US Economics Analyst

The Corporate Debt Maturity Wall: Implications for Capex and Employment (Walker/Mori)

- The Fed's tightening cycle has pushed marginal funding costs for businesses sharply higher over the past couple of years, with yields jumping almost 5pp for high yield bonds. If interest rates remain high, companies will need to devote a greater share of their revenue to cover higher interest expense as they refinance their debt at higher rates. We explore the magnitude of this looming increase in interest expense and the potential impact on capital spending and hiring.
- The path for interest expense depends on future refinancing needs and interest rates. Refinancing needs will remain historically low over the next two years—about 16% of corporate debt will mature over the next two years. The interest rate on refinanced corporate debt will increase substantially because current market rates are roughly 1½pp above the average rate that companies are paying on existing investment grade bonds and 2pp above the average rate on high yield bonds.
- We estimate that the average interest rate on the current stock of corporate debt will rise from 4.20% in 2023 to 4.30% in 2024 and 4.50% in 2025, based on our assumptions about the future path of Fed policy and market interest rates. This would imply that private sector interest expense as a share of current private sector gross output will rise from 3.35% in 2023 to 3.40% in 2024 and 3.60% in 2025, an increase of 0.25pp from 2023 to 2025.
- We find that for each additional dollar of interest expense, firms lower their capital expenditures by 10 cents and labor costs by 20 cents. The increase in interest expense that we estimate would therefore reduce capex growth by 0.10pp in 2024 and 0.25pp in 2025 and labor cost growth by 0.05pp in 2024 and 0.15pp in 2025. Our estimates suggest about half of the reduction in labor costs comes from reduced hiring and half from lower wage growth, implying a 5k drag on monthly payrolls growth in 2024 and a 10k drag in 2025.
- We see reasons why the hit from higher interest expense could be either smaller or larger than usual. On one hand, cash balances are historically high, which could help buffer the hit. On the other hand, the number of unprofitable firms has continued to proliferate, as the exit rate of unprofitable firms has *declined* since the start of the pandemic. In previous research, we have found that unprofitable firms disproportionately cut back on capex and employment when faced with margin pressure.

Jan Hatzius
+1(212)902-0394 | jan.hatzius@gs.com
Goldman Sachs & Co. LLC

Alec Phillips
+1(202)637-3746 | alec.phillips@gs.com
Goldman Sachs & Co. LLC

David Mericle
+1(212)357-2619 |
david.mericle@gs.com
Goldman Sachs & Co. LLC

Spencer Hill, CFA
+1(212)357-7621 | spencer.hill@gs.com
Goldman Sachs & Co. LLC

Ronnie Walker
+1(917)343-4543 |
ronnie.walker@gs.com
Goldman Sachs & Co. LLC

Tim Krupa
+1(202)637-3771 | tim.krupa@gs.com
Goldman Sachs & Co. LLC

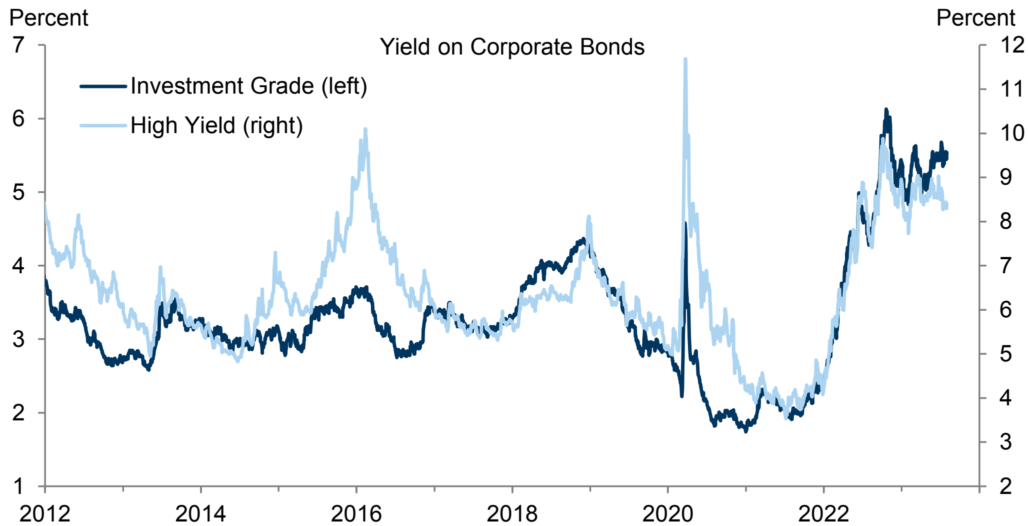
Manuel Abecasis
+1(212)902-8357 |
manuel.abecasis@gs.com
Goldman Sachs & Co. LLC

Sienna Mori
+1(212)902-6712 | sienna.mori@gs.com
Goldman Sachs & Co. LLC

The Corporate Debt Maturity Wall: Implications for Capex and Employment

The Fed's tightening cycle has pushed marginal funding costs for businesses sharply higher over the past couple of years, with yields jumping 3½pp for investment grade bonds and 4¾pp for high yield bonds (Exhibit 1). If interest rates remain high, companies will need to devote a greater share of their revenue to cover higher interest expense as they refinance their debt at higher rates. We explore the magnitude of this looming increase in interest expense and the potential impact on capital spending and hiring.

