



## Fission

University of Chicago is known for its excellent academics, not so much for its athletic prowess. But that wasn't always the case. One hundred years ago, the Maroons<sup>1</sup> were the premier football team in the land, winning multiple national championships, and led by the legendary coach Amos Alonzo Stagg.



Stagg was a star player at Philips Exeter and then at Yale and, as coach at Chicago, from 1896-1932, invented many of the procedures, formations and plays we see today. The huddle, the lateral pass, uniform numbers, and many other innovations came from this great coach.

It's no surprise that in 1927 the university's football stadium was named after Stagg. Five years later, Chicago's athletic director decided that 70 was too old to coach football, and Stagg was fired. He continued coaching elsewhere<sup>2</sup> till he decided to retire. In 1958. When he was 96 years old.<sup>3</sup>

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<sup>1</sup> Not to be confused with the Crimson of Harvard, a totally different color.

<sup>2</sup> At the College of the Pacific in Stockton till 1946, then with his son at Susquehanna, and then back to Stockton.

<sup>3</sup> Stagg died in 1965 at the age of 103.



Beneath the grandstands at Stagg Field, the university built squash courts for the students and faculty. As the 1930s progressed, a stream of academic luminaries fled Europe for America, and Chicago, like many other universities, saw the opportunity to build out its science fac-

ulty. Space was needed for more laboratories, and the squash courts were sacrificed for science. Football, of course, continued to be played at Stagg Field.

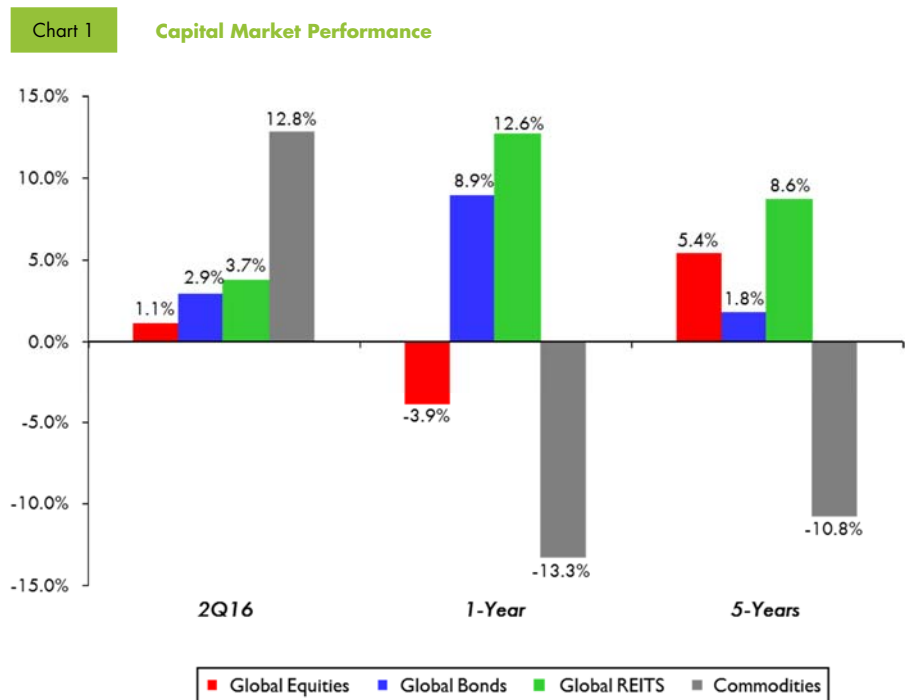
The world of the 1930s was in a delicate balance between order and chaos, but slipping inexorably, it seemed, into a deep, unknown abyss.<sup>4</sup> Likewise, then recent scientific discoveries at the sub-atomic level suggested that the order of the universe was in a very fine balance capable, under just the right circumstances of collapsing upon itself. One brilliant scientist immediately grasped the implications of these new discoveries, and set about to prove them.

A year after America's entry into World War Two, on the converted squash courts underneath the grandstands of Stagg

Field, the most momentous science experiment in history took place. Striking that delicate balance between order and chaos, it changed the world forever.

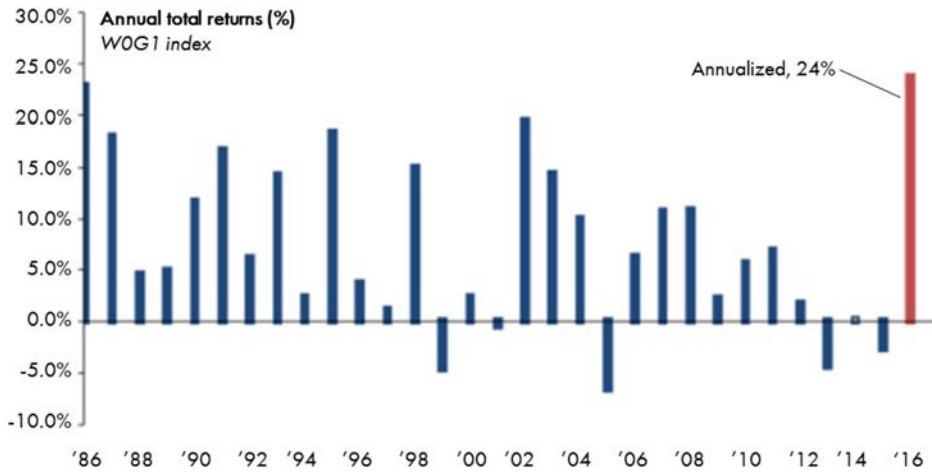
**T**errorist attacks and political upheaval enveloped the globe in the second quarter of the year, yet the markets took them all in stride. Deflationary assets, like sovereign bonds, had strong gains, as did inflationary assets, such as gold and commodities. Gold rose 7% in the quarter, and oil gained 26% (although it is still down 21% in the past year). Commodities have rebounded strongly from last year's pummeling, led by soybeans (up 33% this year) and lean hogs (an apparent oxymoron, but still up 40%).

