD / A	0.105	-0.438***	-0.188**	-0.204***	-0.005	-0.041	-0.089	-0.134***	-0.077
	(0.64)	(-6.25)	(-2.89)	(-4.96)	(-0.14)	(-0.95)	(-1.93)	(-3.63)	(-1.82)
x non-NYSE	-0.203	0.242**	-0.008	0.020	-0.093*	-0.163***	-0.259***	-0.441***	-0.434***
	(-1.21)	(3.11)	(-0.10)	(0.39)	(-2.16)	(-3.43)	(-5.03)	(-9.44)	(-7.41)
LTD / A	-0.069	-0.126***	-0.197***	-0.132***	-0.118***	-0.186***	-0.149***	-0.223***	-0.221***
	(-1.08)	(-4.19)	(-5.78)	(-4.96)	(-4.62)	(-7.16)	(-5.67)	(-11.00)	(-10.41)
x non-NYSE	0.020	0.046	0.066	-0.061	-0.014	-0.034	-0.199***	-0.263***	-0.156***
	(0.29)	(1.36)	(1.56)	(-1.85)	(-0.45)	(-1.16)	(-6.55)	(-9.34)	(-4.52)
Curr. Assets / A	-0.177***	-0.096***	-0.199***	-0.169***	-0.184***	-0.204***	-0.191***	-0.236***	-0.233***
	(-5.34)	(-3.33)	(-8.26)	(-7.57)	(-9.67)	(-11.15)	(-9.65)	(-9.38)	(-8.04)
x non-NYSE	0.094*	0.044	0.012	0.003	-0.034	-0.001	-0.064**	-0.230***	-0.295***
	(2.56)	(1.38)	(0.42)	(0.12)	(-1.42)	(-0.07)	(-2.68)	(-7.82)	(-8.30)
Curr. Liab./ A	0.362**	0.338*	0.276***	0.303***	0.197***	0.242***	0.124***	0.225***	0.277***
	(3.29)	(2.43)	(5.16)	(6.22)	(5.00)	(6.81)	(3.49)	(6.30)	(6.96)
x non-NYSE	-0.230	-0.260	-0.044	-0.166**	-0.066	-0.152***	-0.202***	-0.186***	-0.165**
	(-1.86)	(-1.80)	(-0.66)	(-2.79)	(-1.41)	(-3.74)	(-4.72)	(-4.34)	(-3.17)
Div. payer	0.218	1.558	0.226	1.467	-2.014*	-1.491	-2.144*	-2.570***	-2.777***
	(0.18)	(1.69)	(0.17)	(1.43)	(-2.14)	(-1.80)	(-2.56)	(-4.43)	(-4.12)
x non-NYSE	0.214	2.946**	2.719	0.129	1.257	1.791	-0.648	-2.489**	-0.211
	(0.16)	(2.63)	(1.85)	(0.11)	(1.20)	(1.95)	(-0.62)	(-2.66)	(-0.18)
Rated	-0.907	-1.499	-2.304*	-1.298*	-0.266	0.548	0.011	-0.263	-1.024
	(-0.59)	(-1.72)	(-2.45)	(-2.37)	(-0.68)	(1.26)	(0.01)	(-0.43)	(-1.56)
x non-NYSE	-2.241	0.178	1.203	2.665*	1.510*	1.734*	3.445**	0.795	-3.087*
	(-1.30)	(0.17)	(0.91)	(2.50)	(2.24)	(2.03)	(2.82)	(0.64)	(-2.08)
non-NYSE	-8.305*	-7.228***	-3.428	0.969	3.767	5.385	13.846***	20.027***	24.140***
	(-2.20)	(-3.80)	(-1.49)	(0.42)	(1.40)	(1.81)	(5.09)	(6.56)	(6.81)
Constant	15.796***	17.787***	22.549***	21.006***	19.834***	22.738***	26.412***	30.800***	32.022***
	(4.30)	(10.23)	(11.04)	(10.40)	(8.40)	(8.34)	(10.70)	(11.21)	(10.95)
Adj. R^2	0.264	0.224	0.247	0.273	0.294	0.301	0.334	0.479	0.459
N	1,571	2,211	2,622	2,535	3,150	4,573	4,867	5,776	3,733