Exhibit 1: Marginal Financing Costs Have Increased Sharply Since the Start of the Fed's Tightening Cycle

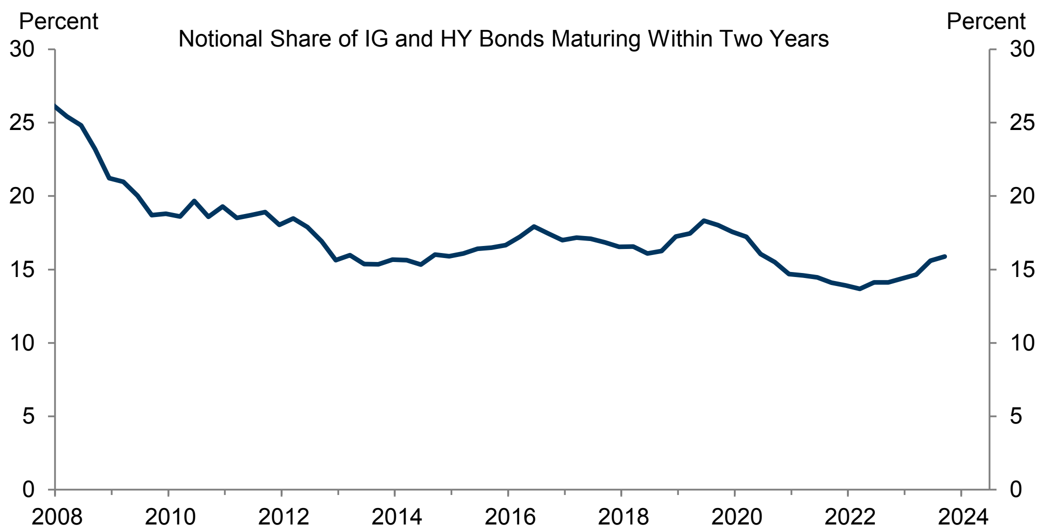


Source: Bloomberg, Goldman Sachs Global Investment Research

The path for interest expense depends on two factors. First, refinancing needs, which are historically quite low in the near-term. Exhibit 2 shows that the share of corporate bonds maturing within the next two years is at the low end of its 15-year range (16% today vs. 26% in 2007). As we highlighted early last year, the duration of corporate debt has roughly doubled over the last thirty years, slowing the pass-through from funds rate hikes to interest rates paid by firms and to investment spending, and therefore reducing the economy's near-term sensitivity to the funds rate. This shift towards longer maturities accelerated during the pandemic, with firms refinancing en masse in 2020 and 2021 to take advantage of lower rates.

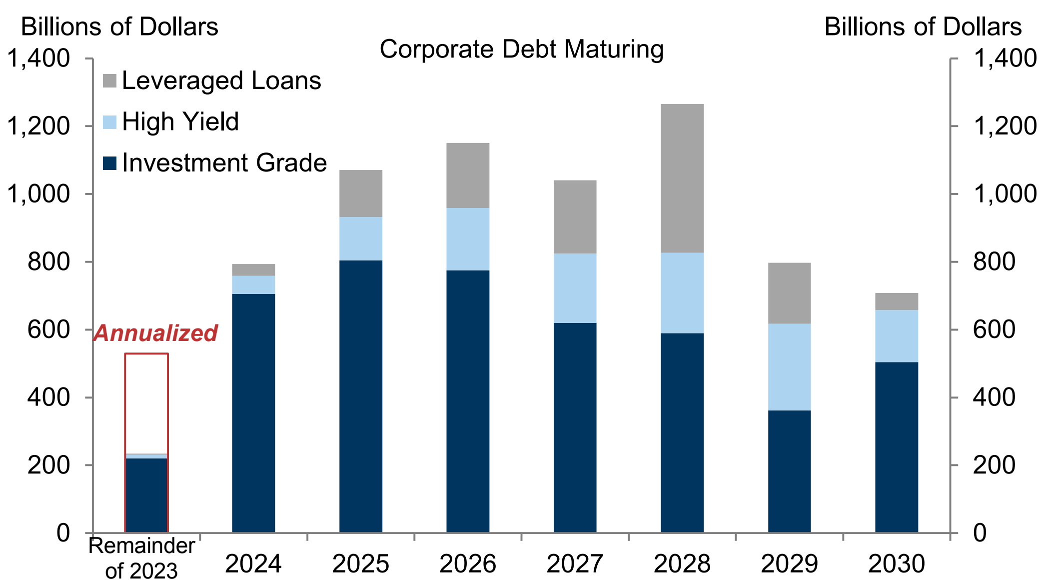
However, while near-term refinancing needs appear limited, Exhibit 3 shows that the pace of corporate debt maturing picks up sharply from 2024 onward.

Exhibit 2: Refinancing Needs Have Been Muted So Far Because Companies Issued So Much Debt in 2020 and 2021



Source: Bloomberg, Goldman Sachs Global Investment Research

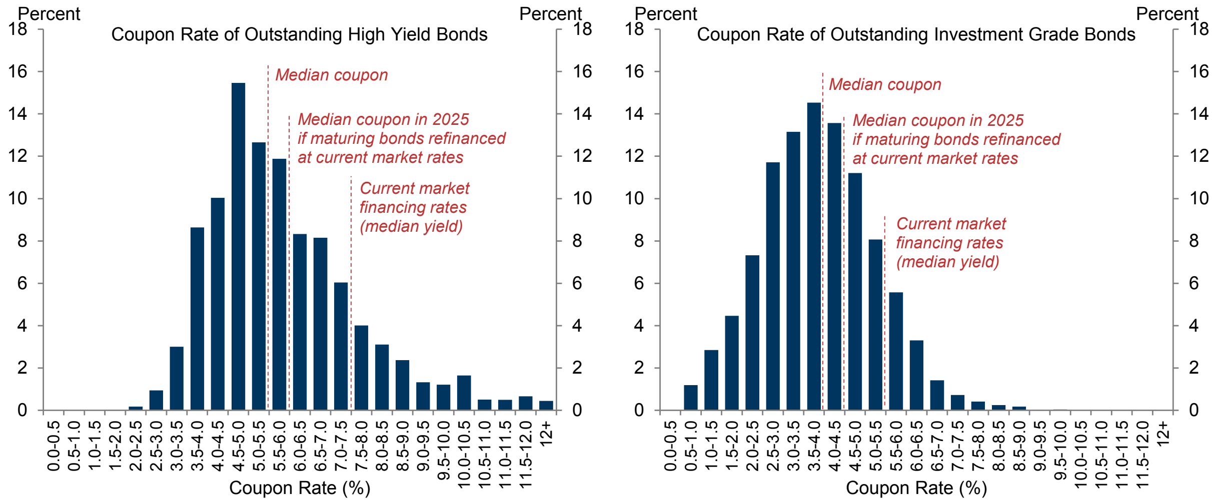
Exhibit 3: $230bn ($525bn Annualized) of Corporate Debt Matures in the Remainder of 2023, $790bn in 2024, and $1,070bn in 2025