Political tumult has investors flocking to government bonds. In the depth of the financial crisis, when the world really was falling apart, the ten-year Treasury yield touched 2%; it's around 1.5% today. The 30-year Treasury has done even better, rising 7% in the past quarter, 17% in the first six months. World-



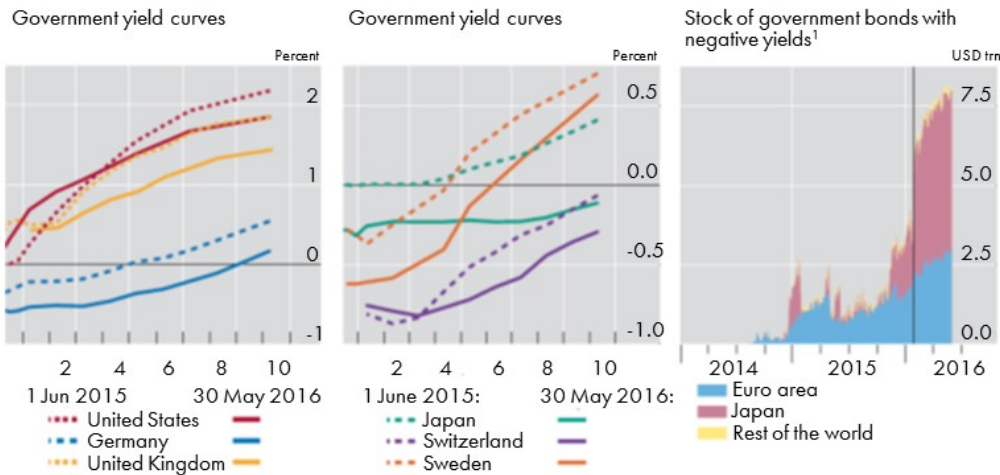
<sup>4</sup> Shades of today?

Chart 2 Annualized total returns on Global Government Bonds



Source: BofA Merrill Lynch Global Investment Strategy, Bloomberg

Chart 3 Global Government Bond Yields



<sup>1</sup> Analysis based on the constituents of the Bank of America Merrill Lynch World Sovereign index. The vertical line indicates 29 January 2016, the date on which the Bank of Japan announced its move to negative interest rates on reserves. Source: Bank of America Merrill Lynch; Bloomberg; BIS calculations.

wide, government bonds are on a pace for their best year in more than three decades (Chart 2). Nearly one-third of government bonds carry negative yields (Chart 3), the lowest (Chart 4 on page 4) in around 5,000 years.<sup>5</sup>

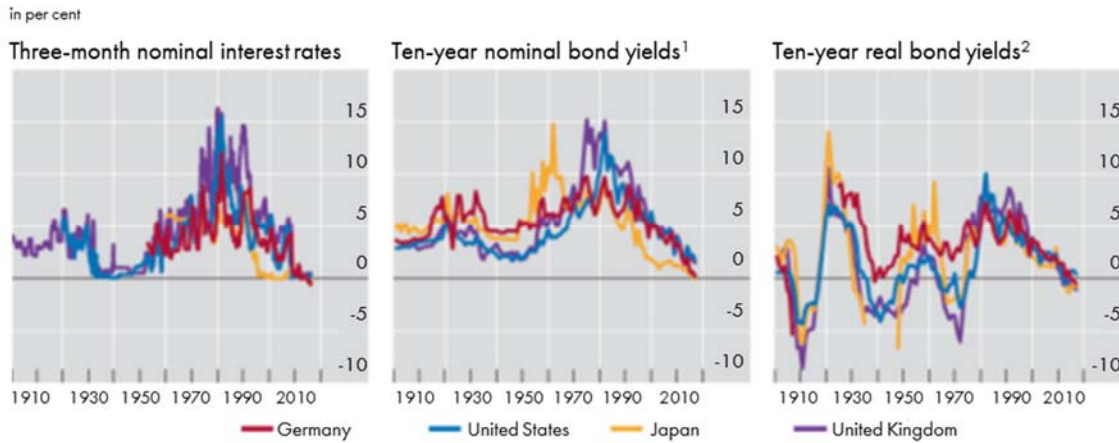
Stock markets also posted (modest) gains last quarter. Leading the pack was Brazil (+13%), whose

economy is still in ruins and politics in disarray (more than half the federal legislature is under indictment), but the Olympics are coming! On the opposite end, Italy and Nigeria both dropped 13% in the quarter.

US equities added a respectable 2.5% in the quarter. Surprisingly and surreptitiously, the US market is

<sup>5</sup> We actually do have references to interest rates from ancient texts 5,000 years ago. I just chose to show the past century.

Chart 4 A historical perspective on record low interest rates and yields



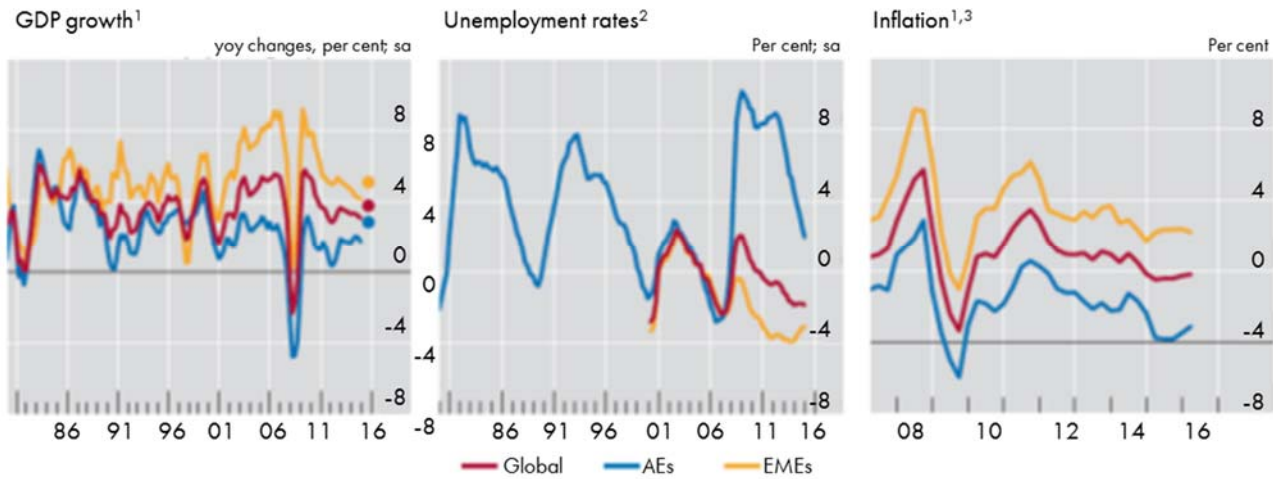
<sup>1</sup> The hyperinflationary years of 1922-23 are excluded for Germany. <sup>2</sup> The hyperinflationary episodes for Germany and Japan are not shown. Prior to 2006, nominal 10-year yields minus average inflation rates during the next 10 years; from 2006 onwards, 10-year index-linked bond yields.  
Source: Barclays; Bloomberg; Global Financial Data; national data; BIS calculations.