Panel B: CRSP Sample

	(1) 1926 - 1933	(2) 1934 - 1943	(3) 1944 - 1953	(4) 1954 - 1963	(5) 1964 - 1973	(6) 1974 - 1983	(7) 1984 - 1993	(8) 1994 - 2003	(9) 2004 - 2013
Ind. CF vol.	41.840*	16.678*	14.391	20.660	46.089***	28.025***	17.459***	24.008***	32.559***
	(3.36)	(2.32)	(1.22)	(2.08)	(6.79)	(11.37)	(7.82)	(10.04)	(19.26)
x non-NYSE					-53.284**	-5.646	-12.146	36.106***	41.141***
					(-3.45)	(-0.68)	(-1.85)	(6.68)	(11.80)
MA/BA	1.466	3.296***	2.309***	0.743*	1.378***	1.811***	1.653***	1.485***	1.836***
	(2.07)	(7.41)	(6.59)	(2.65)	(7.50)	(5.10)	(6.42)	(6.01)	(7.47)
x non-NYSE					-0.855*	-0.568	0.118	0.649*	0.582*
					(-3.12)	(-1.32)	(0.34)	(2.39)	(2.32)
Real Assets	-0.573**	-1.030***	-0.621**	-1.242***	-1.070***	-1.091***	-1.578***	-1.466***	-1.220***
	(-4.73)	(-10.21)	(-3.87)	(-28.12)	(-16.61)	(-9.61)	(-23.46)	(-21.65)	(-16.00)
x non-NYSE					-0.373*	-0.233*	0.707***	1.280***	0.006
					(-2.42)	(-2.62)	(4.88)	(10.88)	(0.04)
Earnings/A	0.372***	0.305***	0.460***	0.454***	0.314***	0.262***	0.133***	0.028	0.086*
	(9.24)	(10.06)	(7.84)	(12.89)	(8.09)	(15.63)	(4.80)	(1.09)	(2.50)
x non-NYSE					-0.042	-0.057	-0.008	-0.038	-0.178***
					(-0.64)	(-1.88)	(-0.31)	(-1.35)	(-4.95)
Invest/A	-0.147***	-0.226***	-0.343***	-0.269***	-0.209***	-0.225***	-0.198***	-0.202***	-0.230***
	(-10.04)	(-6.78)	(-10.89)	(-13.99)	(-8.51)	(-17.36)	(-10.06)	(-14.14)	(-15.24)
x non-NYSE					0.022	-0.012	-0.011	-0.092***	-0.134*
					(0.53)	(-1.09)	(-0.66)	(-5.37)	(-3.10)
STD / A	-0.207	-0.331***	-0.117*	-0.134***	-0.025	-0.069*	-0.103***	-0.160***	-0.163***
	(-2.30)	(-5.41)	(-3.14)	(-5.25)	(-1.75)	(-2.89)	(-8.25)	(-6.22)	(-7.64)
x non-NYSE					-0.125**	-0.106***	-0.204***	-0.204***	-0.224***
					(-4.64)	(-7.33)	(-16.62)	(-11.75)	(-8.63)
LTD / A	-0.106***	-0.204***	-0.175***	-0.109***	-0.091***	-0.125***	-0.155***	-0.178***	-0.201***
	(-10.41)	(-7.09)	(-15.62)	(-16.73)	(-21.20)	(-10.60)	(-18.45)	(-20.74)	(-23.68)
x non-NYSE					-0.045*	-0.082***	-0.133***	-0.165***	-0.120***
					(-2.50)	(-10.40)	(-14.74)	(-17.31)	(-5.69)
Curr. Assets / A	0.002	-0.102***	-0.206***	-0.173***	-0.159***	-0.149***	-0.179***	-0.151***	-0.118***
	(0.10)	(-5.05)	(-11.21)	(-20.63)	(-16.75)	(-16.68)	(-28.04)	(-20.59)	(-9.24)
x non-NYSE					0.050**	-0.015**	-0.031***	-0.144***	-0.289***
					(4.30)	(-3.51)	(-4.80)	(-6.01)	(-29.66)
Curr. Liab./ A	0.169	0.159**	0.288***	0.257***	0.129***	0.176***	0.114***	0.108***	0.136***
	(1.56)	(3.46)	(14.83)	(12.33)	(9.74)	(16.55)	(5.76)	(10.25)	(11.69)
x non-NYSE					-0.157***	-0.122***	-0.157***	-0.092**	-0.084***
					(-5.62)	(-7.91)	(-10.26)	(-4.59)	(-5.54)
Div. payer	2.954*	1.678	1.319	0.776	-0.946**	-0.740*	-2.670***	-2.542***	-1.578***
	(3.20)	(1.78)	(2.23)	(1.93)	(-4.77)	(-2.99)	(-10.14)	(-11.08)	(-7.86)
x non-NYSE					0.873	0.005	0.492	-0.022	0.220
					(1.26)	(0.02)	(1.13)	(-0.06)	(0.69)
Non-NYSE					5.434**	7.807***	5.469**	2.769**	13.344***
					(4.58)	(9.32)	(4.68)	(4.77)	(16.86)
Constant	8.202***	18.264***	20.746***	21.865***	18.793***	18.326***	26.452***	23.761***	20.778***
	(13.87)	(12.65)	(13.58)	(30.05)	(21.19)	(13.06)	(33.17)	(46.81)	(16.64)
Adj. R^2									
N	2,439	4,407	6,097	6,535	10,672	21,497	22,522	25,467	23,062

Table 5

Aggregate Cash: Time-series Regressions

The sample covers the period 1926 - 2014 and includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Financial firms, utilities and railroads are excluded. The dependent variable is the aggregate ratio of cash and short-term investments to total assets. The model is estimated in levels in columns (1) - (4) and in first differences in columns (5) - (8). Newey and West (1987) standard errors, assuming two non-zero lags are used to compute all $t-$statistics (in parentheses). Statistical significance at the 1%, 5% and 10% levels is indicated by ***, **, and *, respectively.

	Levels				1st Diffs			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Firm Characteristics								
CF vol.	-1.616**	0.193	-0.009	-0.011	-0.186	-0.003	-0.030	-0.000
	(-2.10)	(0.38)	(-0.02)	(-0.02)	(-1.07)	(-0.02)	(-0.19)	(-0.00)
MA/BA	-0.229	-1.272***	-1.259***	-0.906**	-0.291**	-0.491***	-0.516***	-0.327**
	(-0.92)	(-3.06)	(-3.04)	(-2.21)	(-2.43)	(-2.91)	(-3.24)	(-2.06)
Real Assets	-2.176***	-1.618***	-1.270***	-0.850**	-0.119	-0.023	-0.010	0.009
	(-3.10)	(-3.61)	(-3.29)	(-2.32)	(-1.30)	(-0.24)	(-0.10)	(0.11)
E[CF]	0.628	0.634**	0.647*	0.659*	0.011	-0.077	-0.062	0.164
	(1.45)	(2.00)	(1.91)	(1.92)	(0.05)	(-0.42)	(-0.33)	(0.80)
E[Invest]	-0.614**	-0.345	-0.233	0.068	-0.138	0.268	0.277	0.116
	(-2.08)	(-1.48)	(-1.01)	(0.30)	(-0.78)	(1.39)	(1.47)	(0.69)
STD/A	-0.683	-1.298***	-1.589***	-1.355***	-0.037	0.015	0.014	0.002
	(-1.54)	(-3.19)	(-4.33)	(-3.80)	(-0.27)	(0.13)	(0.12)	(0.02)
LTD/A	1.700**	1.934***	2.186***	1.697**	0.107	0.023	0.013	-0.053
	(2.32)	(2.76)	(2.83)	(2.52)	(0.86)	(0.13)	(0.08)	(-0.40)
Curr. Assets	-4.052***	-2.629***	-2.755***	-2.900***	-0.570**	-0.409*	-0.437**	-0.382*
	(-4.38)	(-3.74)	(-3.60)	(-3.05)	(-2.03)	(-1.98)	(-2.06)	(-1.72)
Other CL/A	5.189***	2.237***	2.765***	3.022***	0.494	-0.085	-0.017	-0.005
	(9.47)	(2.98)	(3.82)	(5.67)	(1.34)	(-0.39)	(-0.09)	(-0.03)
Earn/A				0.996***				0.610***
				(2.97)				(3.30)
Invest				-0.953***				-0.802***
				(-3.28)				(-4.68)
Macroeconomic Factors								
Cost of carry		-0.370	-0.433*	-0.348		-0.090	-0.084	-0.072
		(-1.39)	(-1.75)	(-1.58)		(-0.58)	(-0.55)	(-0.59)
AAA-Treasury spread		0.105	0.126	0.171		-0.148	-0.159	-0.145
		(0.53)	(0.69)	(0.96)		(-1.11)	(-1.20)	(-1.25)
sd(Mkt Ret.)		-0.066	-0.092	-0.071		-0.147	-0.150	-0.083
		(-0.34)	(-0.48)	(-0.41)		(-0.89)	(-0.90)	(-0.63)
Econ policy uncert.		0.019	-0.010	0.200		0.133	0.162	0.162
		(0.08)	(-0.04)	(0.80)		(0.89)	(1.16)	(1.31)
Real GDP growth		0.303	0.332	0.012		0.729**	0.769***	0.479**
		(1.32)	(1.47)	(0.05)		(2.60)	(2.85)	(2.04)
Productivity		1.710***	1.694***	1.562***		0.907***	0.901***	0.775***
		(4.28)	(4.29)	(4.31)		(4.36)	(4.50)	(4.61)
Corp. tax rate		8.070*				0.139		
		(1.80)				(1.41)		
Cubic trend	Yes	Yes	Yes	Yes				
Adj. R^2	0.92	0.95	0.95	0.96	0.09	0.36	0.36	0.53
N	89	89	89	89	88	88	88	88