Source: Bloomberg, Goldman Sachs Global Investment Research

The second factor is the difference between coupons on new and existing bonds, which is currently substantial. Exhibit 4 shows that current yields are roughly 2pp above coupon rates for the median high yield bond (left), and 1½pp above for the median investment grade bond (right). It is important to note that the increase in the coupon rate would not translate into a proportional increase in interest expense if firms hedge their interest rate exposure. But firms rarely hedge the entirety of their rate exposure, and in many cases, they hedge none of their exposure.

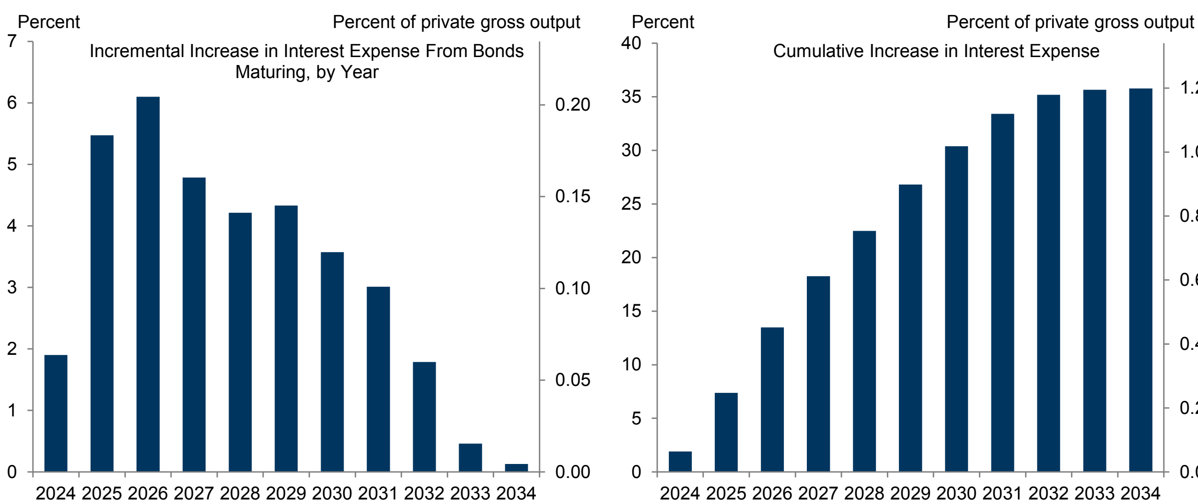
Exhibit 4: The Vast Majority of Outstanding Corporate Debt Was Financed at Rates Well Below Current Market Rates



Source: Bloomberg, Goldman Sachs Global Investment Research

Taking those two factors together, we estimate that interest expense is likely to rise only modestly in 2024, but more quickly thereafter as refinancing needs increase. Our strategists expect the long-end of the Treasury yield curve to remain elevated and credit spreads to narrow only modestly over the medium-term. In a scenario where yields on individual corporate bonds evolve in line with our strategists' view on market interest rates and remain unchanged beyond their forecast horizons, we estimate that refinancing maturing debt would raise the average interest rate on the current stock of corporate debt from 4.20% in 2023 to 4.30% in 2024 and 4.50% in 2025. This would translate to an increase in interest expense for corporates of 2% in 2024 and 5½% in 2025 (or 0.05% and 0.20% of current private sector gross output if economywide interest expense grows at the same rate), as shown in the left panel of Exhibit 5.

Exhibit 5: We Estimate That Refinancing Maturing Debt Will Boost Interest Expense by 2% in 2024 and 5½% in 2025



Note: These projections assume that yields on individual corporate bonds evolve in line with our strategists' view on market interest rates. For horizons that extend beyond our strategists' forecasts, we assume that yields and spreads are unchanged.

Source: Goldman Sachs Global Investment Research

The Spillovers From Higher Interest Expense to Capex and Employment

Using firm-level data on public companies since 1965, we estimate the impact of higher interest expense from refinancing on capital spending and employment. We find that for each additional dollar of interest expense, firms lower their capital expenditures by 10 cents and labor costs by 20 cents, about half of which comes from reduced employment and half of which comes through lower wages.