Table 1: S&P 500 bull markets in excess of 20% - 1929 to present, ranked by time in bull market.

Rank	Start	End	# of Days	# of Month	Start Price	End Price	% Change
1	4-Dec-87	24-Mar-00	4494	149.8	223.92	1527.46	582.15%
2	9-Mar-09	11-Jul-16	2681	89.4	676.53	2137.16	215.90%
6	13-Jun-49	2-Aug-56	2607	86.9	13.55	49.74	267.08%
3	3-Oct-74	28-Nov-80	2248	74.9	62.28	104.52	125.63%
4	12-Aug-82	25-Aug-87	1839	61.3	102.42	336.77	228.81%
5	9-Oct-02	9-Oct-07	1826	60.9	776.76	1565.15	101.50%
7	22-Oct-57	12-Dec-61	1512	50.4	38.98	720.64	86.35%
8	28-Apr-42	29-May-46	1492	49.7	7.47	19.25	157.70%
9	26-Jun-62	9-Feb-66	1324	44.1	52.32	94.06	79.78%
10	26-May-70	11-Jan-73	961	32.0	69.29	120.24	73.53%
11	7-Oct-66	29-Nov-68	784	26.1	73.2	108.37	48.05%
12	14-Mar-35	10-Mar-37	727	24.2	8.06	18.67	131.64%
13	19-May-47	15-Jun-48	393	13.1	13.77	17.06	23.89%
14	31-Mar-38	9-Nov-38	223	7.4	8.5	13.79	62.24%
15	11-Apr-39	25-Oct-39	197	6.6	10.42	13.21	26.78%
16	10-Jun-40	7-Nov-40	150	5.0	9.42	11.39	20.91%
17	13-Nov-29	10-Apr-30	148	4.9	17.66	25.92	46.77%
18	27-Feb-33	18-Jul-33	141	4.7	5.53	12.2	120.61%
19	19-Oct-33	6-Feb-34	110	3.7	8.61	11.82	37.28%
20	21-Sep-01	4-Jan-02	105	3.5	965.8	1172.51	21.40%
21	1-Jun-32	7-Sep-32	98	3.3	4.4	9.31	111.59%
22	16-Dec-30	24-Feb-31	70	2.3	14.44	18.17	25.83%
23	20-Nov-08	6-Jan-09	47	1.6	752.44	934.7	24.22%
24	5-Oct-31	9-Nov-31	35	1.2	8.82	11.52	30.61%
25	2-Jun-31	26-Jun-31	24	0.8	12.2	15.35	25.82%

Source: BofA Merrill Lynch Global Research, Bloomberg.

Chart 5 Global Growth Metric



The dots in the left-hand panel indicates 1982-2007 averages. <sup>1</sup> Weighted averages based on GDP and PPP exchanges rates. <sup>2</sup> Weighted averages based on labour force level; definitions may vary across countries. <sup>3</sup> Consumer prices. Source: IMF, International Financial Statistics and World Economic Outlook; Datastream; national data; BIS calculations

at all-time highs, up more than 200% since March 2009, the fourth strongest bull market without a 20% decline, and the second longest advance in the past century (Table 1 on page 4).

The US economy continues to chug along. From a sluggish start, rising at a 1% pace in the first quarter, GDP likely stepped up to about 2% in the second quarter, paced (as usual) by the consumer. Retail sales surged last quarter, but even manufacturing contributed, led by continued robust auto production.

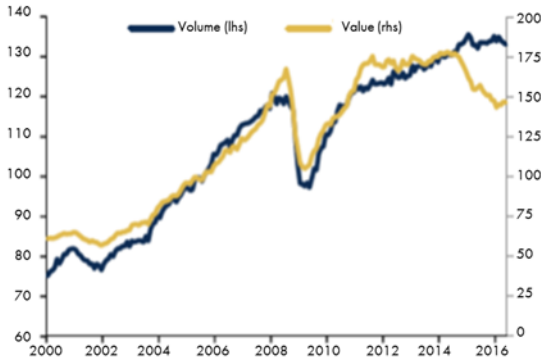
Employment gains slowed to a worrying 11,000 in May, but rebounded sharply in June, adding 287,000. Still, the monthly 147,000 average for the quarter is a noticeable slowdown from +200,000 per month gains we have been posting

for a number of years. The broad measure of unemployment (U-6, which includes discouraged workers and part-timers who want full-time jobs) is down to 9.6%, the lowest since April 2008.

Consumer spending has been strong because incomes are up. Hourly earnings have been rising at a consistent 2.5% pace for the past year, and hours worked are up about 1.5%. That 4% rise in income is well ahead of inflation, up just 1% over the past year.

The rest of the world economy is not faring as well as the US, but neither is it in dire straits. Global GDP growth is close to its long-term average, unemployment is down sharply and inflation has held pretty steady worldwide (Chart 5).

**Chart 6** Global trade hits the brakes (index: 2005 = 100)



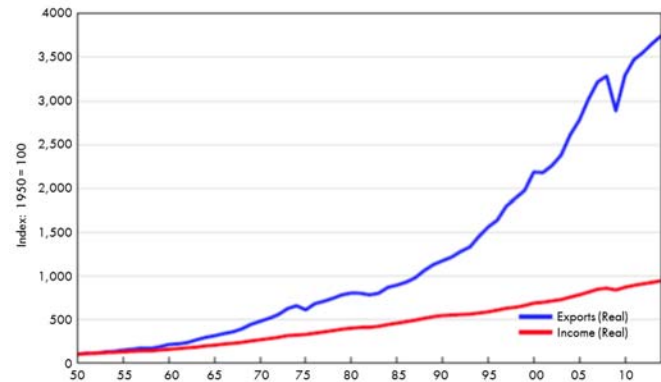
Source: BofA Merrill Lynch Global Research, CPB Netherlands Bureau of Economic Policy Analysis.

A worrisome development in the global economy is the stagnation in world trade (Chart 6). This is highly unusual, as trade has historically far outpaced economic growth. Since 1950, real trade grew at a 5.6% rate (and 9.5% in nominal terms), well ahead of real income growth of 3.5%. This compounds dramatically over time (Chart 7).