Table 6

Contribution to Explanatory Power: Aggregate Regressions

The table reports adjusted r-squares and root mean squared errors for various specifications of the aggregate regressions from Table 5 estimated in first differences. In Panel B, we measure out of sample fit by successively excluding each year from the sample period and using the resulting parameter estimates to predict changes in aggregate cash for the excluded year.

Panel A: In-sample

	Adjusted R^2	RMSE		Adjusted R^2	RMSE
Constant only	0.000	1.276	Full Model	0.535	0.871
Add:			*Remove:*		
Cost of carry	-0.008	1.281	Cost of carry	0.538	0.867
AAA-Treasury spread	0.006	1.272	AAA-Treasury spread	0.531	0.874
sd(Mkt Ret.)	0.025	1.260	sd(Mkt Ret.)	0.538	0.867
Econ. Policy Uncert.	-0.011	1.283	Econ. Policy Uncert.	0.528	0.876
GDP growth	0.011	1.269	GDP growth	0.494	0.908
Productivity	0.104	1.208	Productivity	0.372	1.011
Corp. CF & Invest.	0.323	1.050	Corp. CF & Invest.	0.362	1.020
Productivity, CF & Invest.	0.480	0.920	Productivity, CF & Invest.	0.142	1.182

Panel B: Out of sample (cross-validation)

	RMSE		RMSE
Constant only	1.283	Full Model	1.040
Add:		*Remove:*	
Cost of carry	1.271	Cost of carry	1.027
AAA-Treasury spread	1.280	AAA-Treasury spread	1.039
sd(Mkt Ret.)	1.272	sd(Mkt Ret.)	1.026
Econ. Policy Uncert.	1.296	Econ. Policy Uncert.	1.030
GDP growth	1.299	GDP growth	1.089
Productivity	1.226	Productivity	1.233
Corp. CF & Invest.	1.089	Corp. CF & Invest.	1.152

Table 7

Aggregate Cash and Repatriation Tax Cost

The sample period is 1981 through 2014. Columns (1) and (2) present panel regressions, where the dependent variable is the cash-to-assets ratio. Columns (3)-(6) present aggregate time-series regressions. In columns (3) and (4), the dependent variable is the difference between the ratios of aggregate cash to assets measured using data from US Flow of Funds versus using Compustat and is interpreted as a proxy for "trapped" foreign cash. In columns (5) and (6), the dependent variable is the aggregate ratio of cash and short-term investments to assets from Compustat, which includes domestic plus foreign held cash. *Repat tax cost* is calculated, as in Foley et al. (2007), by first subtracting foreign taxes paid from the product of a firm's foreign pretax income and the U.S. corporate tax rate. Then the maximum of this difference and zero is aggregated across all firms each year and scaled by aggregate book assets. *Earnings* is income before extraordinary items. *NWC* is current assets, net of cash and short-term investments, minus current liabilities. Newey-West (1987) standard errors assuming two non-zero lags are used to compute all t-statistics (in parentheses).

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel Regs.		Aggregate Regressions			
			Comp - FOF cash	Comp - FOF cash	Compustat	Compustat
Repat tax cost (MA)	0.67***	0.50***	1.81***	2.29***	1.68***	2.47***
	(5.64)	(4.22)	(4.35)	(3.42)	(3.16)	(3.29)
Time			-0.03	-0.35***	0.03	-0.41***
			(-0.70)	(-3.09)	(0.44)	(-3.35)
CF vol.	0.14	0.24		-0.10		-0.13
	(0.75)	(1.29)		(-0.26)		(-0.24)
MA/BA	1.70***	1.94***		0.08		0.32
	(5.18)	(5.70)		(0.27)		(0.90)
NWC/A	-6.32***	-6.28***		-0.02		-0.05
	(-20.12)	(-19.16)		(-0.06)		(-0.11)
Real size	-3.47***	-4.05***		1.72***		2.01***
	(-7.97)	(-8.74)		(3.82)		(3.36)
D/A	-2.07***	-1.94***		-0.29**		-0.59***
	(-9.21)	(-8.55)		(-2.14)		(-3.55)
Earn/A	1.43***	1.47***		0.17		0.09
	(5.80)	(5.88)		(1.01)		(0.43)
Capex/A	-1.90***	-1.81***		-1.03***		-1.43***
	(-14.56)	(-13.36)		(-3.14)		(-2.92)
Cost of carry		-0.19		-0.03		-0.17
		(-1.60)		(-0.07)		(-0.37)
AAA-Treas. spread		-0.49***		-0.12		-0.20
		(-3.59)		(-0.58)		(-0.93)
sd(Mkt return)		-5.61		0.30**		0.26**
		(-0.35)		(2.77)		(2.43)
Econ policy uncert.		0.00		0.34**		0.28*
		(1.05)		(2.73)		(1.85)
Real GDP growth		0.00		0.04		0.03
		(0.08)		(0.31)		(0.22)
Productivity		-29.02***		0.70**		0.72*
		(-10.40)		(2.58)		(2.02)
Fixed Effects	Yes	Yes				
Adj. R^2	0.172	0.188	0.852	0.930	0.833	0.947
N	31,163	31,163	34	34	34	34