Exhibit 6: Higher Interest Expense Weighs on Employment and Capex Growth

	Impact of a $1 increase in interest expense on…		
	1	2	3
Capex	-0.11***		
	[-0.005]		
Labor costs		-0.21***	
		[-0.015]	
Labor costs via employment			-0.11***
			[-0.006]

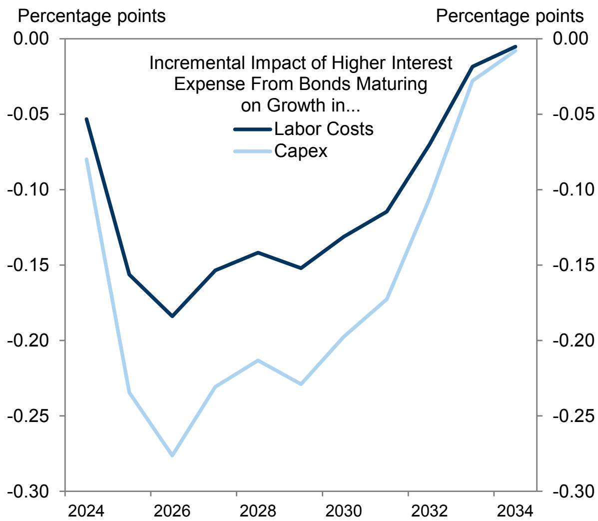
Note: The dependent and interest expense variables are expressed as shares of lagged revenues.
Sample period: 1965-2017
*** Significant at the 1% level.
All regressions control for lagged profits, employment, capex, and assets, firm age, and sector and time fixed effects.

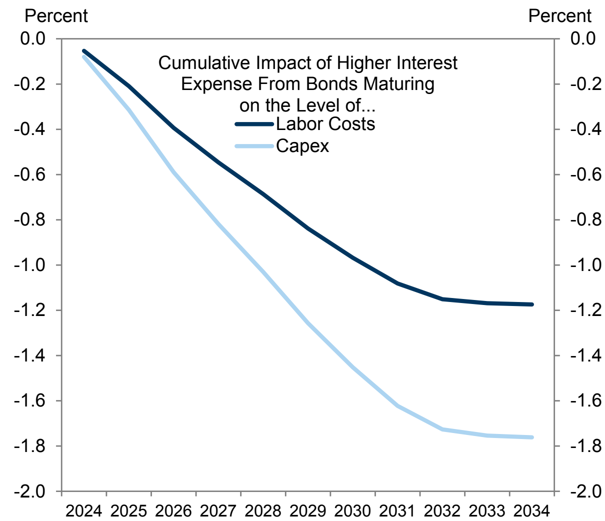
Source: Compustat, Goldman Sachs Global Investment Research

Combining the interest expense scenario outlined in Exhibit 5 with the sensitivities in Exhibit 6 suggests that higher interest expense could reduce capex growth by 0.10pp in 2024 and 0.25pp in 2025 and labor cost growth by 0.05pp in 2024 and 0.15pp in 2025 (Exhibit 7). The reduction in labor costs from lower employment growth translates to a roughly 5k drag on monthly payrolls growth in 2024 and a 10k drag in 2025. The combined drag on GDP growth from these channels is likely relatively modest. We estimate they total a less than a 0.05pp drag on annual GDP growth in 2024 and a 0.10pp drag in 2025 (assuming a 0.7 MPC for the reduction in labor costs).

In principle, these impacts are already accounted for in our financial conditions framework. However, the limited refinancing needs since the start of the Fed's tightening cycle suggest that the impact of higher interest rates on growth is more delayed than the average historical impact that our FCI impulse model projects.

Exhibit 7: We Estimate That Higher Interest Expense Could Reduce Capex Growth by 0.10pp in 2024 and 0.25pp in 2025 and Labor Cost Growth by 0.05pp in 2024 and 0.15pp in 2025

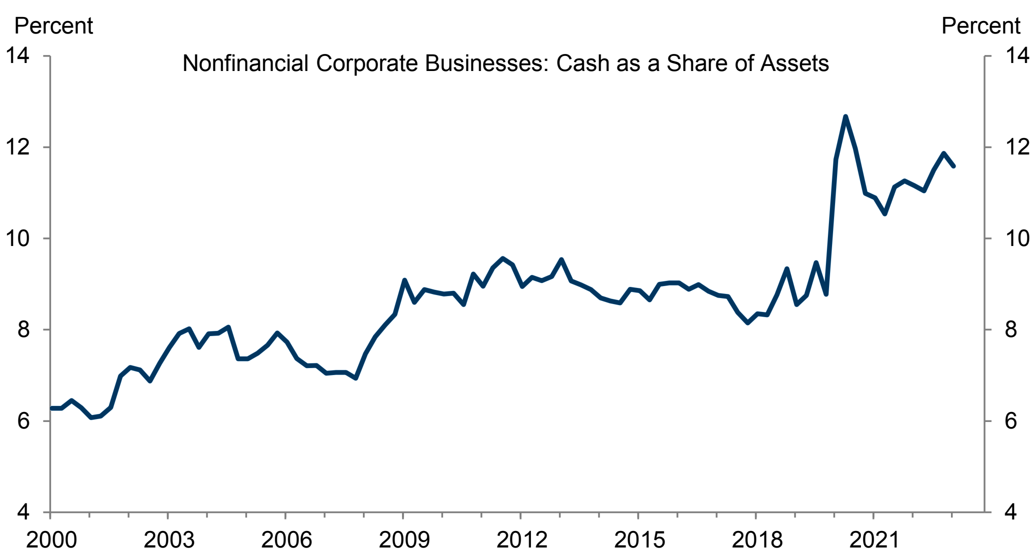




Source: Goldman Sachs Global Investment Research

We see reasons why the hit to activity from higher interest expense could be either smaller or larger than usual. On one hand, cash balances are historically high (Exhibit 8), and firms could use that cash to either reduce their debt load instead of refinancing or to smooth their capital expenditures and labor costs.[1]

Exhibit 8: Firms Still Have an Elevated Level of Cash On Hand in Aggregate, Which Could Help Buffer a Hit from Higher Interest Expense