There are no free lunches, as Milton Friedman sagaciously pointed out, except for trade. Notwithstanding political rhetoric and the pervasive mistake of viewing economic progress as zero-sum, all countries benefit from trade with higher output and consumption through a more efficient allocation of global resources.

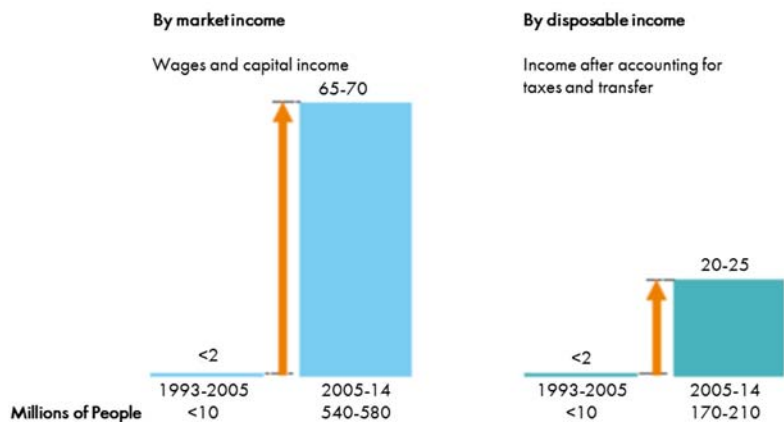
Of course, not every individual benefits equally from trade, and some, whose jobs are displaced, are worse off. The proper policy response is assistance to those workers, not erecting trade barriers, which makes everyone poorer.

**Chart 7** Global Exports and Income, 1950-2014



Source: IMF

**Chart 8** Share of households with flat or falling income<sup>1</sup>

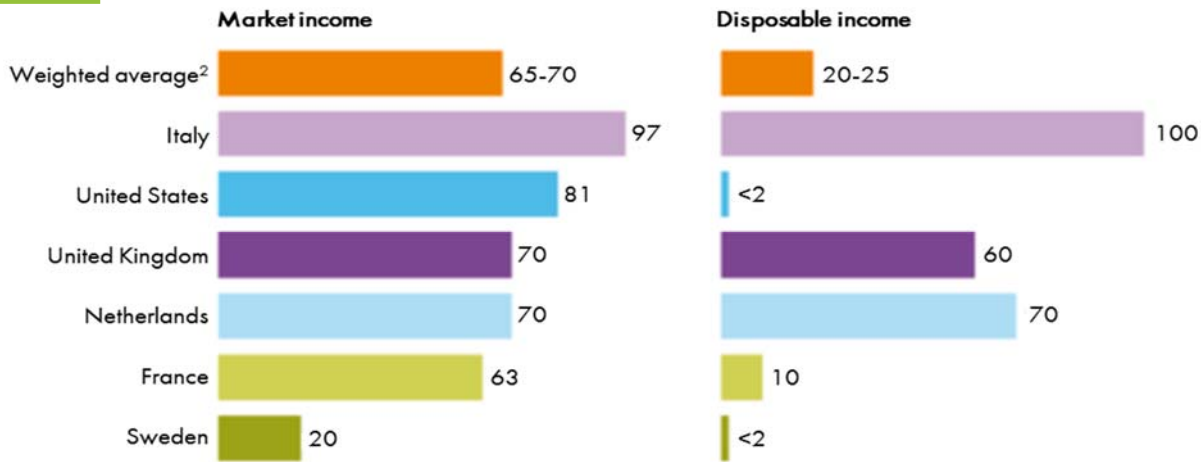


<sup>1</sup> Population-weighted average of 25 countries extrapolated from six country deep dives; for each country we use the latest year the data are available—France (2012), Italy (2012 market income, 2014 disposable income), the Netherlands (2014), Sweden (2013), United Kingdom (2014), and United States (2013). The base year for France is 1996 and for Sweden is 1995. Source: McKinsey Global Institute analysis.

**P**oorer, relatively, is what many in advanced economies have experienced over the past decade. A recent study from McKinsey<sup>6</sup> examined the proportion of income segments (deciles, quintiles, etc.) whose incomes were flat or falling in the last decade versus previous years (Chart 8). Prior to 2005, virtually every income segment in these

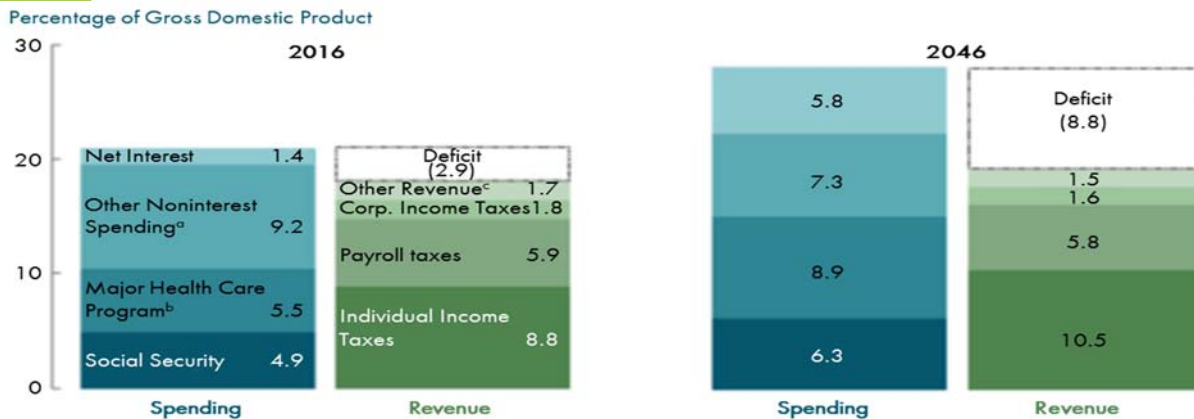
<sup>6</sup> Poorer Than Their Parents, McKinsey Global Institute, July 2016.

**Chart 9** % of households in income segments with flat or falling income, 2005-14<sup>1</sup>



<sup>1</sup> For each country we use the latest year the data are available—France (2012), Italy (2012 market income, 2014 disposable income), the Netherlands (2014), Sweden (2013), United Kingdom (2014), and United States (2013). <sup>2</sup> Population-weighted average of 25 countries extrapolated from six country deep dives. Source: INSEE; Bank of Italy; CBS; Statistics Sweden; ONS; CBO; McKinsey Global Institute analysis.