Table 8

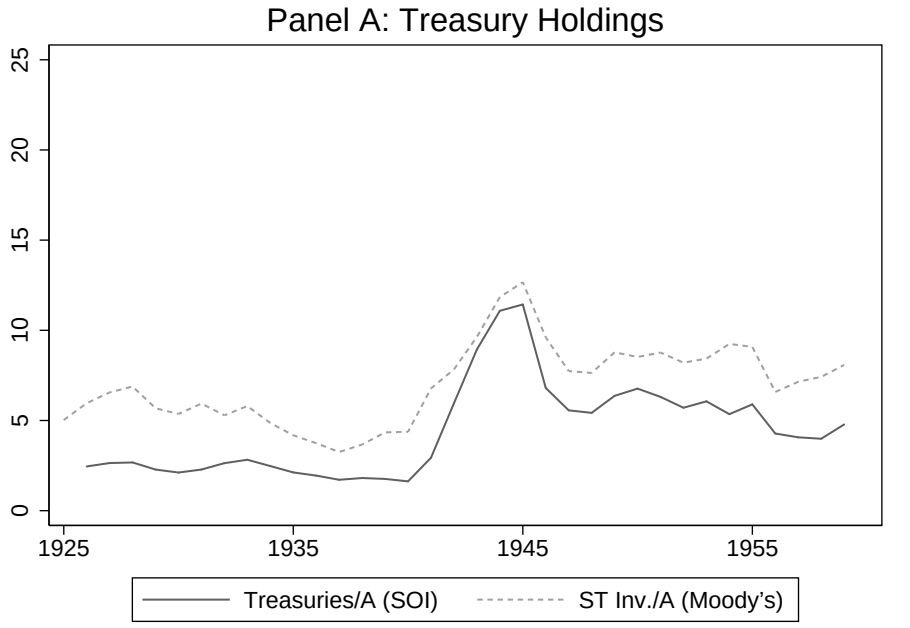
Pre-War Cash Run-up: Cross-sectional evidence

The sample period is 1936 through 1945. Regressions use the CRSP sample, which includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Financial firms, utilities and railroads are excluded. The dependent variable is the ratio of cash and short-term investments to total assets. All models include firm fixed effects. Other controls in columns (4) through (8) include all independent variables used in Table 3. Standard errors are clustered by firm. $t-$statistics are in parentheses. Statistical significance at the 1%, 5% and 10% levels is indicated by ***, **, and *, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Financial Constraint Measures								Sales Growth	
	Unrated/ speculative	Small Firms	Non-Payers	UPT Margin	Unrated/ speculative	Small Firms	Non-Payers	UPT Margin		
Time	1.161***	1.450***	1.420***	1.102***	0.856***	1.163***	1.136***	0.901***	1.500***	1.309***
	(6.54)	(11.10)	(14.41)	(6.39)	(5.73)	(9.69)	(12.73)	(5.66)	(8.86)	(8.18)
Time x Constr.	0.856***	0.507*	0.861**		0.671***	0.399*	0.558*			
	(3.85)	(2.23)	(3.24)		(4.19)	(2.14)	(2.43)			
Time x Type B				0.357				0.263		
				(1.51)				(1.40)		
Time x Type C				0.809***				0.487**		
				(3.63)				(2.72)		
Time x High									-0.286	-0.418
									(-1.08)	(-1.72)
Constant	4.982***	10.083***	10.759***	10.759***	35.436***	39.201***	25.870***	26.355***	10.846***	18.851
	(8.27)	(16.14)	(21.37)	(21.50)	(3.44)	(4.59)	(3.88)	(3.95)	(14.75)	(1.83)
Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other controls					Yes	Yes	Yes	Yes		Yes
Adj. R^2	0.387	0.312	0.275	0.279	0.505	0.456	0.414	0.415	0.249	0.353
N	1,580	2,200	3,300	3,300	1,555	2,169	3,254	3,254	1,165	1,163

Figure A.1. Cash and Treasury Holdings around WWII

Panel A plots the aggregate ratio of corporate holdings of government securities to book assets from U.S. *Statistics of Income* (solid line) and the aggregate ratio of Short-term investments to assets using data collected from Moody's Industrial manuals (dashed line). The latter is from the CRSP sample, which includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Financial firms, utilities and railroads are excluded. Panel B plots the aggregate ratio of cash and short term investments to assets in the dashed line. The solid line plots aggregate cash to assets excluding war-related Treasury holdings, which are estimated as described in Appendix B.



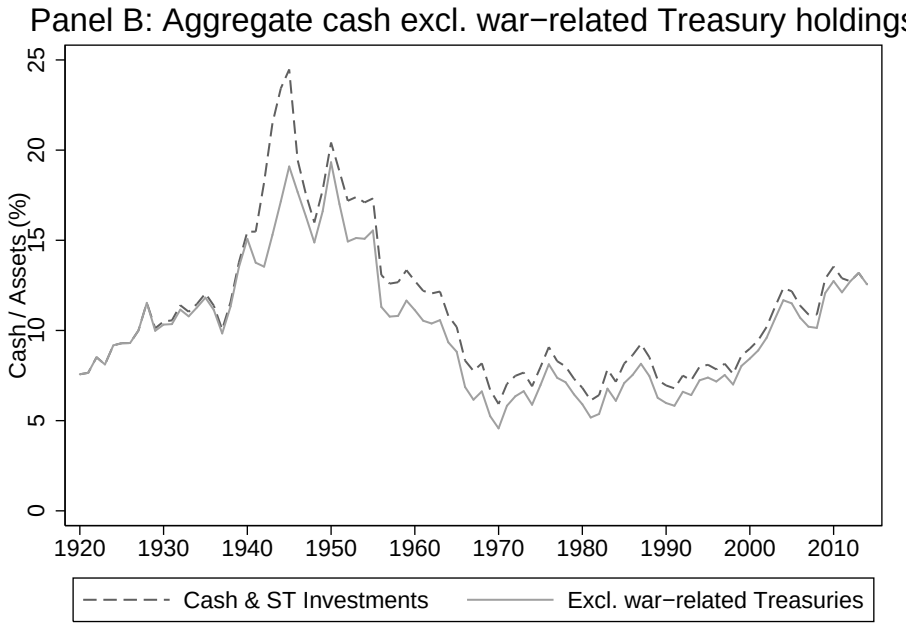


Figure A.2. Distribution of Firm Size: Extended Sample vs. CRSP Sample

The CRSP sample includes all firms in the CRSP database that are also covered either in Compustat or Moody's Industrial Manuals. Financial firms, utilities and railroads are excluded. The Extended sample includes all firms covered in the Moody's Industrial Manual each year (for years ending in "8"). Firm size is measured by book assets, expressed in constant (1994) dollars. For ease of presentation, we winsorize the upper 5% of the size distribution each year.