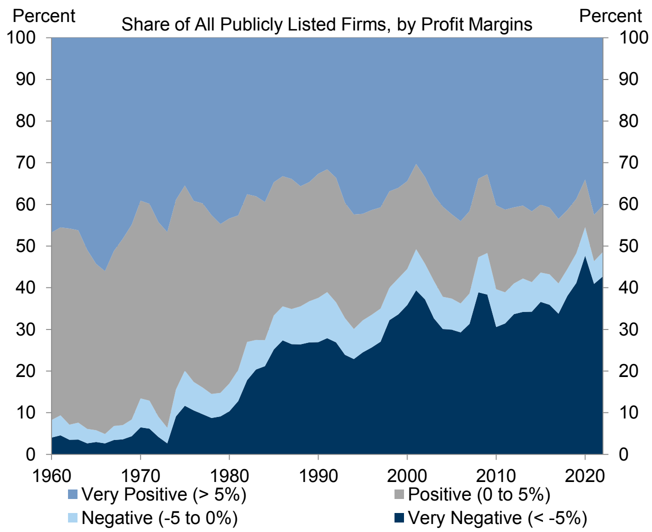
Source: Federal Reserve Board, Goldman Sachs Global Investment Research

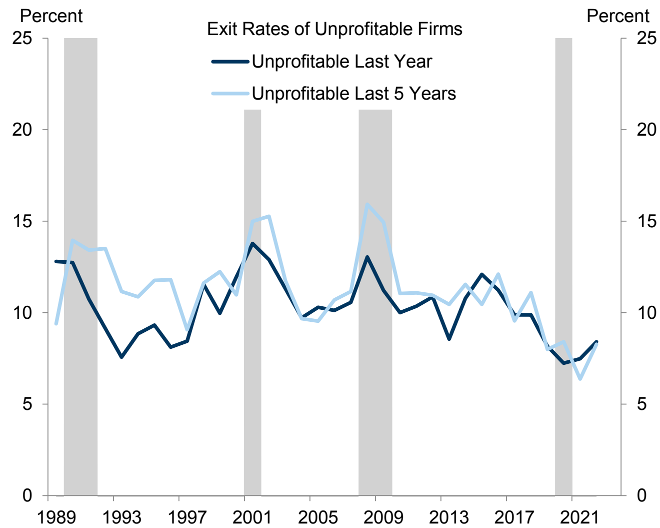
On the other hand, the number of unprofitable firms has continued to proliferate. In

[1] Our equity strategists have flagged that larger firms tend to have less cash on hand, with cash as a share of assets having roughly returned to pre-pandemic levels for the S&P 500, suggesting that smaller firms have particularly large buffers.

previous research, we found that unprofitable firms disproportionately cut back on employment and capex when faced with margin pressure. The left panel of Exhibit 9 shows that almost 50% of all publicly-listed companies were unprofitable in 2022. Unlike in typical recessions, the right panel of Exhibit 9 shows that the exit rate of unprofitable firms has *declined* since the start of the pandemic—likely in part due to the generous fiscal support that is no longer being provided—mirroring the economywide decline in bankruptcies.

Exhibit 9: The Number of Unprofitable Firms Has Continued to Proliferate as Exit Rates for Unprofitable Firms Have Declined Since the Start of the Pandemic





Source: Compustat, Goldman Sachs Global Investment Research

Ronnie Walker

Sienna Mori

We thank Elsie Peng for her extensive contributions to this report.

The US Economic and Financial Outlook

THE US ECONOMIC AND FINANCIAL OUTLOOK
(% change on previous period, annualized, except where noted)