**Chart 10** The Federal Budget Under the Extended Baseline



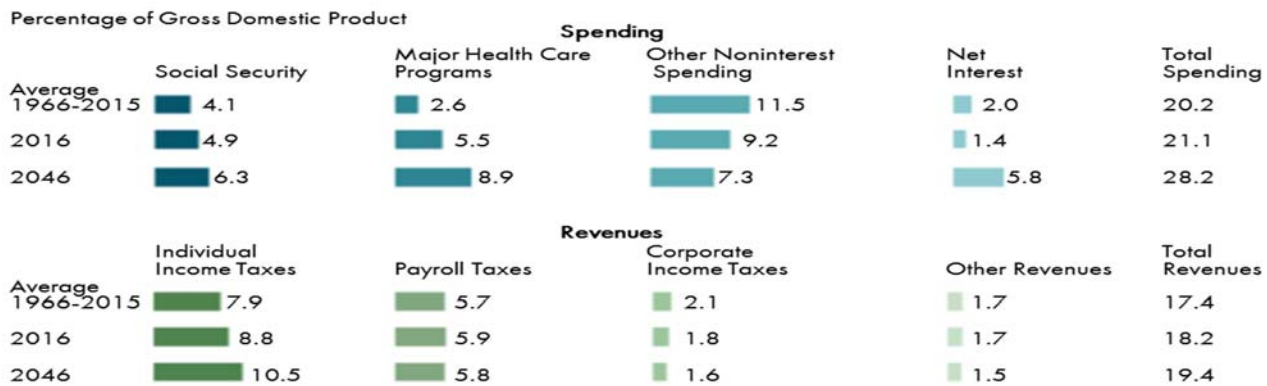
Source: Congressional Budget Office  
 The extended baseline generally reflects current law, following CBO's 10-year baseline projections through 2026 and then extending most of the concepts underlying those baseline projections for the rest of the long-term projection period.  
 a. Consists of all federal spending other than that for Social Security, the major health care programs, and net interest.  
 b. Consists of spending on Medicare (net of offsetting receipts), Medicaid, and the Children's Health Insurance Program, as well as outlays to subsidize health insurance purchased through the marketplaces established under the Affordable Care Act and related spending.  
 c. Consists of excise taxes, remittances to the Treasury from the Federal Reserve System, customs duties, estate and gift taxes, and miscellaneous fees and fines.

25 large countries saw rising real market incomes (wages and capital). But over the past decade, around two-thirds on average experienced flat or falling incomes, and that percentage was higher (81%) in the US. Only Italy, with 97% of income segments losing ground, was higher. The good news (I suppose) is that when government transfers

are included, most households saw higher disposable incomes, including virtually all households in the US (Chart 9).

Government transfers may supplement falling incomes, but this is not a sustainable strategy given aging demographics. Even if it were sustainable, it

Chart 11 Spending and Revenues in the Past and Under CBO's Extended Baseline



Source: Congressional Budget Office

The extended baseline generally reflects current law, following CBO's 10-year baseline projections through 2026 and then extending most of the concepts underlying those baseline projections for the rest of the long-term projection period.

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c. Consists of excise taxes, remittances to the Treasury from the Federal Reserve System, customs duties, estate and gift taxes, and miscellaneous fees and fines.

is not a desirable policy, with corrosive social and economic effects. The study found that those with declining real market incomes are more likely to hold negative views on trade and immigration, for example.

But a growing reliance on government transfers is not sustainable, as the Congressional Budget Office (CBO) notes. Their latest 30-year projections see the federal budget deficit growing to 8.8% of GDP as the rate of spending exceeds revenues (Chart 10 on page 7). Even as income taxes rise to more than 10% of GDP, spending on health care (Medicare/Medicaid), Social Security and interest on the debt account for most of the gap (Chart 11).

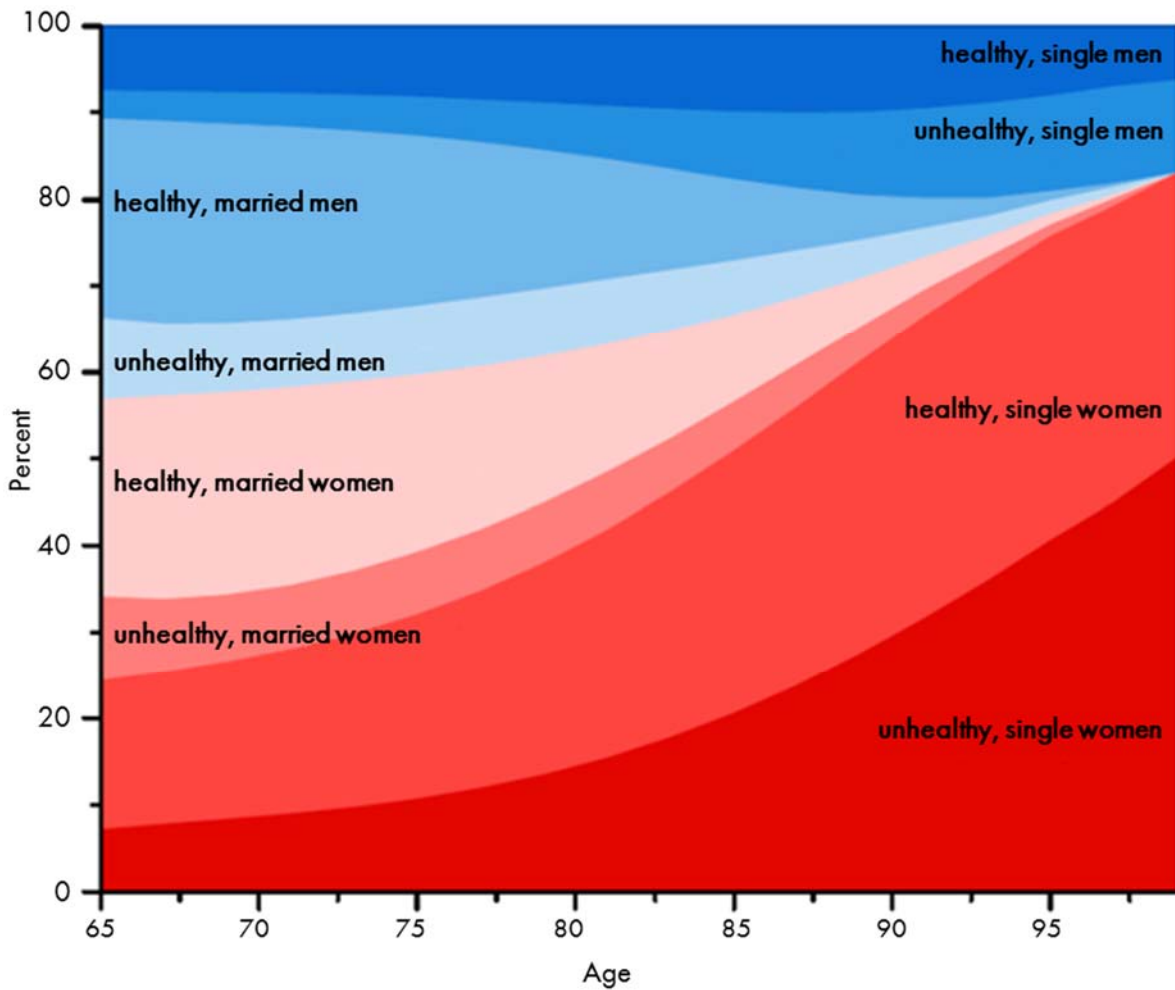
One consequence of these compounding deficits is the accumulation of debt. Federal debt held by the