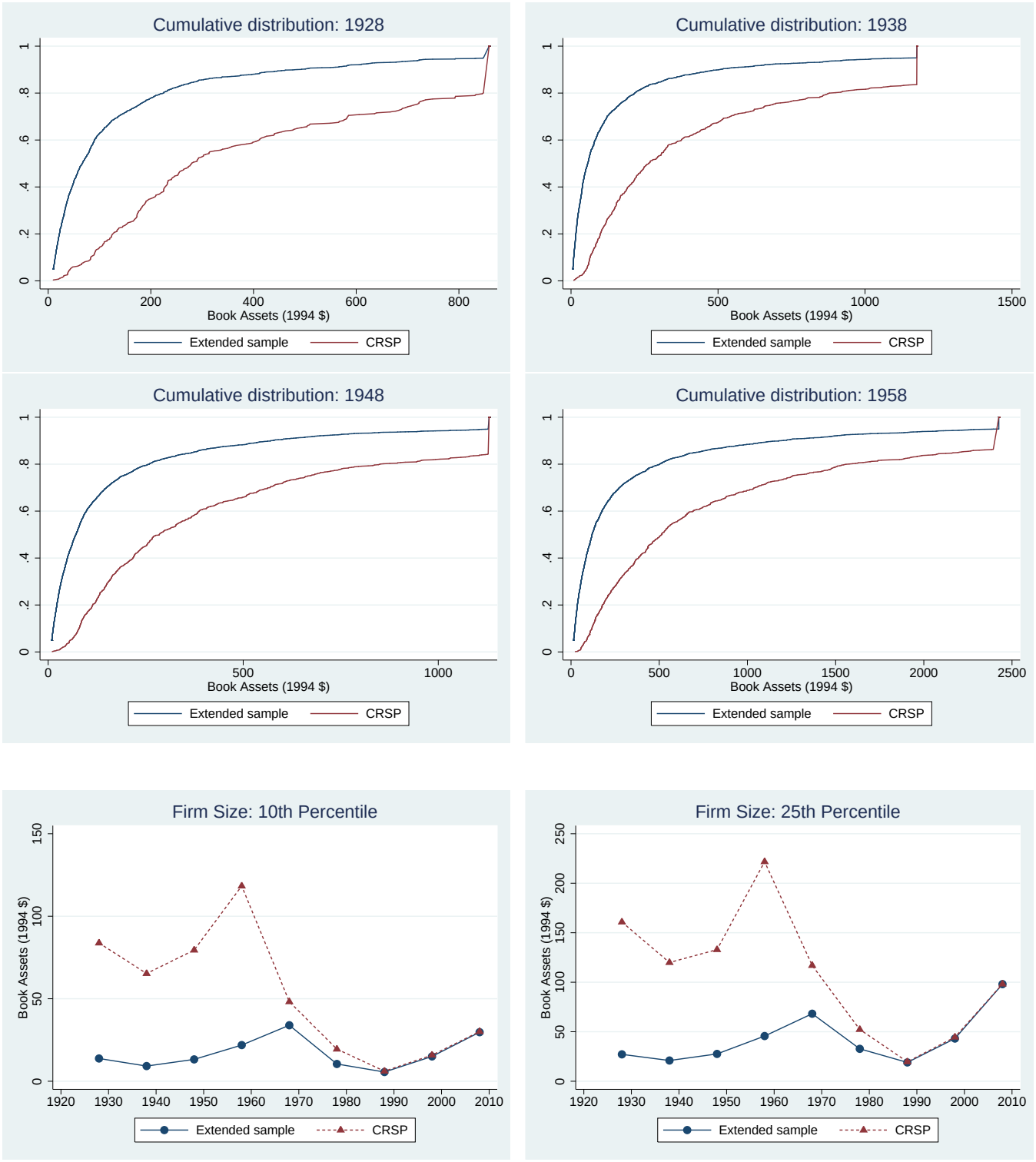
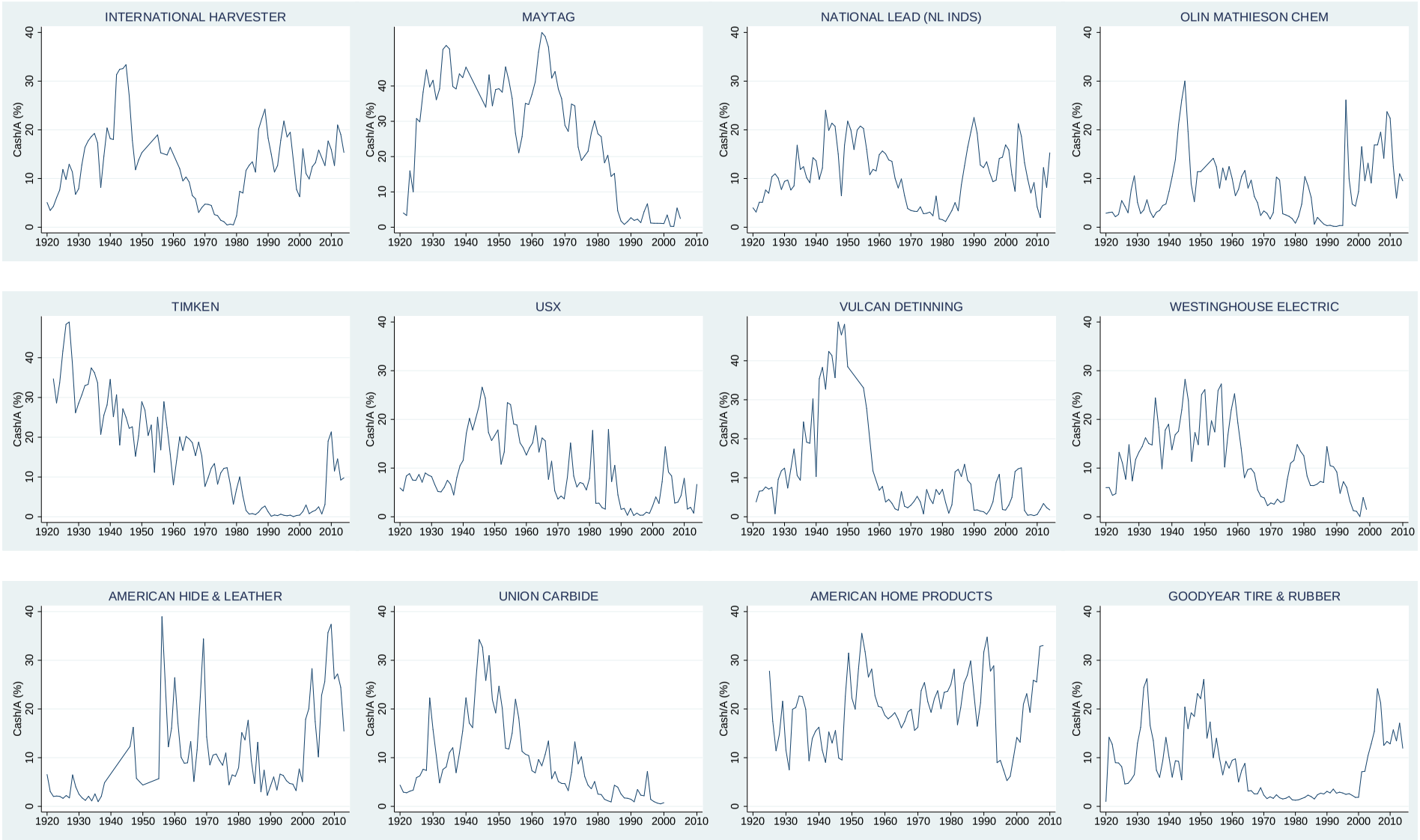
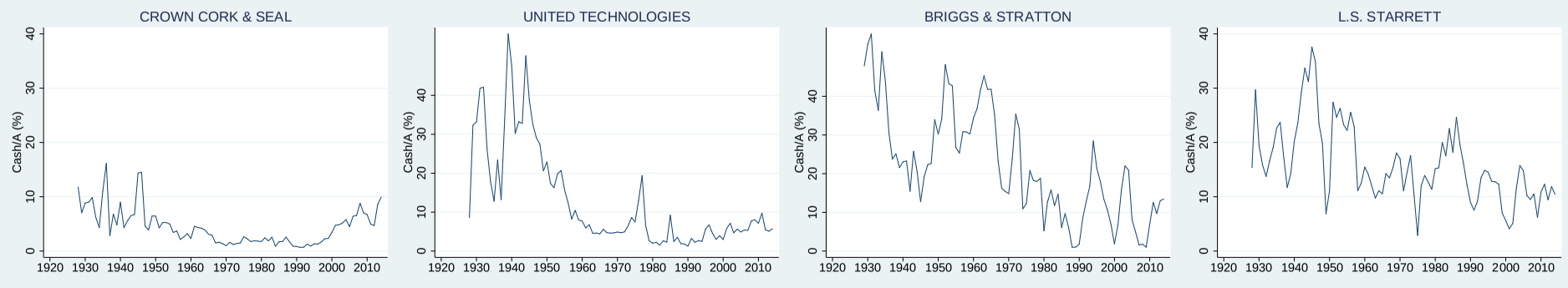