	2021	2022	2023	2024	2025	2026	2022		2023				2024			
			(f)	(f)	(f)	(f)	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
OUTPUT AND SPENDING																
Real GDP	**5.9**	**2.1**	*2.1*	*1.7*	*1.9*	*1.9*	**3.2**	**2.6**	**2.0**	**2.4**	*1.5*	*1.1*	*1.7*	*1.9*	*1.9*	*1.9*
Real GDP (annual=Q4/Q4, quarterly=yoy)	**5.7**	**0.9**	*1.8*	*1.8*	*1.9*	*1.9*	**1.9**	**0.9**	**1.8**	**2.6**	*2.1*	*1.8*	*1.7*	*1.5*	*1.6*	*1.8*
Consumer Expenditures	**8.3**	**2.7**	*2.2*	*1.8*	*1.9*	*1.9*	**2.3**	**1.0**	**4.2**	**1.6**	*1.6*	*1.4*	*1.9*	*1.9*	*1.9*	*1.9*
Residential Fixed Investment	**10.7**	**-10.6**	*-11.3*	*2.9*	*3.2*	*3.0*	**-27.1**	**-25.1**	**-4.0**	**-4.1**	*4.5*	*2.5*	*3.5*	*3.5*	*3.5*	*3.5*
Business Fixed Investment	**6.4**	**3.9**	*3.1*	*2.4*	*3.6*	*3.6*	**6.2**	**4.0**	**0.6**	**7.7**	*-0.7*	*1.3*	*2.2*	*3.1*	*3.7*	*3.9*
Structures	**-6.4**	**-6.6**	*6.4*	*0.8*	*2.8*	*3.0*	**-3.6**	**15.7**	**15.8**	**9.7**	*-3.9*	*-1.5*	*1.0*	*1.5*	*2.5*	*2.5*
Equipment	**10.3**	**4.3**	*-0.1*	*2.4*	*3.2*	*3.0*	**10.6**	**-3.5**	**-8.9**	**10.8**	*-1.8*	*2.0*	*2.0*	*2.5*	*3.5*	*4.0*
Intellectual Property Products	**9.7**	**8.8**	*4.4*	*3.3*	*4.5*	*4.5*	**6.8**	**6.2**	**3.1**	**3.9**	*2.0*	*2.0*	*3.0*	*4.5*	*4.5*	*4.5*
Federal Government	**2.3**	**-2.5**	*3.1*	*0.2*	*0.0*	*0.0*	**3.7**	**5.8**	**6.0**	**0.9**	*1.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
State & Local Government	**-0.5**	**0.7**	*2.8*	*0.5*	*0.9*	*1.0*	**3.7**	**2.6**	**4.4**	**3.6**	*0.8*	*0.0*	*0.0*	*0.1*	*0.9*	*0.9*
Net Exports ($bn, '12)	**-1,233**	**-1,357**	*-1,205*	*-1,247*	*-1,280*	*-1,298*	**-1,269**	**-1,239**	**-1,208**	**-1,206**	*-1,197*	*-1,210*	*-1,226*	*-1,239*	*-1,253*	*-1,269*
Inventory Investment ($bn, '12)	**-19**	**125**	*10*	*45*	*60*	*60*	**39**	**137**	**4**	**9**	*11*	*15*	*30*	*40*	*50*	*60*
Industrial Production, Mfg.	**4.9**	**2.7**	*0.0*	*2.4*	*3.3*	*3.3*	**0.0**	**-3.3**	**-0.3**	**1.5**	*1.4*	*1.8*	*2.5*	*2.9*	*3.1*	*3.4*
HOUSING MARKET																
Housing Starts (units, thous)	**1,606**	**1,551**	*1,424*	*1,539*	*1,539*	*1,539*	**1,446**	**1,405**	**1,385**	**1,447**	*1,425*	*1,437*	*1,539*	*1,539*	*1,539*	*1,539*
New Home Sales (units, thous)	**769**	**637**	*695*	*713*	*716*	*716*	**583**	**598**	**638**	**694**	*726*	*721*	*713*	*710*	*714*	*716*
Existing Home Sales (units, thous)	**6,128**	**5,081**	*4,360*	*4,750*	*4,995*	*5,026*	**4,777**	**4,197**	**4,327**	**4,250**	*4,371*	*4,492*	*4,614*	*4,709*	*4,804*	*4,872*
Case-Shiller Home Prices (%yoy)*	**19.0**	**7.4**	*1.3*	*1.7*	*2.4*	*3.8*	**13.1**	**7.4**	**2.2**	*-1.1*	*-0.3*	*1.3*	*1.9*	*1.4*	*1.6*	*1.7*
INFLATION (% ch, yr/yr)																
Consumer Price Index (CPI)**	**7.2**	**6.4**	*2.9*	*3.0*	*2.4*	*2.4*	**8.3**	**7.1**	**5.8**	**4.1**	*3.1*	*2.8*	*2.7*	*2.7*	*2.8*	*3.0*
Core CPI **	**5.5**	**5.7**	*3.8*	*3.0*	*2.5*	*2.5*	**6.3**	**6.0**	**5.6**	**5.2**	*4.3*	*3.8*	*3.5*	*3.1*	*3.2*	*3.1*
Core PCE** †	**5.0**	**4.6**	*3.4*	*2.4*	*2.2*	*2.1*	**4.9**	**4.8**	**4.7**	**4.4**	*3.9*	*3.5*	*3.0*	*2.6*	*2.6*	*2.4*
LABOR MARKET																
Unemployment Rate (%)^	**3.9**	**3.5**	*3.6*	*3.6*	*3.6*	*3.5*	**3.5**	**3.5**	**3.5**	**3.6**	*3.5*	*3.6*	*3.6*	*3.6*	*3.6*	*3.6*
U6 Underemployment Rate (%)^	**7.3**	**6.5**	*6.8*	*6.8*	*6.8*	*6.7*	**6.8**	**6.5**	**6.7**	**6.9**	*6.7*	*6.8*	*6.8*	*6.8*	*6.8*	*6.8*
Payrolls (thous, monthly rate)	**606**	**399**	*209*	*100*	*80*	*78*	**423**	**284**	**312**	**228**	*162*	*133*	*100*	*100*	*100*	*100*
Employment-Population Ratio (%)^	**59.5**	**60.1**	*60.4*	*60.3*	*60.1*	*59.9*	**60.1**	**60.1**	**60.4**	**60.3**	*60.4*	*60.4*	*60.4*	*60.3*	*60.3*	*60.3*
Labor Force Participation Rate (%)^	**62.0**	**62.3**	*62.6*	*62.5*	*62.3*	*62.3*	**62.3**	**62.3**	**62.6**	**62.6**	*62.6*	*62.6*	*62.6*	*62.6*	*62.5*	*62.5*
Average Hourly Earnings (%yoy)	**4.2**	**5.3**	*4.3*	*3.9*	*3.6*	*3.6*	**5.3**	**4.9**	**4.5**	**4.4**	*4.2*	*4.1*	*4.1*	*3.9*	*3.8*	*3.7*
GOVERNMENT FINANCE																
Federal Budget (FY, $bn)	**-2,775**	**-1,375**	*-1,700*	*-1,650*	*-1,800*	*-1,800*	--	--	--	--	--	--	--	--	--	--
FINANCIAL INDICATORS																
FF Target Range (Bottom-Top, %)^	**0-0.25**	**4.25-4.5**	*5.25-5.5*	*4.5-4.75*	*3.5-3.75*	*3-3.25*	**3-3.25**	**4.25-4.5**	**4.75-5**	**5-5.25**	*5.25-5.5*	*5.25-5.5*	*5.25-5.5*	*5-5.25*	*4.75-5*	*4.5-4.75*
10-Year Treasury Note^	**1.52**	**3.88**	*3.90*	*3.75*	*3.75*	*3.75*	**3.83**	**3.88**	**3.48**	**3.81**	*3.90*	*3.90*	*3.80*	*3.75*	*3.75*	*3.75*
Euro (€/$)^	**1.13**	**1.07**	*1.08*	*1.15*	*1.15*	*1.15*	**0.98**	**1.07**	**1.09**	**1.09**	*1.09*	*1.08*	*1.10*	*1.11*	*1.12*	*1.15*
Yen ($/¥)^	**115**	**132**	*138*	*125*	*125*	*125*	**145**	**132**	**133**	**144**	*142*	*138*	*133*	*128*	*125*	*125*