public was 39% of GDP in 2008. It is already 75% of GDP today, the highest since World War Two (when it peaked at 106%), and is projected to soar to 141% of GDP in 30 years.

Both Medicare and Social Security are self-funded. The CBO projects that the Medicare trust will run out in less than a decade, and Social Security will be depleted by 2030. Current law requires major cuts in benefits (31% in the case of Social Security) when these funds run out. The problem (or, at least, one of the problems) is that an aging population will require more, not fewer, benefits. Today, the largest groups of 65-year olds are healthy, married men and women. The largest group of 95-year olds, which is where many of today's 65-year olds will be in 30 years, is unhealthy, single women (Chart 12 on page 9). Closing this gap by demanding more



Chart 12 Demographic Structure of Elderly Population in the US

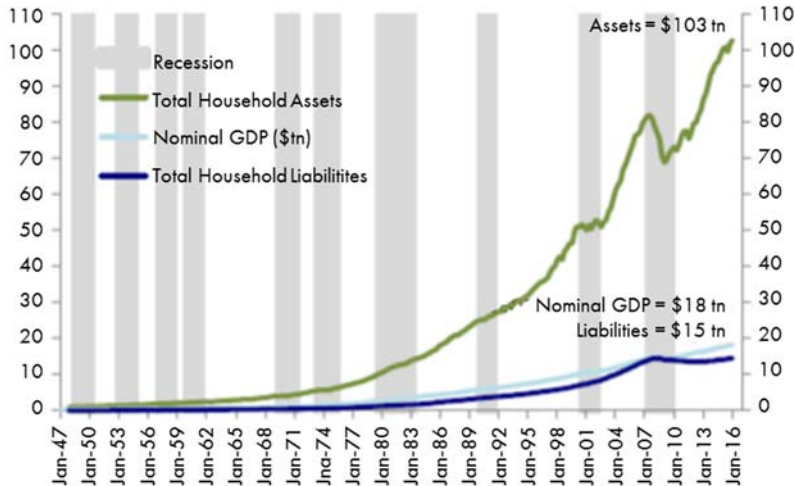


Demographic Structure of Elderly Population in the US by Anton Braun, Karen A. Kopecky, and Tatyana Koreshkova.

contributions and cutting benefits may be inevitable, as Japan's largest public fund, the Government Pension Investment Fund, has done. In 2004, the GPIF raised workers' contributions by 25% over ten years, at the same time cutting benefits by around 20% by raising the retirement age from 60 to 65, and reducing the payout from 62% of final salary to 50%, among other shifts. There are no easy trade-offs.

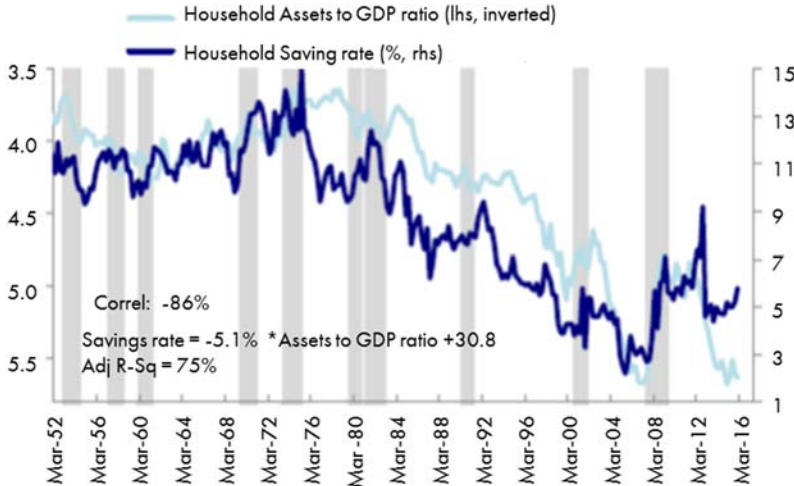
Central bankers are given (and happy to take) credit for whatever economic growth there is in the world through their progressively creative forms of monetary easing, from slashing interest rates to below zero to purchasing the majority of government bond issuance. The ECB is now buying every investment-grade bond denominated in euros, and the BOJ is adding Japanese equities to its balance sheet. All forms of monetary stimulus which, it

Chart 13 But household debt (and GDP) is very low relative to the size of household assets.



Source: BEA, FRB, Haver, Deutsche Bank

Chart 14 The savings rate is well explained by the ratio of assets in GDP



Source: BEA, FRB, Haver, Deutsche Bank

is hoped, will boost economic growth. Is it working?

It's hard to know, because no one can argue the counterfactual, what would have happened to the global economy in the absence of these extraordinary monetary efforts. It seems likely that monetary policy was effective in halting the financial meltdown in early 2009 by providing ample liquidity (cash) to the financial system. But the collapse of a debt bubble is only partly due to a liquidity squeeze, which monetary policy can be effective in arresting. The other part of a debt bubble is insolvency, and it's less clear that monetary policy is effective in redressing the excesses of debt.

Eight years after the debt bubble burst, taking the financial system down with it, it's reasonable to question whether aggressively easy money is having the desired effect (stimulating economic growth), little impact (pushing on a string), or perhaps even generating perverse consequences.

One underlying premise of exceptionally easy money is that cheap debt will encourage consumers and businesses to borrow and spend. At around \$14 trillion, household debt is near a record of GDP, so cheap debt should have a material impact. Except that the other (asset) side of consumers' balance sheets is many multiples of its liabilities (Chart 13). Thus the subsidy to borrowers of low interest rates is more than offset by the penalty paid in foregone interest by savers.

Another assumption of using monetary policy to stimulate growth is by bringing forward future consumption through lowered savings. But the evidence is actually to the contrary. Households seem to target a level of wealth (Chart 14 on page 10, shows that savings closely track the inverse of assets/GDP), thus as interest rates fall, savings have to rise to compensate for lower yields, thereby postponing consumption.

There is considerable doubt whether this extraordinary monetary regime is actually helping the economy, or that additional easing will prove stimulative.

The consensus analysis supporting the current monetary approach sees an economy in the throes of secular stagnation, a phrase first used in the 1930s, and since taken up by esteemed economists today.<sup>7</sup> In this view, the proximate cause of secular stagnation is a deficiency in aggregate demand, in turn caused by aging demographics, technological advances and income inequality. The decline in real interest rates is symptomatic of this demand deficiency. The cure is a series of policies, both monetary and fiscal, designed to stimulate demand (consumption).

An alternative narrative for the weak recovery rests on the nature of the preceding bust, that is, the global financial crisis was caused not by the typical, cyclical tightening of money in response to building inflationary pressures, the pattern seen in every downturn in the past 80 years, but was the result of a debt implosion, a very different economic phenomenon.

Debt-fueled financial booms have consequences well beyond the inevitable busts. These periods are marked by a massive misallocation of resources, as

both labor and capital pour into inefficient sectors (housing, and all its related activities, in the preceding years). Consequently, both labor and capital are destroyed in the subsequent bust, and the repair period for both takes years as the economy struggles in a negative feedback loop: excessive debt reduces investment, which lowers productivity, which lessens investment, etc.

The economic problem is not weak aggregate demand, but rather the opposite: little incentive to invest. An accommodative monetary policy can be part of an effective response, but alone is insufficient to promote economic growth. Rationalizing (and lowering) tax rates, streamlining bureaucracy and regulations, permanent incentives such as accelerated depreciation are all measures to boost investment. Creating the conditions for growth is the single biggest economic challenge we face.

**R**adioactivity describes the emission of particles from an unstable atom. Marie Curie invented the term after Henri Becquerel first reported in 1896 that uranium was emitting some sort of radiation. Ernest Rutherford then identified, and named, these particles, alpha, beta and gamma.

Much about radioactivity remained a mystery, including an apparent violation of the law of conservation of energy. In beta decay, an electron is expelled from the nucleus, but what happened to the missing energy?<sup>8</sup> In 1932, James Chadwick, Rutherford's student at Cambridge, discovered the neutron, which would eventually hold the key to understanding what was really happening in radioactivity. And that insight would come from a brilliant Italian, Enrico Fermi.

<sup>7</sup> Economist Alvin Hansen of Harvard first wrote of this in 1938; Larry Summers (also of Harvard) is one of the leading advocates of this view today.

<sup>8</sup> Mass and energy are equivalent, as Einstein's theory of special relativity proved.



Fermi's genius was evident early. He was born in Rome, where his father, Alberto, was Italy's chief inspector of the railroads. He entered the University of Pisa at the age of 17 and left four years later with a Ph.D. in physics. He joined the University of Florence and focused his attention on the Bose-Einstein equations that describe the behavior of bosons.<sup>9</sup> Other particles did not obey these equations,<sup>10</sup> and Fermi set out to describe the rules they follow.<sup>11</sup> These particles are now known as fermions.

Fermi solved the beta decay mystery by postulating that a neutrino<sup>12</sup> was also involved in the radiation,

thus restoring the energy balance in beta decay.<sup>13</sup> When Chadwick announced his discovery of the neutron, Fermi immediately realized that it was the ideal particle to use to bombard nuclei to generate radioactivity.

Fermi shot 60 different elements with neutrons, and discovered an unusual property with uranium: it seemed to produce elements that were higher than its own atomic number 92.<sup>14</sup> This made no sense. Nuclei could emit small particles such as alpha and beta particles, protons and neutrons, but something bigger was happening.

<sup>9</sup> Bosons are particles that obey the Bose-Einstein equations, such as photons, gluons, et. al.

<sup>10</sup> Such as quarks and leptons.

<sup>11</sup> These rules are called the Fermi-Dirac statistics; Paul Dirac, working independently, contributed to this knowledge.

<sup>12</sup> A near-massless particle hypothesized by Wolfgang Pauli.

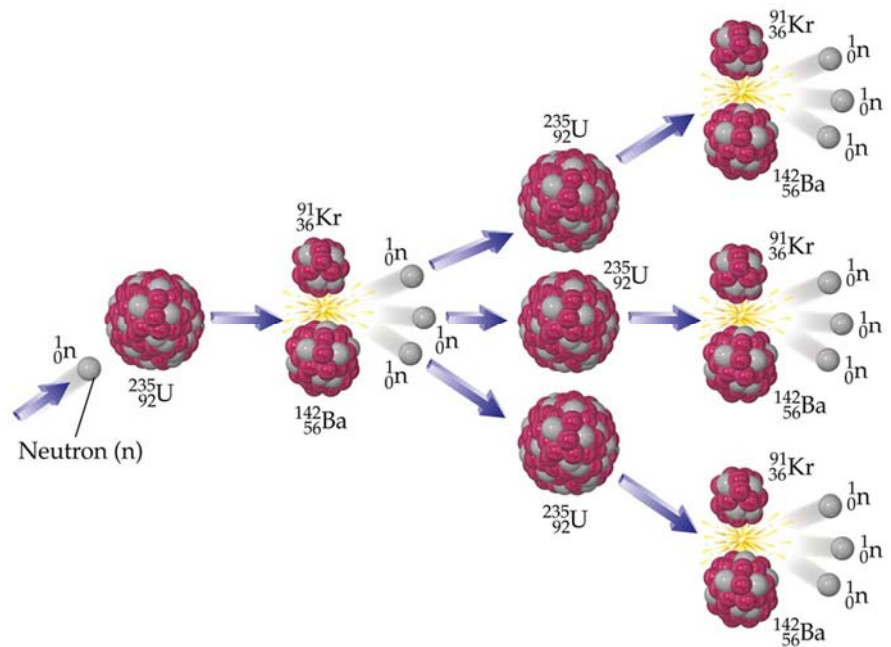
<sup>13</sup> It was discovered to be an anti-neutrino involved. But, in one of the great embarrassments in scientific literature, the prestigious journal, *Nature*, rejected Fermi's paper on the grounds that it was so speculative to be of little interest.

<sup>14</sup> The atomic number comes from the number of protons in an atom.

In 1938, Fermi received a phone call that he had been awarded the Nobel Prize in Physics.<sup>15</sup> The call came the day after *Kristallnacht*, and Mussolini had just announced new measures to proscribe Jewish activity in solidarity with his ally, Hitler. Fermi's wife, Laura, was Jewish, and they secretly made plans to leave. Later that year, they flew to Stockholm to accept the Nobel award, and then headed directly to the United States.

That same year, two teams working in Germany and in Austria<sup>16</sup> provided an answer to what Fermi had discovered with uranium: he was seeing a splitting of the atom. When the uranium atom fissioned (split) mass was converted to energy,<sup>17</sup> but a few neutrons were also released. Fermi immediately grasped the implication: if those neutrons could be slowed and controlled, they could cause the uranium atom to split again, and again, emitting ever more energy in mere seconds.

Criticality refers to the balance of neutrons in a system. When more neutrons are lost than are being produced, the system is subcritical, and will not be self-sustaining. An excess of neutrons produced, supercritical, results in a massive amount of energy released. The key is controlling the optimal balance of neutrons produced to neutrons lost: critical mass.

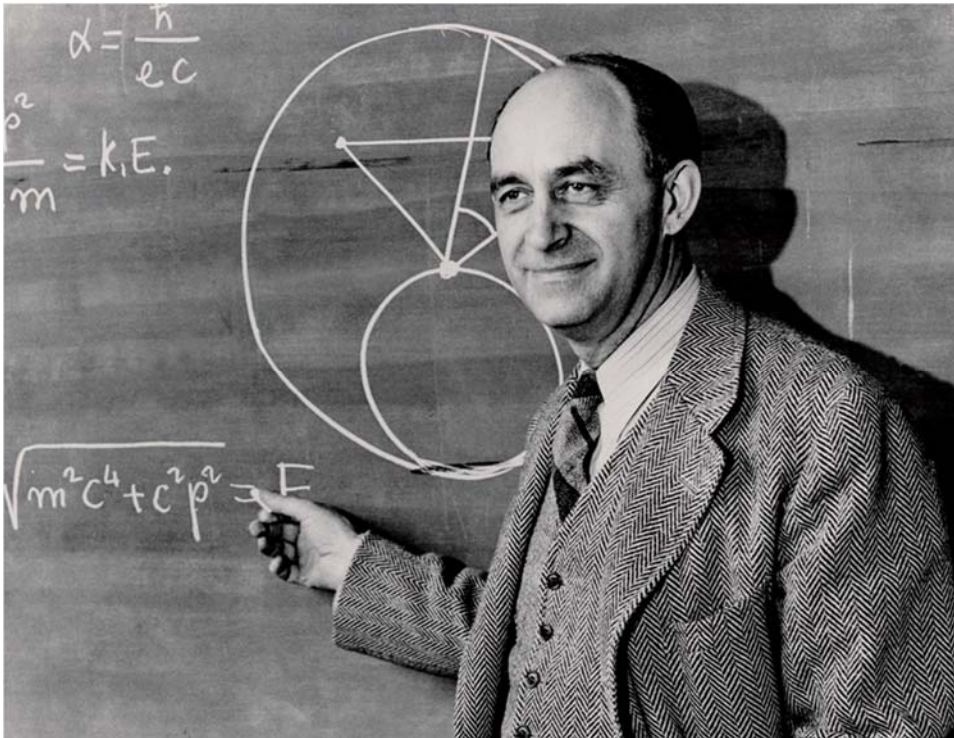


Hungarian physicist Leo Szilard was the first to hypothesize of the possibility of a nuclear chain reaction. He was one of the large group of brilliant scientists fleeing Europe for the United States in the 1930s. He and Fermi began working on an experiment that would create the first self-sustaining nuclear chain reaction. Knowing that the key was in moderating the production of neutrons during fission, Szilard suggested using graphite to absorb the excess neutrons, so he and Fermi approached the National Carbon Company about supplying them with a lot of graphite. In quizzing the company about manufacturing impurities, Szilard learned that graphite contained boron, a neutron absorber, which would have slowed the chain reaction to sub-

<sup>15</sup> For demonstrating "the existence of new radioactive elements produced by neutron irradiation and related discovery of nuclear reactions brought about by slow neutrons."

<sup>16</sup> German chemists Otto Hahn and Fritz Strassmann and Austrian physicists Lise Meiner and her nephew Otto Frisch.

<sup>17</sup>  $E=mc^2$



critical. So he demanded boron-free graphite. Four hundred tons would do.

On the old squash courts underneath the stands of Stagg Field, Fermi began assembling the uranium pile, interspersed with graphite rods, layer upon layer, 20 feet high and 25 feet wide. On 2 December 1942, they were ready to put this pile of uranium and graphite to the test. If anything went wrong, they had a bucket of cadmium nitride to throw over the pile, hoping that would prevent them from blowing up Chicago. Slowly, they removed one control rod six inches at a time, then another rod, and so on, while Fermi monitored the neutron activity. Late that afternoon, Fermi announced that they had achieved critical mass: a self-sustaining nuclear chain reaction capable of releasing enormous

amounts of energy.

What an extraordinary achievement. Not just in conceptualizing sub-atomic activity, an impressive intellectual leap in itself, but to be able to set in motion, *and to control* the progression of nuclear fission. Fermi knew that once you began bombarding uranium atoms with neutrons, inducing nuclear fission, it was a very fine balance between having little effect and uncontrolled, unimaginable chaos.

We live in a time today of political fracturing, from the splitting of the

European Union to what passes for political discourse in this country. But splitting anything, from a uranium atom to a political party, risks unleashing a chain reaction of events that may be difficult to control.

Fermi, Szilard, and other scientists at the time had only a basic theoretical understanding of nuclear fission. Through their sheer genius, and a bit of luck, they were able to harness the enormous power of nuclear fission. Those who seek to induce political fission today should be mindful of the unknown consequences their actions release, the fine balance between political order and chaos. Especially mindful, since none have the genius of Enrico Fermi.

Founded in 2001, Angeles Investment Advisors LLC provides investment advice to select institutions and high net worth families and individuals.

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## Michael A. Rosen

### Principal & Chief Investment Officer

JULY 2016

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