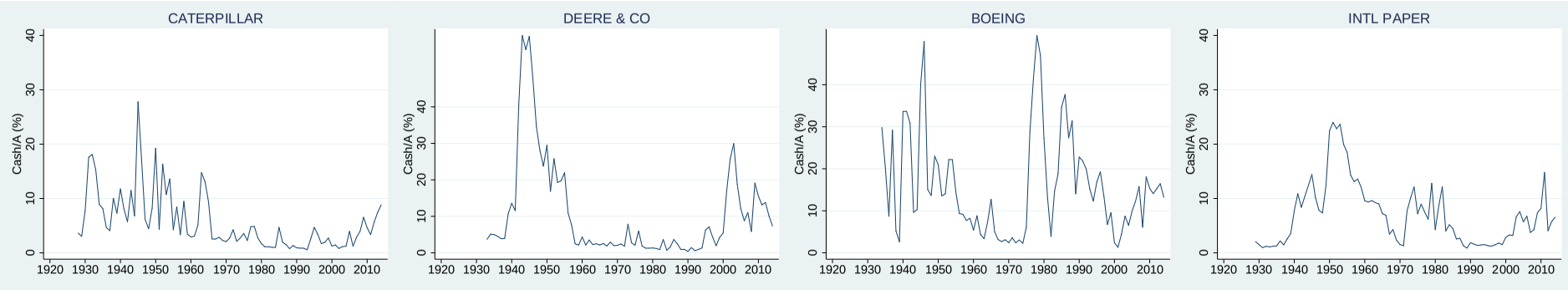
Figure A.3. Firm-specific Cash Holdings (Long-lived sample)

Data are from Moody's Industrial Manuals and Compustat. The plots display the ratio of cash and marketable securities to total book assets for each firm-year.

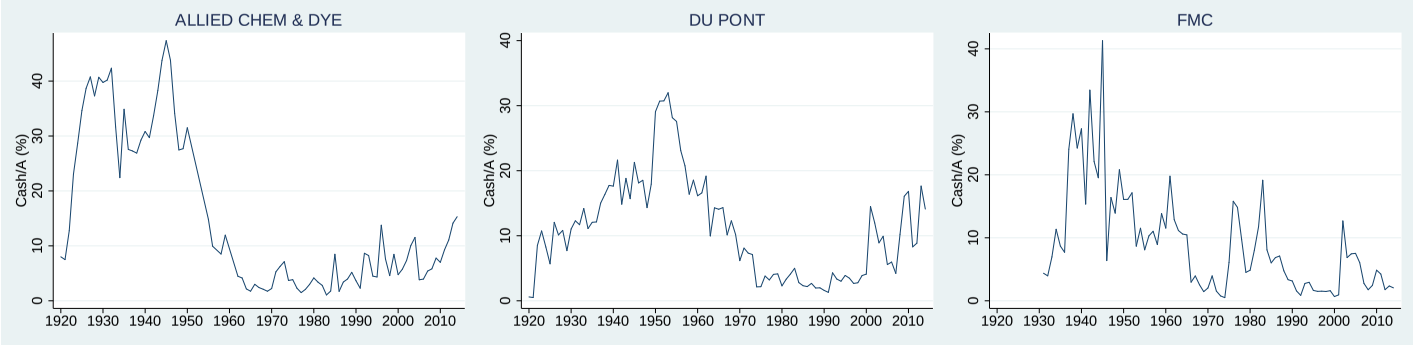
Panel A: Manufacturing


INTERNATIONAL HARVESTER
MAYTAG
NATIONAL LEAD (NL INDS)
OLIN MATHIESON CHEM
TIMKEN
USX
VULCAN DETINNING
WESTINGHOUSE ELECTRIC
AMERICAN HIDE & LEATHER
UNION CARBIDE
AMERICAN HOME PRODUCTS
GOODYEAR TIRE & RUBBER
Cash/A (%)
0
10
20
30
40
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