* Weighted average of metro-level HPIs for 381 metro cities where the weights are dollar values of housing stock reported in the American Community Survey. Annual numbers are Q4/Q4.
** Annual inflation numbers are December year-on-year values. Quarterly values are Q4/Q4.
† PCE = Personal consumption expenditures. ^ Denotes end of period.
Note: Published figures in bold.

Source: Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

We, Jan Hatzius, Alec Phillips, David Mericle, Spencer Hill, CFA, Ronnie Walker, Tim Krupa, Manuel Abecasis and Sienna Mori, hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

Disclosures

Regulatory disclosures

Disclosures required by United States laws and regulations

See company-specific regulatory disclosures above for any of the following disclosures required as to companies referred to in this report: manager or co-manager in a pending transaction; 1% or other ownership; compensation for certain services; types of client relationships; managed/co-managed public offerings in prior periods; directorships; for equity securities, market making and/or specialist role. Goldman Sachs trades or may trade as a principal in debt securities (or in related derivatives) of issuers discussed in this report.

The following are additional required disclosures: **Ownership and material conflicts of interest:** Goldman Sachs policy prohibits its analysts, professionals reporting to analysts and members of their households from owning securities of any company in the analyst's area of coverage. **Analyst compensation:** Analysts are paid in part based on the profitability of Goldman Sachs, which includes investment banking revenues. **Analyst as officer or director:** Goldman Sachs policy generally prohibits its analysts, persons reporting to analysts or members of their households from serving as an officer, director or advisor of any company in the analyst's area of coverage. **Non-U.S. Analysts:** Non-U.S. analysts may not be associated persons of Goldman Sachs & Co. LLC and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with subject company, public appearances and trading securities held by the analysts.

Additional disclosures required under the laws and regulations of jurisdictions other than the United States

The following disclosures are those required by the jurisdiction indicated, except to the extent already made above pursuant to United States laws and regulations. **Australia:** Goldman Sachs Australia Pty Ltd and its affiliates are not authorised deposit-taking institutions (as that term is defined in the Banking Act 1959 (Cth)) in Australia and do not provide banking services, nor carry on a banking business, in Australia. This research, and any access to it, is intended only for "wholesale clients" within the meaning of the Australian Corporations Act, unless otherwise agreed by Goldman Sachs. In producing research reports, members of Global Investment Research of Goldman Sachs Australia may attend site visits and other meetings hosted by the companies and other entities which are the subject of its research reports. In some instances the costs of such site visits or meetings may be met in part or in whole by the issuers concerned if Goldman Sachs Australia considers it is appropriate and reasonable in the specific circumstances relating to the site visit or meeting. To the extent that the contents of this document contains any financial product advice, it is general advice only and has been prepared by Goldman Sachs without taking into account a client's objectives, financial situation or needs. A client should, before acting on any such advice, consider the appropriateness of the advice having regard to the client's own objectives, financial situation and needs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests and a copy of Goldman Sachs' Australian Sell-Side Research Independence Policy Statement are available at: https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html. **Brazil:** Disclosure information in relation to CVM Resolution n. 20 is available at https://www.gs.com/worldwide/brazil/area/gir/index.html. Where applicable, the Brazil-registered analyst primarily responsible for the content of this research report, as defined in Article 20 of CVM Resolution n. 20, is the first author named at the beginning of this report, unless indicated otherwise at the end of the text. **Canada:** This information is being provided to you for information purposes only and is not, and under no circumstances should be construed as, an advertisement, offering or solicitation by Goldman Sachs & Co. LLC for purchasers of securities in Canada to trade in any Canadian security. Goldman Sachs & Co. LLC is not registered as a dealer in any jurisdiction in Canada under applicable Canadian securities laws and generally is not permitted to trade in Canadian securities and may be prohibited from selling certain securities and products in certain jurisdictions in Canada. If you wish to trade in any Canadian securities or other products in Canada please contact Goldman Sachs Canada Inc., an affiliate of The Goldman Sachs Group Inc., or another registered Canadian dealer. **Hong Kong:** Further information on the securities of covered companies referred to in this research may be obtained on request from Goldman Sachs (Asia) L.L.C. **India:** Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (India) Securities Private Limited, Research Analyst - SEBI Registration Number INH000001493, 951-A, Rational House, Appasaheb Marathe Marg, Prabhadevi, Mumbai 400 025, India, Corporate Identity Number U74140MH2006FTC160634, Phone +91 22 6616 9000, Fax +91 22 6616 9001. Goldman Sachs may beneficially own 1% or more of the securities (as such term is defined in clause 2 (h) the Indian Securities Contracts (Regulation) Act, 1956) of the subject company or companies referred to in this research report. **Japan:** See below. **Korea:** This research, and any access to it, is intended only for "professional investors" within the meaning of the Financial Services and Capital Markets Act, unless otherwise agreed by Goldman Sachs. Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (Asia) L.L.C., Seoul Branch. **New Zealand:** Goldman Sachs New Zealand Limited and its affiliates are neither "registered banks" nor "deposit takers" (as defined in the Reserve Bank of New Zealand Act 1989) in New Zealand. This research, and any access to it, is intended for "wholesale clients" (as defined in the Financial Advisers Act 2008) unless otherwise agreed by Goldman Sachs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests is available at: https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html. **Russia:** Research reports distributed in the Russian Federation are not advertising as defined in the Russian legislation, but are information and analysis not having product promotion as their main purpose and do not provide appraisal within the meaning of the Russian legislation on appraisal activity. Research reports do not constitute a personalized investment recommendation as defined in Russian laws and regulations, are not addressed to a specific client, and are prepared without analyzing the financial circumstances, investment profiles or risk profiles of clients. Goldman Sachs assumes no responsibility for any investment decisions that may be taken by a client or any other person based on this research report. **Singapore:** Goldman Sachs (Singapore) Pte. (Company Number: 198602165W), which is regulated by the Monetary Authority of Singapore, accepts legal responsibility for this research, and should be contacted with respect to any matters arising from, or in connection with, this research. **Taiwan:** This material is for reference only and must not be reprinted without permission. Investors should carefully consider their own investment risk. Investment results are the responsibility of the individual investor. **United Kingdom:** Persons who would be categorized as retail clients in the United Kingdom, as such term is defined in the rules of the Financial Conduct Authority, should read this research in conjunction with prior Goldman Sachs research on the covered companies referred to herein and should refer to the risk warnings that have been sent to them by Goldman Sachs International. A copy of these risks warnings, and a glossary of certain financial terms used in this report, are available from Goldman Sachs International on request.