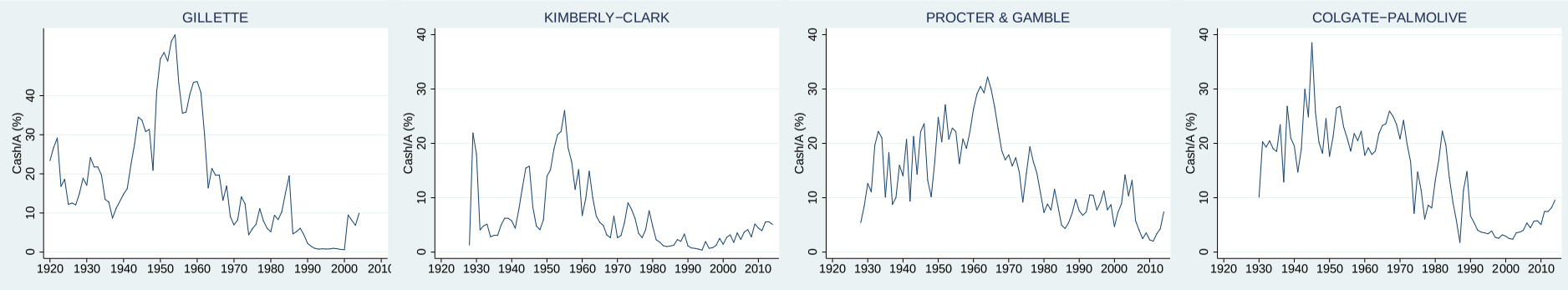




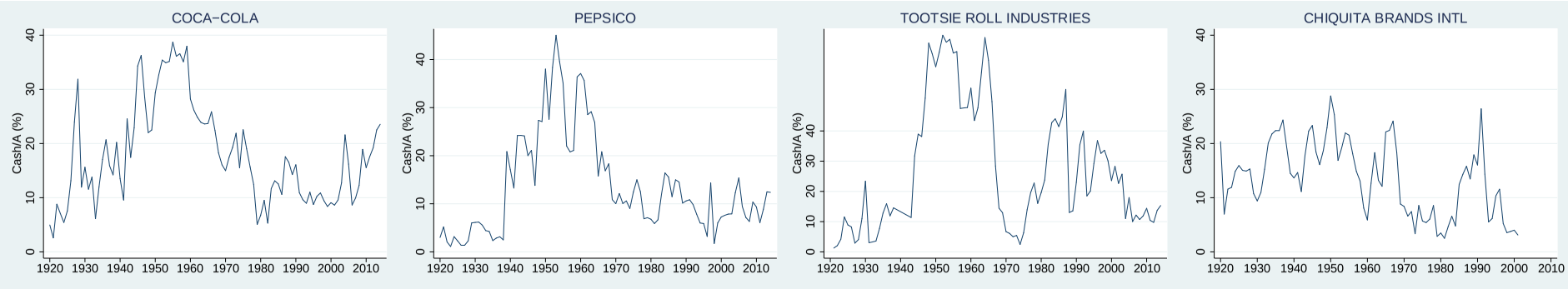
Panel B: Chemicals

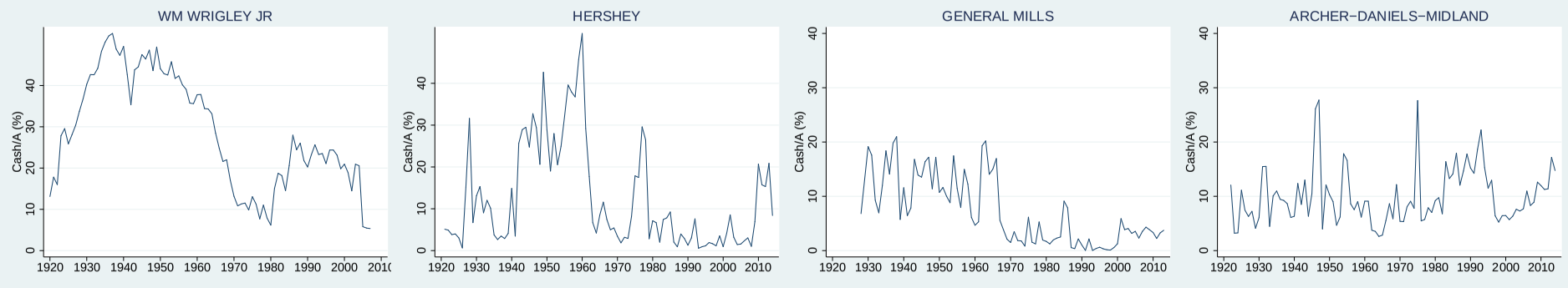


Panel C: Consumer products

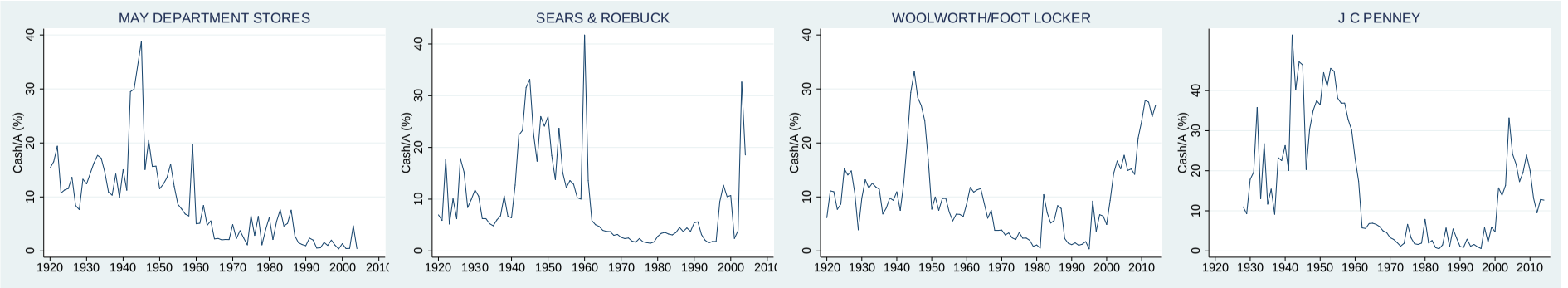


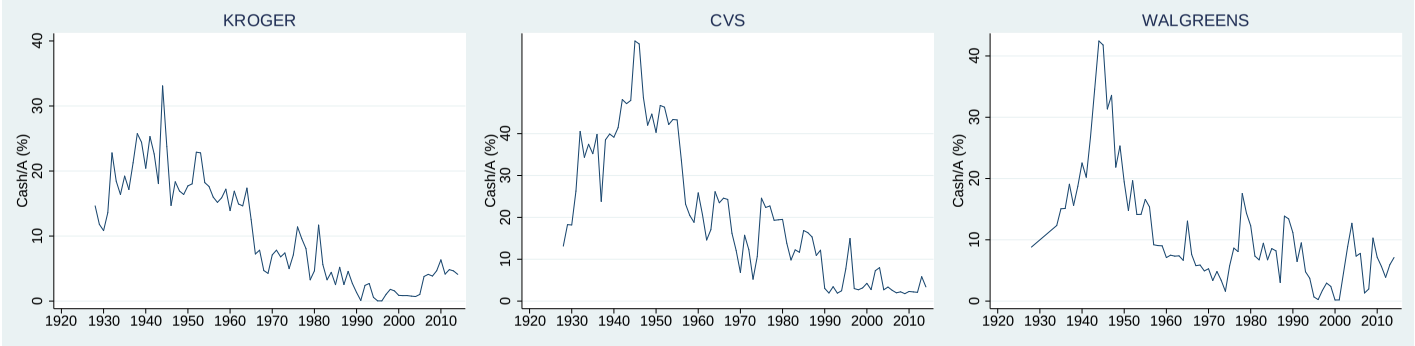
Panel D: Food Products



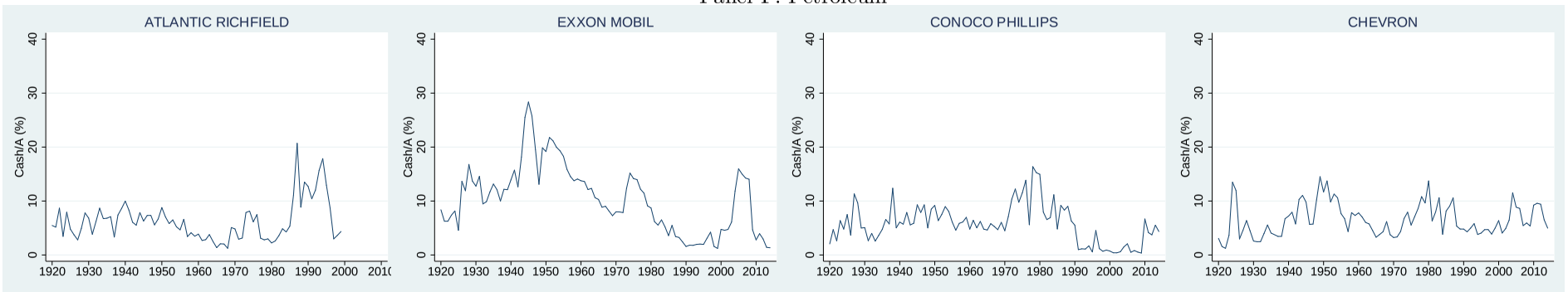


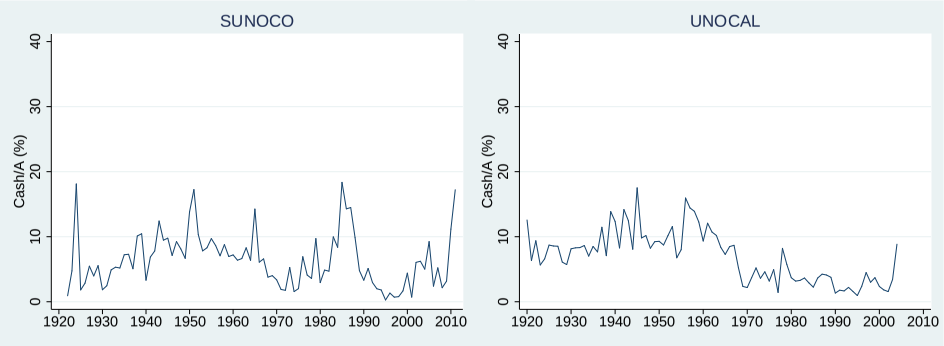
Panel E: Retail



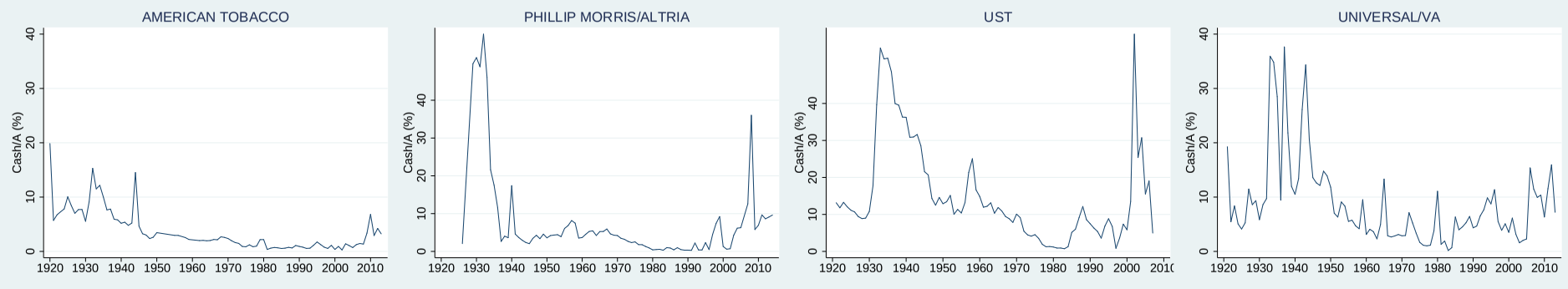


Panel F: Petroleum





Panel G: Tobacco



Panel H: Other Industries