European Union and United Kingdom: Disclosure information in relation to Article 6 (2) of the European Commission Delegated Regulation (EU) (2016/958) supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council (including as that Delegated Regulation is implemented into United Kingdom domestic law and regulation following the United Kingdom's departure from the European Union and the European Economic Area) with regard to regulatory technical standards for the technical arrangements for objective presentation of investment recommendations or other information recommending or suggesting an investment strategy and for disclosure of particular interests or indications of conflicts of interest is available at https://www.gs.com/disclosures/europeanpolicy.html which states the European Policy for Managing Conflicts of Interest in Connection with Investment Research.

Japan: Goldman Sachs Japan Co., Ltd. is a Financial Instrument Dealer registered with the Kanto Financial Bureau under registration number Kinsho 69, and a member of Japan Securities Dealers Association, Financial Futures Association of Japan Type II Financial Instruments Firms Association, The Investment Trusts Association, Japan, and Japan Investment Advisers Association. Sales and purchase of equities are subject to commission pre-determined with clients plus consumption tax. See company-specific disclosures as to any applicable disclosures required by Japanese stock exchanges, the Japanese Securities Dealers Association or the Japanese Securities Finance Company.

Global product; distributing entities

Goldman Sachs Global Investment Research produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Public Communication Channel Goldman Sachs Brazil: 0800 727 5764 and / or contatogoldmanbrasil@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Canal de Comunicação com o Público Goldman Sachs Brasil: 0800 727 5764 e/ou contatogoldmanbrasil@gs.com. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom.

Goldman Sachs International ("GSI"), authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA, has approved this research in connection with its distribution in the United Kingdom.

European Economic Area: GSI, authorised by the PRA and regulated by the FCA and the PRA, disseminates research in the following jurisdictions within the European Economic Area: the Grand Duchy of Luxembourg, Italy, the Kingdom of Belgium, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Finland and the Republic of Ireland; GSI - Succursale de Paris (Paris branch) which is authorised by the French Autorité de contrôle prudentiel et de resolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de resolution and the Autorité des marches financiers ("AMF") disseminates research in France; GSI - Sucursal en España (Madrid branch) authorized in Spain by the Comisión Nacional del Mercado de Valores disseminates research in the Kingdom of Spain; GSI - Sweden Bankfilial (Stockholm branch) is authorized by the SFSA as a "third country branch" in accordance with Chapter 4, Section 4 of the Swedish Securities and Market Act (Sw. lag (2007:528) om värdepappersmarknaden) disseminates research in the Kingdom of Sweden; Goldman Sachs Bank Europe SE ("GSBE") is a credit institution incorporated in Germany and, within the Single Supervisory Mechanism, subject to direct prudential supervision by the European Central Bank and in other respects supervised by German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and Deutsche Bundesbank and disseminates research in the Federal Republic of Germany and those jurisdictions within the European Economic Area where GSI is not authorised to disseminate research and additionally, GSBE, Copenhagen Branch filial af GSBE, Tyskland, supervised by the Danish Financial Authority disseminates research in the Kingdom of Denmark; GSBE - Sucursal en España (Madrid branch) subject (to a limited extent) to local supervision by the Bank of Spain disseminates research in the Kingdom of Spain; GSBE - Succursale Italia (Milan branch) to the relevant applicable extent, subject to local supervision by the Bank of Italy (Banca d'Italia) and the Italian Companies and Exchange Commission (Commissione Nazionale per le Società e la Borsa "Consob") disseminates research in Italy; GSBE - Succursale de Paris (Paris branch), supervised by the AMF and by the ACPR disseminates research in France; and GSBE - Sweden Bankfilial (Stockholm branch), to a limited extent, subject to local supervision by the Swedish Financial Supervisory Authority (Finansinpektionen) disseminates research in the Kingdom of Sweden.

General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by Global Investment Research. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (https://www.sipc.org).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

We and our affiliates, officers, directors, and employees will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research, unless otherwise prohibited by regulation or Goldman Sachs policy.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is focused on investment themes across markets, industries and sectors. It does not attempt to distinguish between the prospects or performance of, or provide analysis of, individual companies within any industry or sector we describe.

Any trading recommendation in this research relating to an equity or credit security or securities within an industry or sector is reflective of the investment theme being discussed and is not a recommendation of any such security in isolation.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors.