

perfect storm

energy, finance and the end of growth

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part one:

the end of an era

the four factors which are bringing down the curtain on growth

summary

The economy as we know it is facing a lethal confluence of four critical factors – the fall-out from the biggest debt bubble in history; a disastrous experiment with globalisation; the massaging of data to the point where economic trends are obscured; and, most important of all, the approach of an energy-returns cliff-edge.

Through technology, through culture and through economic and political change, society is more short-term in nature now than at any time in recorded history. Financial market participants can carry out transactions in milliseconds. With 24-hour news coverage, the media focus has shifted inexorably from the analytical to the immediate. The basis of politicians' calculations has shortened to the point where it can seem that all that matters is the next sound-bite, the next headline and the next snapshot of public opinion. The corporate focus has moved all too often from strategic planning to immediate profitability as represented by the next quarter's earnings.

This report explains that this acceleration towards ever-greater immediacy has blinded society to a series of fundamental economic trends which, if not anticipated

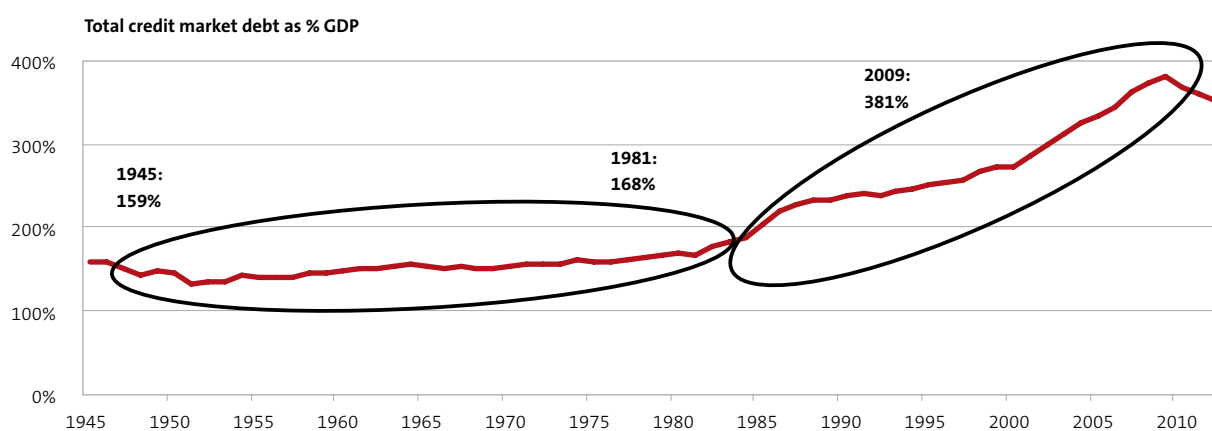
and tackled well in advance, could have devastating effects. The relentless shortening of media, social and political horizons has resulted in the establishment of self-destructive economic patterns which now threaten to undermine economic viability.

We date the acceleration in short-termism to the early 1980s. Since then, there has been a relentless shift to immediate consumption as part of something that has been called a "cult of self-worship". The pursuit of instant gratification has resulted in the accumulation of debt on an unprecedented scale. The financial crisis, which began in 2008 and has since segued into the deepest and most protracted economic slump for at least eighty years, did not result entirely from a short period of malfeasance by a tiny minority, comforting though this illusion may be. Rather, what began in 2008 was

the denouement of a broadly-based process which had lasted for thirty years, and is described here as "the great credit super-cycle".

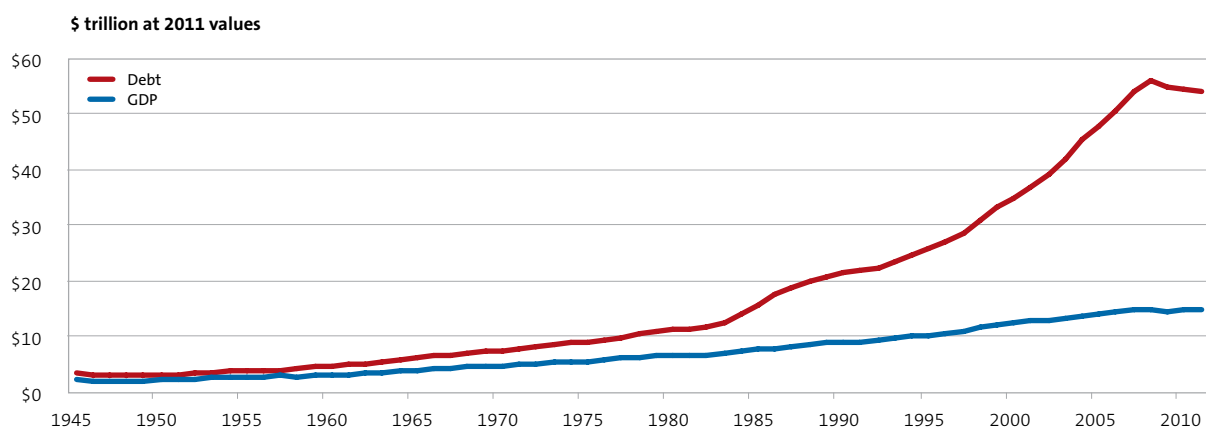
The credit super-cycle process is exemplified by the relationship between GDP and aggregate credit market debt in the United States (see fig. 1.1). In 1945, and despite the huge costs involved in winning the Second World War, the aggregate indebtedness of American businesses, individuals and government equated to 159% of GDP. More than three decades later, in 1981, this ratio was little changed, at 168%. In real terms, total debt had increased by 214% since 1945, but the economy had grown by 197%, keeping the debt ratio remarkably static over an extended period which, incidentally, was far from shock-free (since it included two major oil crises).

Fig. 1.1: The debt-GDP ratio in the United States since 1945*



* Sources: Federal Reserve, Bureau of Economic Analysis and *Economic Report of the President*

Fig. 1.2: US real GDP and debt since 1945*



* Sources: Federal Reserve, Bureau of Economic Analysis and *Economic Report of the President*



From the early 1980s, as figs. 1.1 and 1.2 show, an unmistakable and seemingly relentless upwards trend in indebtedness became established. Between 1981 and 2009, debt grew by 390% *in real terms*, far out-pacing the growth (of 120%) in the American economy. By 2009, the debt ratio had reached 381%, a level unprecedented in history. Even in 1930, when GDP collapsed, the ratio barely topped 300%, and thereafter declined very rapidly indeed.

This report is not, primarily, about debt, and neither does it suggest that the problems identified here are unique to the United States. Rather, the massive escalation in American indebtedness is one amongst a host of indicators of a state of mind which has elevated immediate consumption over prudence throughout much of the world.

This report explains that we need only look beyond the predominant short-termism of contemporary thinking to perceive that we are at the confluence of four extremely dangerous developments which,

individually or collectively, have already started to throw more than two centuries of economic expansion into reverse.

Before the financial crisis of 2008, this analysis might have seemed purely theoretical, but the banking catastrophe, and the ensuing slump, should demonstrate that the dangerous confluence described here **is already underway**. Indeed, more than two centuries of near-perpetual growth probably went into reverse as much as ten years ago.

Lacking longer-term insights, today's policymakers seem bewildered about many issues. Why, for instance, has there been little or no recovery from the post-2008 economic slump? Why have traditional, tried-and-tested fiscal and monetary tools ceased to function? Why have both austerity and stimulus failed us?

The missing piece of the economic equation is an appreciation of four underlying trends, each of which renders many of the lessons of the past irrelevant.

trend #1 – the madness of crowds

The first of the four highly dangerous trends identified here is the creation, over three decades, of the worst financial bubble in history. In his 1841 work *Extraordinary Popular Delusions and the Madness of Crowds*, Charles Mackay (1814-89) identified a common thread of individual and collective idiocy running through such follies of the past as alchemy, witch-hunts, prophecies, fortune-telling, magnetizers, phrenology, poisoning, the admiration of thieves, duels, the imputation of mystic powers to relics, haunted houses, crusades – *and financial bubbles*.

A clear implication of Mackay's work was that all of these follies had been consigned to the past by intelligence, experience and enlightenment. For the most part, he has been right. Intelligent people today do not put faith in alchemy, fortune-telling, witchcraft or haunting, and – with the arguable exception of the invasion of Iraq – crusades have faded into the history books.

But one folly remains alive and well. Far from confining financial bubbles to historical tales of Dutch tulips and British South Sea stock, the last three decades have witnessed the creation and the bursting of the biggest bubble in financial history.

Described here as ‘the credit super-cycle’, this bubble confirmed that one aspect, at least, of the idiocy identified by Mackay continues to wreak havoc. Insane though historic obsessions with tulip bulbs and south seas riches may appear, they are dwarfed by the latter-day, ‘money for nothing’ lunacy that, through the credit super-cycle, has mired much of the world in debts from which no escape (save perhaps hyper-inflation) exists.

Perhaps the most truly remarkable feature of the super-cycle was that it endured for so long in defiance of all logic or common sense. Individuals in their millions believed that property prices could only ever increase, such that either borrowing against equity (by taking on invariably-expensive credit) or spending it (through equity release) was a safe, rational and even normal way to behave.

Regulators, meanwhile, believed that there was nothing wrong with loosening banking reserve criteria (both by risk-weighting assets in ways that masked leverage, and by broadening definitions of bank capital to the

point where even some forms of debt counted as shock-absorbing equity).

Former Federal Reserve boss Alan Greenspan has been ridiculed for believing that banks would always act in the best interests of their shareholders, and that the market would sort everything out in a benign way. But regulators more generally bent over backwards to ignore the most obvious warning signs, such as escalating property price-to-incomes ratios, soaring levels of debt-to-GDP, and such obviously-abusive practices as sub-prime mortgages, NINJA¹ loans and the proliferation of unsafe financial instruments.

Where idiocy and naïveté were concerned, however, regulators and the general public were trumped by policymakers and their advisors. Gordon Brown, for example, proclaimed an end to “boom and bust” and gloried in Britain’s “growth” despite the way in which debt escalation was making it self-evident that the apparent expansion in the economy was neither more nor less than the simple spending of borrowed money.

Between 2001-02 and 2009-10, Britain added £5.40 of private and public debt for each £1 of ‘growth’ in GDP (fig. 1.3). Between 1998 and 2012, real GDP increased by just £338bn (30%) whilst debt soared by £1,133bn (95%) (fig. 1.4). Asset managers have a very simple

term to describe what happened to Britain under Brown – it was a collapse in returns on capital employed.

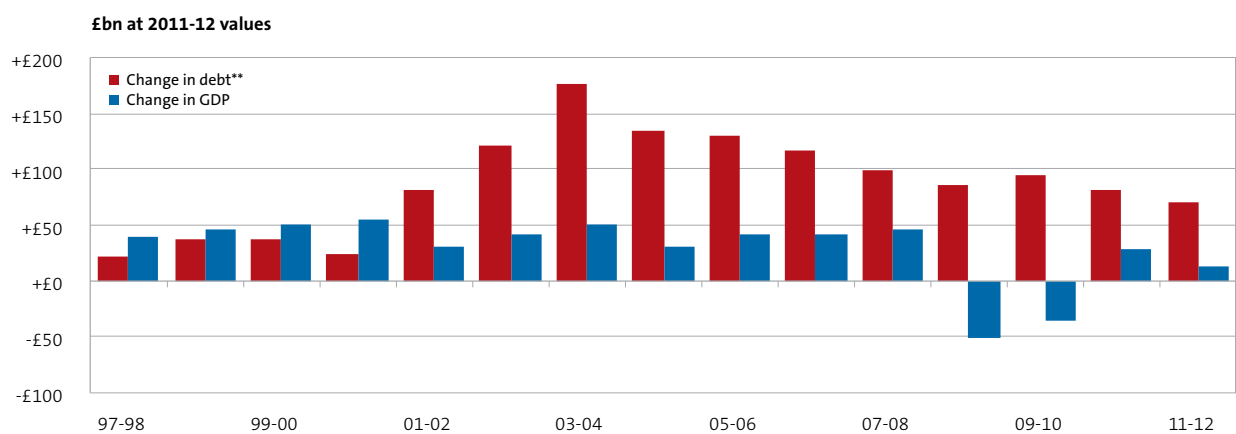
No other major economy got it quite as wrong as Britain under Brown, but much the same was happening across the Western world, most notably in those countries which followed the disastrous Anglo-American philosophy of “light-touch” financial regulation.

trend #2 – the globalisation disaster

The compounding mistake, where the Western countries were concerned, was a wide-eyed belief that ‘globalisation’ would make everyone richer, when the reality was that the out-sourcing of production to emerging economies was a self-inflicted disaster with few parallels in economic history. One would have to look back to a Spanish empire awash with bullion from the New World to find a combination of economic idiocy and minority self-interest equal to the folly of globalization.

The big problem with globalisation was that Western countries reduced their production *without making corresponding reductions in their consumption*. Corporations’ outsourcing of production to emerging economies boosted their earnings (and, consequently, the incomes of the minority at the very top) whilst hollowing out their domestic economies through the export of skilled jobs.

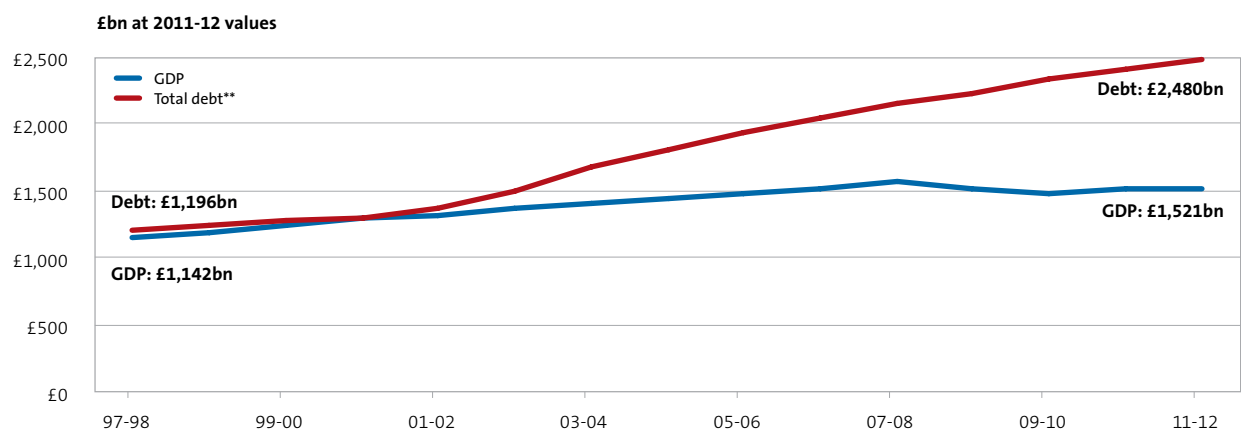
Fig. 1.3: Changes in UK real debt and GDP*



* Source: Tullett Prebon UK Economic & Fiscal Database 2012

** Government and private individual debt

Fig. 1.4: UK real debt and GDP*



* Source: Tullett Prebon UK Economic & Fiscal Database 2012

** Government and private individual debt

This report uses a measure called ‘globally-marketable output’ (GMO) as a metric for domestic production, a measure which combines manufacturing, agriculture, construction and mining with net exports of services. By definition, activities falling outside this category consist of services provided to each other.

At constant (2011) values, consumption by Americans increased by \$6,500bn between 1981 and 2011, whilst consumption on their behalf by the government rose by a further \$1,700bn, but the combined output of the manufacturing, construction, agricultural and extractive industries grew by barely \$600bn. At less than \$200bn in 2011, net exports of services did almost nothing to bridge the chasm between consumption and production.

This left two residuals – domestically-consumed services, and debt – with debt the clincher. Between 1981 and 2011, and again expressed *at constant values*, American indebtedness soared from \$11 trillion to almost \$54 trillion.

Fundamentally, what had happened here was that skilled, well-paid jobs had been exported, consumption had increased, and ever-greater quantities of debt had been used to fill the gap. This was, by any definition,

unsustainable. Talk of Western economies modernising themselves by moving from production into services contained far more waffle than logic – Western consumers sold each other ever greater numbers of hair-cuts, ever greater quantities of fast food and ever more zero-sum financial services whilst depending more and more on imported goods and, critically, on the debts used to buy them. Corporate executives prospered, as did the gate-holders of the debt economy, whilst the vast majority saw their real wages decline and their indebtedness spiral.

For our purposes, what matters here is that reducing production, increasing consumption and taking on escalating debt to fill the gap was never a remotely sustainable course of action. What this in turn means is that no return to the pre-2008 world is either possible or desirable.

trend #3 – an exercise in self-delusion

One explanation for widespread public (and policymaker) ignorance of the truly parlous state of the Western economies lies in the delusory nature of economic and fiscal statistics, many of which have been massaged out of all relation to reality.

There seems to have been no ‘grand conspiracy’ here, but the overall effect

of accretive changes has been much the same. In America, for example, the benchmark measure of inflation (CPI-U) has been modified by ‘substitution’, ‘hedonics’ and ‘geometric weighting’ to the point where reported numbers seem to be at least six percentage points lower than they would have been under the ‘pre-tinkering’ basis of calculation used until the early 1980s. US unemployment, reported at 7.8%, excludes so many categories of people (such as “discouraged workers”) that it hides very much higher levels of inactivity.

The critical distortion here is clearly inflation, which feeds through into computations showing “growth” even when it is intuitively apparent (and evident on many other benchmarks) that, for a decade or more, the economy has, at best, stagnated, not just in the United States but across much of the Western world. Distorted inflation also tells wage-earners that they have become better off even though such statistics do not accord with their own perceptions. It is arguable, too, that real (inflation-free) interest rates were negative from as long ago as the mid-1990s, a trend which undoubtedly exacerbated an escalating tendency to live on debt.

Fiscal figures, too, are heavily distorted, most noticeably in the way in which

quasi-debt obligations are kept off the official balance sheet. As we explain in this report, the official public debts of countries such as the United States and the United Kingdom exclude truly enormous commitments such as pensions.

trend #4 – the growth dynamo winds down

One of the problems with economics is that its practitioners preach a concentration on money, whereas *money is the language rather than the substance of the real economy*. Ultimately, the economy is – and always has been – a surplus energy equation, governed by the laws of thermodynamics, not those of the market.

Society and the economy began when agriculture created an energy surplus which, though tiny by later standards, liberated part of the population to engage in non-subsistence activities.

A vastly larger liberation of surplus energy occurred with the discovery of the heat engine, meaning that the energy delivered by human labour could be leveraged massively by exogenous sources of energy such as coal, oil and natural gas. A single US gallon of gasoline delivers work equivalent to between 360 and 490 hours of strenuous human

labour, labour which would cost perhaps \$6,500 if it were paid for at prevailing rates. Of the energy – a term coterminous with ‘work’ – consumed in Western societies, well over 99% comes from exogenous sources, and probably less than 0.7% from human effort.

Energy does far more than provide us with transport and warmth. In modern societies, manufacturing, services, minerals, food and even water are functions of the availability of energy. The critical equation here is not the absolute quantity of energy available but, rather, the difference between energy extracted and energy consumed in the extraction process. This is measured by the mathematical equation EROEI (energy return on energy invested).

For much of the period since the Industrial Revolution, EROEIs have been extremely high. The oil fields discovered in the 1930s, for example, provided at least 100 units of extracted energy for every unit consumed in extraction (an EROEI of 100:1). For some decades now, though, global average EROEIs have been falling, as energy discoveries have become both smaller and more difficult (meaning energy-costly) to extract.

The killer factor is the non-linear nature of EROEIs. As fig. 1.5 shows, the effects of a fall-off in EROEI from, say,

80:1 to 20:1 do not seem particularly disruptive but, once returns ratios have fallen below about 15:1, there is a dramatic, ‘cliff-edge’ slump in surplus energy, combined with a sharp escalation in its cost.

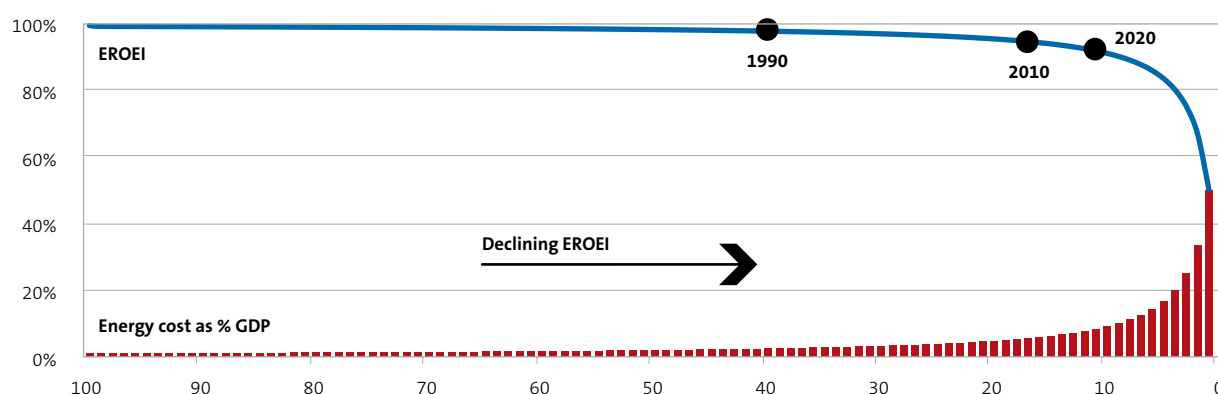
Research set out in this report suggests that the global average EROEI, having fallen from about 40:1 in 1990 to 17:1 in 2010, may decline to just 11:1 by 2020, at which point energy will be about 50% more expensive, *in real terms*, than it is today, a metric which will carry through directly into the cost of almost everything else – *including food*.

crisis, culpability and consequences

If the analysis set out in this report is right, we are nearing the end of a period of more than 250 years in which growth has been ‘the assumed normal’. There have been setbacks, of course, but the near-universal assumption has been that economic growth is the usual state of affairs, a rule to which downturns (even on the scale of the 1930s) are the exceptions. That comfortable assumption is now in the process of being over-turned.

The views set out here must provoke a host of questions. For a start, if we really are nearing a cliff-edge economic crisis, why isn’t this visible already? Second, who is to blame for this?

Fig. 1.5: Nearing the energy returns cliff-edge*



* Source: Tullett Prebon analysis

Third, how bad could it get? Last, but surely most important, can anything be done about it?

Where visibility is concerned, our belief is that, if the economy does tip over in the coming few years, retrospect – which always enjoys the 20-20 vision of hindsight – will say that the signs of the impending crash were visible well before 2013.

For a start, anyone who believed that a globalisation model (in which the West unloaded production but *expected to consume as much, or even more, than ever*) was sustainable was surely

guilty of wilful blindness. Such a state of affairs was only ever viable on the insane assumption that debt could go on increasing indefinitely. Charles Mackay chronicled many delusions, but none – not even the faith placed in witchcraft – was ever quite as irrational as the belief (seldom stated, but always implicit in Western economic policy) that there need never be an end to a way of life which was wholly dependent on ever-greater debt.

Even to those who were happy to swallow the nonsense of perpetually-expanding indebtedness, the sheer

scale of debt – and, relevantly in this context, of quasi-debt commitments as well – surely should have sounded warning bells. From Liverpool to Los Angeles, from Madrid to Matsuyama, the developed world is mired in debts that can never be repaid. In addition to formal debt, governments have entered into pension and welfare commitments which are only affordable if truly heroic assumptions are made about future prosperity.

At the same time, there is no real evidence that the economy is recovering from what is already

a more prolonged slump than the Great Depression of the 1930s. We are now more than four years on from the banking crisis and, under anything approaching normal conditions, there should have been a return to economic expansion by now. Governments have tried almost everything, from prolonged near-zero interest rates and stimulus expenditures to the creation of money on a gigantic scale. These tools have worked in the past, and the fact that, this time, they manifestly are *not* working should tell us that something profoundly different is going on.

The question of culpability has been the equivalent of Sherlock Holmes' "dog that did not bark in the night", in that very few individuals have been held to account for what is unarguably the worst economic disaster in at least eighty years. A small number of obviously-criminal miscreants have been prosecuted, but this is something that happens on a routine basis in normal times, so does not amount to an attribution of blame for the crisis.

There has been widespread public vilification of bankers, the vast majority of whom were, in any case, only acting within the parameters of the 'debt-fuelled, immediate gratification' ethos established across Western societies as a whole.



Governments have been ejected by their electorates, but their replacements have tended to look very similar indeed to their predecessors.

The real reason for the seeming lack of retribution is that culpability is far too dispersed across society as a whole. If, say, society was to punish senior bankers, what about the thousands of salesmen who *knowingly* pushed millions of customers into mortgages that were not remotely affordable? The suspicion lingers that there has been a 'grand conspiracy of culpability', but even the radical left has failed to tie this down to specifics in a convincing way.

The real causes of the economic crash are the cultural norms of a society that has come to believe that immediate material gratification, fuelled if necessary by debt, can ever be a sustainable way of life. We can, if we wish, choose to blame the advertising industry (which spends perhaps \$470bn annually pushing the consumerist message), or the cadre of corporate executives who have outsourced skilled jobs in pursuit of personal gain. We can blame a generation of policymakers whose short-termism has blinded them to underlying trends,

or regulators and central bankers who failed to "take away the punch-bowl" long after the party was self-evidently out of control.

But blaming any of these really means blaming ourselves – for falling for the consumerist message of instant gratification, for buying imported goods, for borrowing far more than was healthy, and for electing glib and vacuous political leaders.

Beyond visibility and culpability, the two big questions which need to be addressed are 'how bad can it get?' and 'is there anything that we can do about it?'

Of these, the first question hardly needs an answer, since the implications seem self-evident – economies will lurch into hyper-inflation in a forlorn attempt to escape from debt, whilst social strains will increase as the vice of resource (including food) shortages tightens.

In terms of solutions, the first imperative is surely a cultural change away from instant gratification, a change which, if it is not adopted willingly, will be enforced upon society anyway by the reversal of economic growth.

The magic bullet, of course, would be the discovery of a new source of energy which can reverse the winding-down of the critical energy returns equation. Some pin their faith in nuclear fusion (along lines being pioneered by ITER²) but this, even if it works, lies decades in the future – that is, long after the global EROEI has fallen below levels which will support society as we know it. Solutions such as biofuels and shales are rendered non-workable by their intrinsically-low EROEIs.

Likewise, expecting a technological solution to occur would be extremely unwise, because technology *uses* energy – it does not create it. To expect technology to provide an answer would be equivalent to locking the finest scientific minds in a bank-vault, providing them with enormous computing power and vast amounts of money, and expecting them to create a ham sandwich.

In the absence of such a breakthrough, really promising energy sources (such as concentrated solar power) need to be pursued together, above all, with social, political and cultural adaptation to "life after growth".





part two:

this time *is* different

the implosion of the credit super-cycle

summary

The 2008 crash resulted from the bursting of the biggest bubble in financial history, a ‘credit super-cycle’ that spanned more than three decades. How did this happen?

As Carmen Reinhart and Kenneth Rogoff have demonstrated in their magisterial book *This Time Is Different*, asset bubbles are almost as old as money itself. The Reinhart and Rogoff book tracks financial excess over eight centuries, but it would be no surprise at all if the Hittites, the Medes, the Persians and the Romans, too, had bubbles of their own. All you need for a bubble is ready credit and collective gullibility.

Some might draw comfort from the observation that bubbles are a long-established aberration, arguing that the boom-and-bust cycle of recent years is nothing abnormal. Any such comfort would be misplaced, for two main reasons.

First, the excesses of recent years have reached a scale which exceeds anything that has been experienced before.

Second, and more disturbing still, the developments which led to the financial crisis of 2008 amounted

to a process of *sequential* bubbles, a process in which the bursting of each bubble was followed by the immediate creation of another.

Though the sequential nature of the pre-2008 process marks this as something that really *is* different, we can, nevertheless, learn important lessons from the bubbles of the past. First, bubbles follow an approximately symmetrical track, in which the spike in asset values is followed by a collapse of roughly similar scale and duration. If this holds true now, we are in for a very long and nasty period of retreat.

Second, easy access to leverage is critical, as bubbles cannot happen if investors are limited to equity. Third, most bubbles look idiotic when seen with hindsight. Fourth – and although institutional arrangements are critical – the real driving dynamic of bubbles is a psychological process which combines greed, the willing suspension of disbelief and the development of a herd mentality.

“tulips from Amsterdam”

One of the most famous historical bubbles is the tulip mania which gripped the United Provinces (the Netherlands) during the winter of 1636-37. Tulip bulbs had been introduced to Europe from the Ottoman Empire by Obier de Busbeq in 1554, and found particular favour in the United Provinces after 1593, when Carolus Clusius proved that these exotic plants could thrive in the harsher Dutch climate.

The tulip was a plant whose beauty and novelty had a particular appeal, but tulip mania would not have occurred without favourable social and economic conditions. The Dutch had been engaged in a long war for independence from Spain since 1568 and, though final victory was still some years away, the original Republic of the Seven Provinces of the Netherlands declared independence from Spain in 1581. This was the beginning of the great Dutch Golden Age. In this

remarkable period, the Netherlands underwent some fundamental and pioneering changes which included the establishment of trading dominance, great progress in science and invention, and the creation of corporate finance, as well as the accumulation of vast wealth, the accession of the Netherlands to global power status, and great expansion of industry.

This was a period in which huge economic, business, scientific, trading and naval progress was partnered by remarkable achievements in art (Rembrandt and Vermeer), architecture and literature. The prosperity of this period created a wealthy bourgeoisie which displayed its affluence in grand houses with exquisite gardens. Enter the tulip.

For the newly-emergent Dutch bourgeoisie, the tulip was the “must-have” consumer symbol of the 1630s, particularly since selective breeding had produced some remarkably exotic new plants. Tulips cannot be grown overnight, but take between seven and twelve years to reach maturity. Moreover, tulips bloom for barely a week during the spring, meaning that bulbs can be uprooted and sold during the autumn and winter months.

A thriving market in bulbs developed in the Netherlands even though short-selling was outlawed in 1610. Speculators seem to have entered the

tulip market in 1634, setting the scene for tulip mania.

The tulip bubble did not revolve around a physical trade in bulbs but, rather, involved a paper market in which people could participate with no margin at all. Indeed, the tulip bubble followed immediately upon the heels of the creation by the Dutch of the first futures market. Bulbs could change hands as often as ten times each day but, because of the abrupt collapse of the paper market, no physical deliveries were ever made.

Price escalation was remarkable, with single bulbs reaching values that exceeded the price of a large house. A *Viceroy* bulb was sold for 2,500 florins at a time when a skilled worker might earn 150 florins a year. Putting these absurd values into modern terms is almost impossible because of scant data, but the comparison with skilled earnings suggests values of around £500,000³, which also makes some sense in relation to property prices. In any event, a bubble which began in mid-November 1636 was over by the end of February 1637.

Though tulip mania was extremely brief, and available data is very limited, we can learn some pertinent lessons from this strange event.

For a start, this bubble looks idiotic from any rational perspective – how on earth could a humble bulb become as

valuable as a mansion, or equivalent to 17 years of skilled wages?

Second, trading in these ludicrously overvalued items took place in then-novel forms (such as futures), and were conducted on unregulated fringe markets rather than in the recognised exchanges.

Third, participants in the mania lost the use of their critical faculties. Many people – not just speculators and the wealthy, but individuals as diverse as farmers, mechanics, shopkeepers, maidservants and chimney-sweeps – saw bulb investment as a one-way street to overnight prosperity. Huge paper fortunes were made by people whose euphoria turned to despair as they were wiped out financially.

The story that a sailor ate a hugely valuable bulb, which he mistook for an onion, is probably apocryphal (because it would have poisoned him), but there can be little doubt that this was a period of a bizarre mass psychology verging on collective insanity.

all at sea

The South Sea Bubble of 1720 commands a special place in the litany of lunacy that is the history of bubbles.

The South Sea Company was established in 1711 as a joint government and private entity created to manage the national debt. Britain's involvement in the War of the Spanish

³ A bulb worth 2,500 florins in 1637 was equivalent to 16.7x an annual skilled wage of 150 florins. Assuming a skilled wage today of £30,000, the bulb would be worth £500,000

Succession was imposing heavy costs on the exchequer, and the Bank of England's attempt to finance this through two successive lotteries had not been a success. The government therefore asked an unlicensed bank, the Hollow Sword Blade Company, to organise what became the first successful national lottery to be floated in Britain. The twist to this lottery was that prizes were paid out as annuities, thus leaving the bulk of the capital in government hands.

After this, government set up the South Sea Company, which took over £9m of national debt and issued shares to the same amount, receiving an annual payment from government equivalent to 6% of the outstanding debt (£540,000) plus operating costs of £28,000. As an added incentive, government granted the company a monopoly of trade with South America, a monopoly which would be without value unless Britain could break the Spanish hegemony in the Americas, an event which, at that time, was wildly implausible.

The potentially-huge profits from this monopoly grabbed speculator attention even though the real likelihood of any returns ever actually accruing was extremely remote. Despite very limited concessions secured in 1713 at the end of the war, the trading monopoly remained all

but worthless, and company shares remained below their issue price, a situation not helped by the resumption of war with Spain in 1718.

Even so, shares in the company, effectively backed by the national debt, began to rise in price, a process characterised by insider dealing and boosted by the spreading of rumours.

Between January and May 1720, the share price rose from £128 to £550 as rumours of lucrative returns from the monopoly spread amongst speculators. What, many argued, could be better than a government-backed company with enormous leverage to monopolistic profits in the fabled Americas? Legislation, passed under the auspices of Company insiders and banning the creation of unlicensed joint stock enterprises, spurred the share price to a peak of £890 in early June. This was bolstered by Company directors, who bought stock at inflated prices to protect the value of investments acquired at much lower levels. The share price peaked at £1,000 in August 1720, but the shares then lost 85% of their inflated market value in a matter of weeks.

Like the Dutch tulip mania, the South Sea Bubble was an example which fused greed and crowd psychology with novel market practices, albeit compounded by rampant corruption

in high places. Even Sir Isaac Newton, presumably a man of common sense, lost £20,000 (equivalent to perhaps £2.5m today) in the pursuit of the chimera of vast, but nebulous, *unearned* riches.

Any rational observer, even if unaware of the insider dealing and other forms of corruption in which the shares were mired, should surely have realised that an eight-fold escalation in the stock price based entirely on implausible speculation was, quite literally, 'too good to be true'.

In his *Extraordinary Popular Delusions and the Madness of Crowds*, Charles Mackay ranked the South Sea Company and other bubbles with alchemy, witch-hunts and fortune-telling as instances of collective insanity. Whilst other such foibles have tended to retreat in the face of science, financial credulity remains alive and well, which means that we need to know how and why these instances of collective insanity seem to be hard-wired into human financial behaviour.

made in Japan

In some respects, the Japanese asset bubble of the 1980s provided a 'dry run' for the compounded bubbles of the super-cycle. Japan's post-war economic miracle was founded on comparatively straightforward policies. Saving was encouraged, and was channelled into domestic rather than foreign capital markets, which meant that investment capital was available very cheaply indeed. Exports were encouraged, imports were deterred by tariff barriers, and consumption at home was discouraged. The economic transformation of Japan in the four

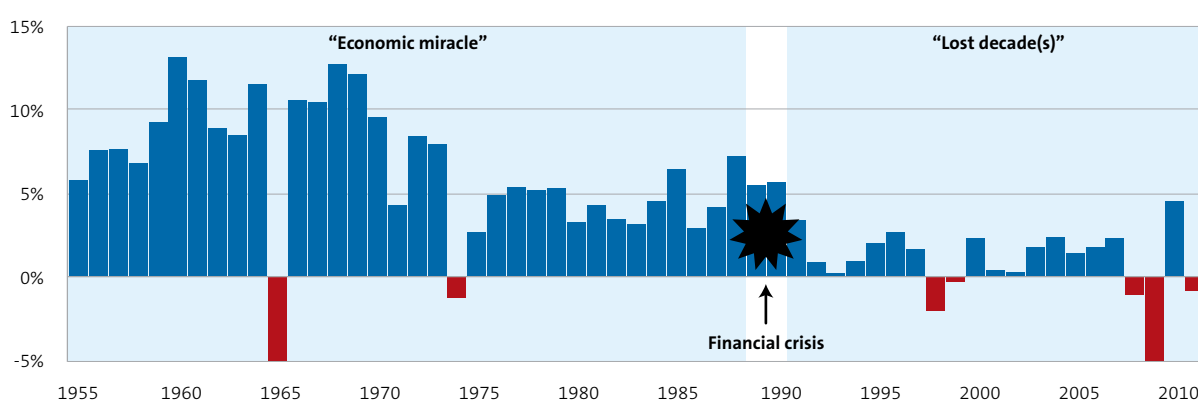
decades after 1945 was thus export-driven, and led by firms which had access to abundant, low-cost capital.

By the early 1980s, Japan's economic success was beginning to lead to unrealistic expectations about future prosperity. Many commentators, abroad as well as at home, used the 'fool's guideline' of extrapolation to contend that Japan would, in the foreseeable future, oust America as the world's biggest economy. The international expansion of Japanese banks and securities houses was reflected in the proliferation of sushi

bars in New York and London. Boosted by the diversion of still-cheap capital from industry into real estate, property values in Japan soared, peaking at \$215,000 per square metre in the prized Ginza district of Tokyo.

Comforted by inflated property values, banks made loans which the borrowers were in no position to repay. The theoretical value of the grounds of the Imperial Palace came to exceed the paper value of the entire state of California. Meanwhile, a soaring yen was pricing Japanese exports out of world markets.

Fig. 2.1: From miracle to disaster – Japanese GDP growth since 1955*



* Source: Tullett Prebon calculations based on data from IMF

Though comparatively gradual – mirroring, in true bubble fashion, the relatively slow build-up of asset values – the bursting of the bubble was devastating. Properties lost more than 90% of their peak values, and the government’s policy of propping up insolvent banks and corporations created “zombie companies” of the type that exist today in many countries. Having peaked at almost 39,000 at the end of 1989, the Nikkei 225 index of leading industrial stocks deteriorated relentlessly, bottoming at 7,055 in March 2009.

The Japanese economy was plunged into the “lost decade” which, in reality, could now be called the ‘lost two decades’. In 2011, Japanese government debt stood at 208% of GDP, a number regarded as sustainable only because of the country’s historic high savings ratio (though this ratio is, in fact, subject to ongoing deterioration as the population ages).

2008 – the biggest bust

With hindsight, we now know that the Japanese asset bust was an early manifestation of the ‘credit super-cycle’, which can be regarded as ‘the biggest bubble in history’. The general outlines of the super-cycle bubble are reasonably well understood, even if the underlying dynamic is not. To understand this enormous boom-bust

event, we need to distinguish between the tangible components of the bubble and its underlying psychological and cultural dimensions.

Conventional analysis argues that tangible problems began with the proliferation of subprime lending in the United States. Perhaps the single biggest contributory factor to the subprime fiasco was the breaking of the link between borrower and lender. Whereas, traditionally, banks assessed the viability of the borrower in terms of long-term repayment, the creation of bundled MBSs (mortgage-backed securities) severed this link. Astute operators could now strip risk from return, pocketing high returns whilst unloading the associated high risk. The securitisation of mortgages was a major innovative failing in the system, as was the reliance mistakenly placed on credit-rating agencies which, of course, were paid by the issuers of the bundled securities. Another contributory innovation was the use of ARM (adjustable rate mortgage) products, designed to keep the borrower solvent just long enough for the originators of the mortgages to divest the packaged loans.

The authorities (and, in particular, the Federal Reserve) must bear a big share of culpability for failing to spot the mispricing of risk which resulted

from the on-sale of mortgage debt. The way in which banks were keeping the true scale of potential liabilities off their balance sheets completely eluded regulators, and Alan Greenspan’s belief that banks would always act in the best interests of shareholders was breathtakingly naive. In America, as for that matter in Britain and elsewhere, central banks’ monetary policies were concentrated on retail inflation (which had for some years been depressed both by benign commodity markets and by the influx of ever-cheaper goods from Asia), and ignored asset price escalation.

Meanwhile, banks’ capital ratios had expanded, in part because of ever-looser definitions of capital and assets and in part because of sheer regulatory negligence. Just as Greenspan’s Fed believed that bankers were the best people to determine their shareholders’ interests, British chancellor Gordon Brown took pride in a “light touch” regulatory system which saw British banks’ total risk assets surge to more than £3,900bn on the back of just £120bn of pure loss-absorbing capital or TCE (tangible common equity).

It does not seem to have occurred to anyone – least of all to the American, British and other regulatory authorities – that a genuine capital reserve of less than 2% of assets could be overwhelmed by even a relatively modest correction in asset prices.

Both sides of the reserves ratio equation were distorted by regulatory negligence. On the assets side, banks were allowed to risk-weight their assets, which turned out to be a disastrous mistake. Triple-A rated government bonds were, not unnaturally, regarded as AFS ('available for sale') and accorded a zero-risk rating, but so, too, in practice, were the AAA portions that banks, with the assistance of the rating agencies, managed to slice out of MBSs (mortgage-backed securities) and CDOs (collateralised debt obligations).

Mortgages of all types were allowed to be risk-weighted downwards to 50% of their book value which, at best, reflected a nostalgic, pre-subprime understanding of mortgage risk on the part of the regulators. In the US, banks were allowed to net-off their derivatives exposures, such that J.P. Morgan Chase, for example, carried derivatives of \$80bn on its balance sheet even though the gross value of securities and derivatives was close to \$1.5 trillion⁴. The widespread

assumption that potential losses on debt instruments were covered by insurance overlooked the fact that all such insurances were placed with a small group of insurers (most notably AIG) which were not remotely capable of bearing system-wide risk.

Meanwhile, innovative definitions allowed banks' reported capital to expand from genuine TCE to include book gains on equities, and provisions for deferred tax and impairment. Even some forms of loan capital were allowed to be included in banks' reported equity.

Together, the risk-weighting of assets, and the use of ever-looser definitions of capital, combined to produce seemingly-reassuring reserves ratios which turned out to be wildly misleading. Lehman Brothers, for example, reported a capital adequacy ratio of 16.1% shortly before it collapsed, whilst the reported pre-crash ratios for Northern Rock and Kaupthing were 17.5% and 11.2% respectively⁵.

Well before 2007, the escalation in the scale of indebtedness had rendered a crash inevitable. Moreover, the two triggers that would bring the edifice crashing down could hardly have been more obvious. First, the resetting of ARM mortgage interest rates made

huge subprime default losses inevitable unless property prices rose indefinitely, which was a logical impossibility. Subprime defaults would in turn undermine the asset bases of banks holding the toxic assets that the sliced-and-diced mortgage-based instruments were bound to become as soon as property price escalation ceased.

The second obvious trigger was a seizure in liquidity. The escalation in the scale of debt had far exceeded domestic depositor funds, not least because savings ratios had plunged as borrowing and consumption had displaced saving and prudence in the Western public psyche. Unlike depositors – a stable source of funding, in the absence of bank runs – the wholesale funding markets which had provided the bulk of escalating leverage were perfectly capable of seizing up virtually overnight. For this reason, a liquidity seizure crystallised what was essentially a leverage problem.

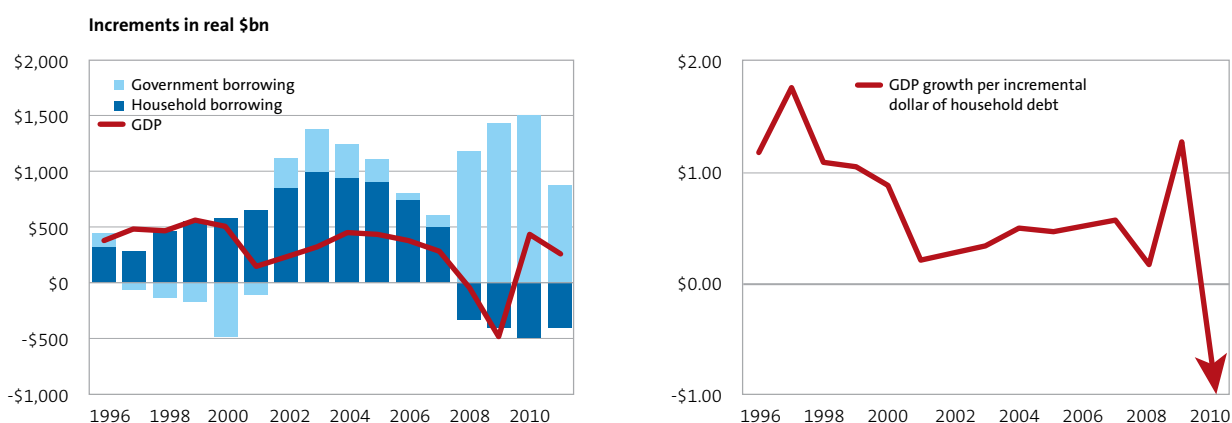
At this point, three compounding problems kicked in. The first was the termination of a long-standing 'monetary ratchet' process – low rates created bubbles, and the authorities countered each ensuing downturn by cutting rates still further, but, this time around, prior rate reductions left little scope for further relaxation.

⁴ See James Ferguson, 'What went wrong?', Patrick Young (ed.), *The Gathering Storm*, Derivatives Vision Publishing, 2010

⁵ Ferguson, op cit



Figs. 2.2 & 2.3: The relationship between borrowing and growth in the US*



* Sources: Federal Reserve and Economic Report of the President

Second, economies had become dependent upon debt-fuelled consumption, and any reversal in debt availability was bound to unwind the earlier (and largely illusory) 'growth' created by debt-fuelled consumer spending. As figs. 2.2 and 2.3 show, the relationship between borrowing and associated growth had been worsening for some years, such that the \$4.1 trillion expansion in nominal US economic output between 2001 and 2007 had been far exceeded by an increase of \$6.7 trillion in consumer debt, and the growth/borrowing equation had slumped.

Third, some countries – most notably the United Kingdom – had compounded consumer debt dependency by mistaking illusory (debt-fuelled) economic expansion for 'real' growth, and had expanded public spending accordingly, a process which created huge fiscal deficits as soon as leverage expansion ceased.

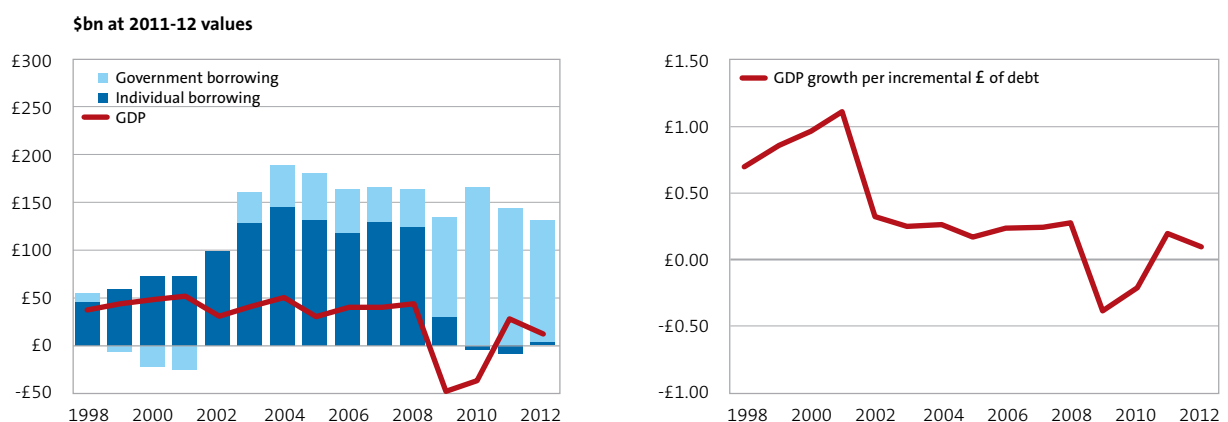
Ultimately, the leverage-driven 'great bubble' in pan-Western property values had created the conditions for a *deleveraging* downturn, something for which governments' previous experience of destocking recessions had provided no realistic appreciation.

familiar features

Though, as we shall see, the bursting of the super-cycle in 2008 had some novel aspects, the process nevertheless embraced many features of past bubbles.

A number of points are common to these past bubbles, factors which include easy credit, low borrowing costs, financial innovation (in the form of activities which take place outside established markets, and/or are unregulated, and/or are outright illegal), weak institutional structures, opportunism by some market participants, and the emergence of some form of mass psychology in

Figs. 2.4 & 2.5: The relationship between borrowing and growth in the UK*



* Source: Tullett Prebon UK Economic & Fiscal Database 2012

which fear is wholly ousted by greed. Often, the objects of speculation are items which can seem wholly irrational with the benefit of hindsight (how on earth could tulip bulbs, for instance, have become so absurdly over-valued?)

A further important point about bubbles is that they can inflate apparent prosperity, but the post-burst effects include the destruction of value and the impairment of economic output for an extended period. In reality, though, the bursting of a bubble does not destroy capital, but simply exposes the extent to which value has already been destroyed by rash investment.

Of course, the characteristics of earlier excesses have not been absent in contemporary events. As with tulip bulbs, South Sea stock and Victorian railways, recent years have witnessed the operation of mass psychologies in which rational judgement has been suspended as greed has triumphed over fear. Innovative practices, often lying outside established markets, have abounded. Examples of such innovations have included subprime and adjustable-rate mortgages, and the proliferation of an 'alphabet soup' of the derivatives that Warren Buffett famously described as "financial weapons of mass destruction".

Credit became available in excessive amounts, and the price of credit was far too low (a factor which, we believe, may have been exacerbated by a widespread under-reporting of inflation).

why this time is different

Whilst it shared many of the characteristics of previous such events, the credit super-cycle bubble which burst in 2008 differed from them in at least two respects, and arguably differed in a third dimension as well.



The first big difference was that the scale and scope of the 2008 crash far exceeded anything that had gone before. Though it began in America (with parallel events taking place in a number of other Western countries), globalisation ensured that the crash was transmitted around the world. The total losses resulting from the crash are almost impossible to estimate, not least because of notional losses created by falling asset prices, but even a minimal estimate of \$4 trillion equates to about 5.7% of global GDP, with every possibility that eventual losses will turn out to have been far greater than this.

The second big difference between the super-cycle and previous bubbles lay in timing. A gap of more than 80 years elapsed between the tulip mania of 1636-37 and the South Sea bubble of 1720, though the latter had an overseas corollary in the Mississippi bubble of the same year. The next major bubble, the British railway mania of the 1840s, followed an even longer time-gap, and a further interval of about seven decades separated the dethroning of the crooked “railway king” (George Hudson) in 1846 from the onset of the ‘roaring twenties’ bubble which culminated in the Wall Street Crash.

Though smaller bubbles (such as Poseidon) occurred in between, the next really big bubble did not occur until the 1980s, when Japanese asset values lost contact with reality.

In recent years, however, intervals between bubbles have virtually disappeared, such that the decade prior to the 2008 crash was characterised by a series of events which overlapped in time. Property price bubbles were the greatest single cause of the financial crisis, but there were complementary bubbles in a variety of other asset categories.

The dotcom bubble (1995-2000) reflected a willing suspension of critical faculties where the potential for supposedly ‘high tech’ equities were concerned, and historians of the future are likely to marvel at the idiocy which attached huge values to companies which lacked earnings, cash flow or a proven track record, and were often measured by the bizarre metric of “cash-burn”. Other bubbles occurred in property markets in the United States, Britain, Ireland, Spain, China, Romania and other countries, as well as in commodities such as uranium and rhodium. Economy-wide bubbles developed in countries such as

Iceland, Ireland and Dubai. Perhaps the most significant bubble of the lot – for reasons which will become apparent later – was that which carried the price of oil from an average of \$25/b in 2002 to a peak of almost \$150/b in 2008.

This rash of bubbles suggests that recent years have witnessed the emergence of a distinctive new trend, which is described here as a credit super-cycle, a mechanism which compounds individual bubbles into a broader pattern.

This report argues that a third big difference may be that the super-cycle bubble coincided with a weakening in the fundamental growth dynamic.

What we need to establish is the ‘underlying narrative’ that has compressed the well-spaced bubble-forming processes of the past into the single, compounded-bubble dynamic of the credit super-cycle.

It is suggested here that this narrative must include:

- **A mass psychological change** which has elevated the importance of immediate consumption whilst weakening perceptions both of risks and of longer-term consequences.

- **Institutional weaknesses** which have undermined regulatory oversight whilst simultaneously facilitating the provision of excessive credit through the creation of high-risk instruments.
- **Mispricing of risk**, compounded by false appreciation of economic prospects and by the distortion of essential data.
- A political, business and consumer **mind-set** which elevates the importance of the immediate whilst under-emphasising the longer term.
- **A distortion of the capitalist model** which has created a widening chasm between ‘capitalism in principle’ and ‘capitalism in practice’.

Before we can put the credit super-cycle into its proper context, however, we need to appreciate three critical issues, each of which is grossly misunderstood.

The first of these is the vast folly of globalisation. This has impoverished and weakened the West whilst ensuring that few countries are immune from the consequences of the unwinding of a world economy

which has become a hostage to future growth assumptions at precisely the same time that the scope for generating real growth is deteriorating.

The second critical issue is the undermining of official economic and fiscal data, a process which has disguised many of the most alarming features of the super-cycle.

Third, there has been a fundamental misunderstanding of the dynamic which really drives the economy. Often regarded as a monetary construct, the economy is, in the final analysis, an energy system, and the critical supply of surplus energy has been in seemingly-inexorable decline for at least three decades.



part three:

the globalisation disaster

globalisation and the western economic catastrophe

summary

The Western developed nations are particularly exposed to the adverse trends explored in this report, because globalisation has created a lethal divergence between burgeoning consumption and eroding production, with out-of-control debt used to bridge this widening chasm.

Our collective understanding of trends informing recent and impending economic developments has been undermined by at least three conceptual shortcomings.

First, insufficient attention has been devoted to the behavioural and psychological dimensions of economics, a blind-spot which allowed policymakers to watch the creation and subsequent bursting of the biggest bubble in economic history without taking preventative or corrective action, despite the clear and unequivocal lessons that can be learned from history.

Second, policymakers and the general public have been misled by data which, in many important respects, has become ever less representative of what is really happening.

Third, there has been a failure to grasp the most critical point of all, which is that the economy is an energy dynamic, not a financial one.

Despite these major handicaps, policymakers, analysts, strategists and investors really should have developed a much better understanding of the stagnation and deterioration of the Western economies, not least because one of the most prominent drivers has been happening in plain sight.

That driver is globalisation. Put very bluntly, the process of globalisation has distorted the normal relationships between production, consumption and debt beyond the point of sustainability. The West is in deep (and perhaps irreversible) trouble because it has consumed more, just as it has produced less.

globalisation – dangerously simple, simply dangerous

The globalisation process is pretty easy to describe (which makes the ignorance of policymakers and their advisors even less excusable). Suppose that an American company manufactured a television at a cost

of \$350, and sold it for \$400, earning a margin of \$50. The company then became able, courtesy of globalisation, to manufacture the same television in China for \$50, boosting its profit margin dramatically.

This outsourcing of manufacturing in this way boosted corporate profitability enormously, and created big cash inflows that were placed in the banking system. At the same time, there was a hemorrhaging of skilled jobs from the United States and other Western economies, and countervailing increases in skilled employment in China and in other emerging countries. In terms of the West, it is a simplification, but also a truism, that corporate profits expanded whilst wages deteriorated.

As globalisation gained traction, Chinese workers, though still very poorly paid by Western standards, enjoyed big increases in their earnings, increases which, partly for cultural

reasons, they chose to save rather than to spend. Just as production was declining and consumption increasing in the West, the reverse was happening in the emerging economies, where production outstripped much smaller increases in consumption.

Like Western companies profiting from globalisation, Chinese and other emerging-country manufacturers, too, had swelling profits to bank, as had many of their governments. Cash piles were now expanding both in the emerging economies and in the West.

As with the dislocating influx of petrodollars in an earlier era, the accumulation of huge cash sums initially presented banks with a problem, in that they needed to lend this money profitably. Fortunately for the banks, they found ready takers amongst Americans and other Westerners who, having lost well-paid jobs and taken lower-wage employment instead, became increasingly dependent on debt to maintain their standards of living.

Next, bankers, trying to establish an even larger borrowing market beyond this group, created the ultimately-disastrous phenomenon known as subprime, in which mortgage funds

were advanced to borrowers who were not remotely capable of keeping up repayments, particularly when initial low “teaser” interest rates reset to much higher levels under the terms of ARMs (adjustable-rate mortgages). Interest rates fell, reflecting both surplus cash and a policy decision to boost consumer spending in pursuit of economic growth.

credit market distortion

Of course, as Western savings ratios collapsed, developing nations’ net surpluses became dominant, but Western banks nevertheless retained access to these funds in a process which saw the rapid replacement of internally-generated savings with capital sourced from wholesale markets, another development which was to have a very nasty sting in its tail. Banks financed primarily from wholesale rather than from depositor funding stand at far greater risk of sudden creditor flight, particularly where wholesale funds are being used on a short-term, recycling basis.

Meanwhile, and largely unnoticed by regulators who were either inept or complaisant, banks were moving out of the pure lending business and finding a new metiér as packagers of lending. This process – made much

simpler by the disastrous 1999 repeal of the Glass-Steagall legislation which, hitherto, had separated retail banking from investment activities – appeared to be boosting banks’ profits (and, of course, the remuneration of many of their employees), but the apparent uptrend in returns actually consisted of earnings created at the expense of balance sheets. Worse still, much of the newly-created securitised debt was actually being bought by the banks themselves through off-balance-sheet special purpose vehicles (SPVs).

So far, so logical – companies were acting rationally by outsourcing production to cheaper locations and could, indeed, argue that a failure to do this would have put individual corporations at an insurmountable competitive disadvantage. But what was really happening here, on a macroeconomic scale, was that, in America and in the West generally, *production was declining just as consumption was increasing*, a process which made individuals ever more dependent on debt.

Seen from a national, macro rather than a corporate perspective, of course, increasing consumption whilst reducing production is, by definition, an unsustainable course of action.

As other manufacturers got in on the globalisation act, the prices of imported manufactured goods fell steadily (though margins remained high). The declining prices of such goods led policymakers to worry about deflation, and to act accordingly by cutting policy rates still further.

“taking in each others’ washing” – the shift to internal services

The deflation concern was misplaced, primarily because the expansion of activity in China (and in other emerging economies) was boosting demand for raw materials. This had countervailing, *inflationary* effects, since surges in the costs of commodities more than outweighed declines in the prices of manufactured goods. Indeed, and as we shall see, it was the surge in commodity costs which was to stop the debt/consumption party in its tracks. Long before this, however, the steady increase in credit-fuelled consumption in the West had tipped the balance decisively in favour of inflation rather than deflation.

Unfortunately, this rise in inflation was masked by ever-more-misleading official data, such that real interest rates turned negative. Comparing

American government bond yields with real (rather than officially-reported) inflation suggests that effective rates probably turned negative as long ago as 1996.

The Western response to diminishing production was to expand service industries, but there has to be significant doubt about how much real value is created by doing each others’ washing, eating more fast food or having more frequent manicure sessions. Meanwhile, the relationship between debt and incomes was getting ever further out of control.

In order to illustrate these trends, we need to be able to compare movements in production, consumption and borrowing. Our methodology for identifying a measure of ‘internal production’ lies in dividing economic output between:

1. Output which is globally marketable; and
2. Services which citizens (including their government) provide to each other.

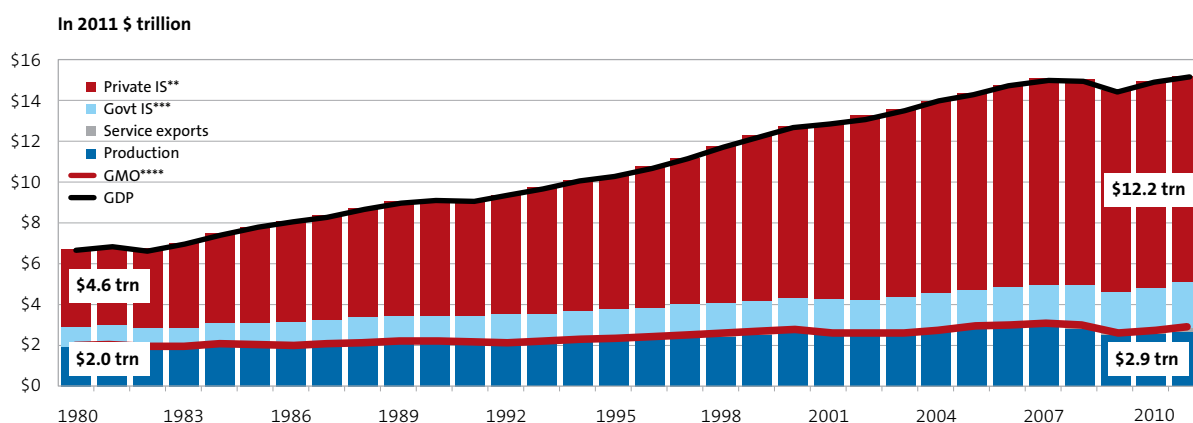
Manufactured goods, plus the products of the extractive and agricultural industries, clearly fall into the ‘globally

marketable’ category, not least because, if they were not competitively priced, consumers would be likely to purchase imports instead. The same can be said of services which are actually sold on the global market, net, of course, of services purchased from abroad.

This gives us two output categories. The first is ‘Globally-Marketable Output’ (GMO), which represents output potentially capable of sale at world market values, and consists of production activities (where ‘production’ includes not just manufacturing but the extractive industries and agriculture as well) plus net exports of services.

The second, residual category – ‘Internally-Consumed Services’ (ICS) – comprises services which citizens provide to each other, a number which can be divided further into private and government provision.

Fig. 3.1: The switch from production in the United States, 1980-2011*



* Source: Tullett Prebon calculations based on data from *The Economic Report of the President*, 2012 edition

** Private internally-consumed services

*** Government internally-consumed services

**** Globally marketable output

Imperfect though these measures are, they do provide an insight into the structural changes happening in the American economy as production was out-sourced and displaced by internally-consumed service activities (fig. 3.1).

Between 1980 and 2011, the American economy expanded by \$8.5 trillion (128%) in real terms. Within this expansion, however, only \$0.9 trillion (10% of the total increase) was provided by Globally-Marketable Output ('production') activities.

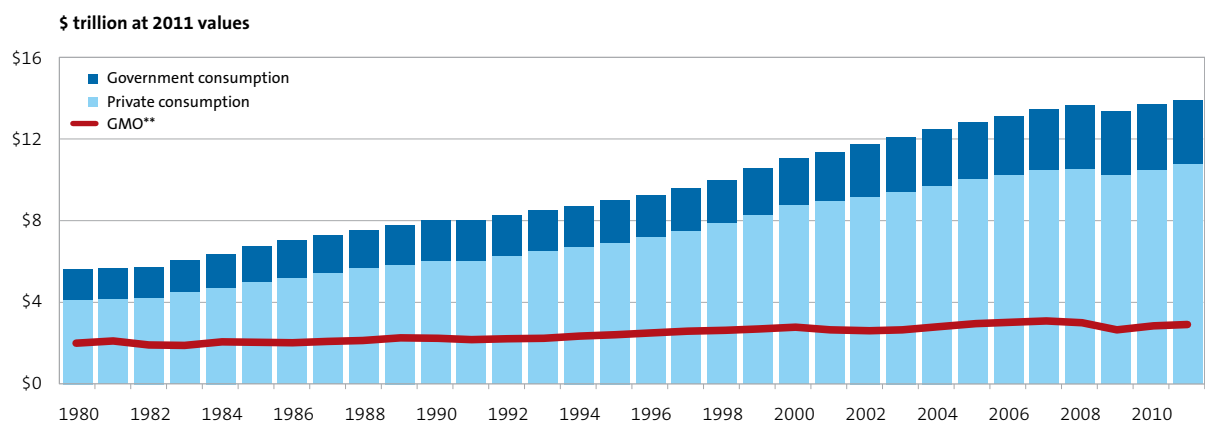
The remaining \$7.6 trillion resulted from increases in the services which Americans provide to each other, either privately (+\$6.4 trillion) or through government (+\$1.2 trillion). This represented a massive shift in the centre of gravity of the US economy away from production and towards output which can only be consumed internally.

There is always scope for legitimate debate about the "production boundary" which divides monetised, GDP-included activities from

non-monetised (but undoubtedly important) services such as the care that parents provide for children. Even so, there has been an unmistakable trend within the Western economies – particularly since the onset of globalisation – towards the expansion of GDP through the monetisation of previously-informal or peripheral activities, combined with the expansion of services whose only market value is a domestic one.

Fig. 3.2 shows the relationship between consumption and production

Fig. 3.2: The production-consumption gap in America, 1980-2011*



* Source: Tullett Prebon calculations based on data from *The Economic Report of the President*, 2012 edition

** Globally marketable output

in the United States since 1980, where ‘production’ is represented by the Globally-Marketable Output (GMO) measure. There has been a relentless increase in private consumption over three decades even though there has been very little growth in production.

In 1980, the ratio of private consumption to GMO production was 2.1:1, but by 2010 this ratio had almost doubled, to 3.8:1, meaning that individual Americans were consuming \$3.84 for every \$1 of the country’s globally-marketable output.

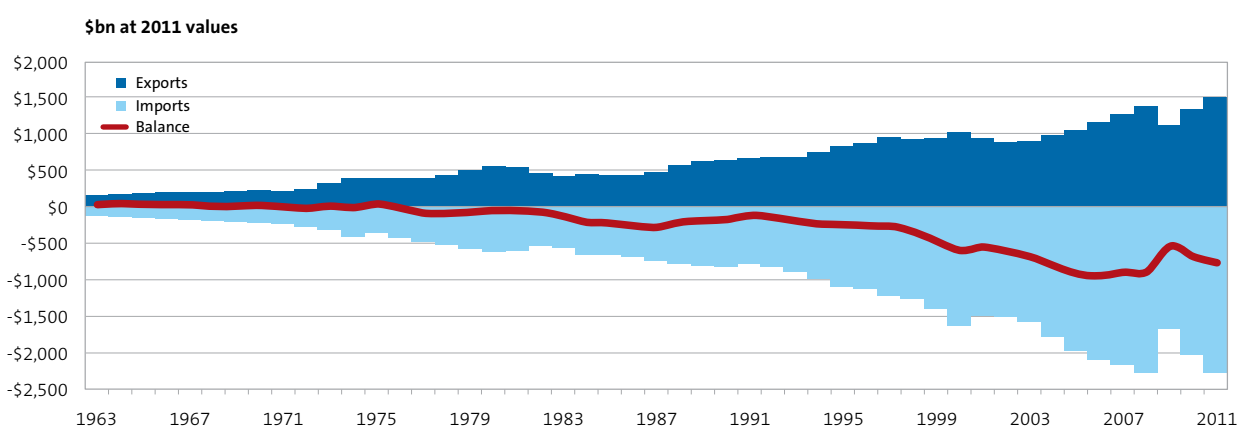
Put colloquially, Americans were “taking in each others’ washing” at a huge and unprecedented scale. It should be emphasised that this pattern was by no means unique to the United States but was replicated across the Western economies, and was particularly noticeable in Britain.

Needless to say, these trends exerted a steadily worsening effect on Western trade in goods and commodities. At the end of the Second World War, the United States could be described – as Britain had been, a century earlier – as

“the workshop of the world”. The oil price spikes of the early and late 1970s pushed the US into deficit, but the real acceleration in this trend coincided with globalisation.

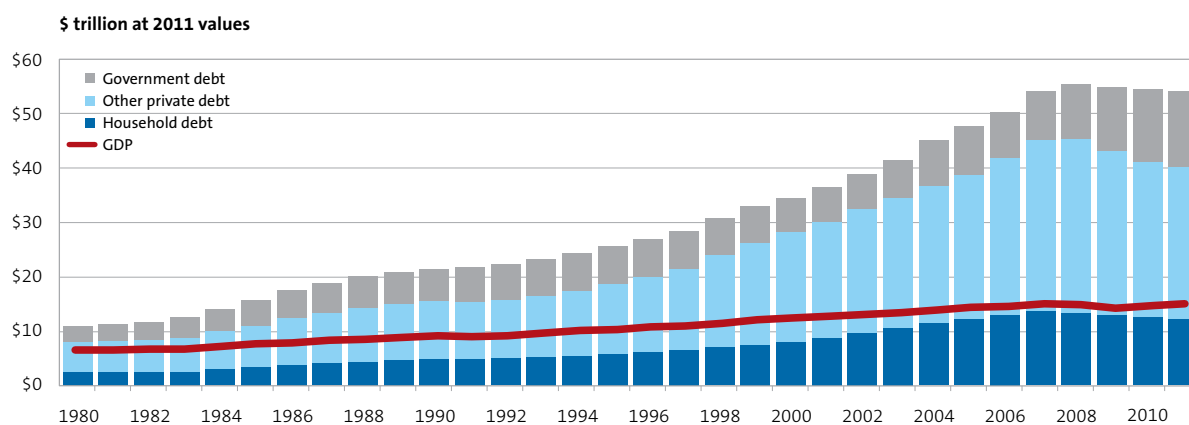
The US trade in goods is set out in fig. 3.3, which, it should be noted, shows real (inflation-adjusted) values. In 2011, the United States ran a deficit of \$765bn in goods, only partially offset by net services exports of \$187bn.

Fig. 3.3: US net trade in goods, 1963-2011*



* Source: Tullett Prebon calculations based on data from *The Economic Report of the President*, 2012 edition

Fig. 3.4: US real debt and GDP, 1963-2011*



* Source: Tullett Prebon calculations based on data from *The Economic Report of the President* (GDP and deflators) and the Federal Reserve Board (debt)

debt – deep in the hole

Long before the banking crisis, the relationships between production, consumption and debt had become completely unsustainable throughout most of the Western world. In the United States, for example, total credit market debt had soared to \$54 trillion by the end of 2011, up from \$29 trillion just ten years previously.

Even on an inflation-adjusted basis, debt was 48% higher in 2011 than it had been in 2001. By contrast, GDP had

expanded by a real-terms \$2.2 trillion over a ten-year period in which debt had increased by \$17.4 trillion (see fig. 3.4).

As fig. 3.5 reveals, it took \$2.95 of incremental debt to add \$1 to American real GDP during the 1980s. The overall figure during the 1990s was higher (at \$3.20), despite a pause in the escalation of federal government debt. This reflected temporary fiscal improvements resulting both from capital investment in the internet-

driven rewiring of America and from a temporarily-benign oil price environment. There was a sharp deterioration in the fiscal balance in the 2000s, of course, since the Bush administration saw no contradiction between cutting taxes and waging two major wars.

Fig. 3.5: Changes in American debt and GDP*

	1960s	1970s	1980s	1990s	2000s
Change in:					
GDP	+\$1.00	+\$1.00	+\$1.00	+\$1.00	+\$1.00
Private debt	+\$1.42	+\$1.50	+\$2.37	+\$2.99	+\$4.36
Government debt**	+\$0.12	+\$0.25	+\$0.59	+\$0.21	+\$1.31
Total debt	+\$1.55	+\$1.74	+\$2.95	+\$3.20	+\$5.67

* Source: Tullett Prebon calculations based on data from *The Economic Report of the President* (GDP) and the Federal Reserve funds flow statements (debt)

** Federal debt



The deterioration in the relationship between GDP and non-government borrowing continued in the 1990s, with the private debt required for each incremental dollar of GDP continuing to increase, to \$2.99 in the 1990s from \$2.37 during the 1980s.

After 2000, deterioration accelerated markedly. The decade to 2010 witnessed a dramatic escalation in the amount of debt required (\$5.67) for each incremental dollar of economic output. Between 2000 and 2010, *and after adjustment for inflation*, the indebtedness of individual Americans increased by \$4.35 trillion (52%), most of which was accounted for by growth in mortgage commitments at a time when stagnating real incomes coincided with ever-easier access to mortgage funding.

The sheer quantitative scale (not to mention the qualitative weakness) of the banks' massively-expanded mortgage books showed how the over-valued property sector acted as a conduit for feeding consumption with borrowing.

By 2007, non-government debt had risen above 300% of GDP, a figure that increases to 360% inclusive of Federal, state and local government

indebtedness. Arguably, and as we shall see, the real total, including huge government off-balance-sheet quasi-debt obligations, was (and is) very much higher still. Banks were exposed to a massive pool of lethally-extended mortgage debt, and the true scale of indebtedness was disguised by the various forms of securitised debt, much of it actually held by the banks themselves through off-balance-sheet SPVs (special purpose vehicles).

crisis onset – the debt pile topples over

At this point, the merest whiff of suspicion about the impossibility of servicing (let alone repaying) the mountain of debt was all that it took to spook credit markets and, by reversing the surge in the prices of collateral assets, to expose gaping holes in banks' balance sheets. This was a process which occurred during 2007-08, first freezing wholesale debt markets and then, with utter inevitability, taking the entire banking system to the brink of collapse.

The central banks were forced to step in to rescue the banking system, a process evident in the explosion in the balance sheets of, for example, the Federal Reserve (fig. 3.6) and the Bank of England. With central banks, too,

now reaching the limits of sustainable leverage, no option remained but to resort to quantitative easing (QE).

It is worth noting that, in addition to the sheer quantum of debt, the financial crisis saw the termination of one financial trend and the inauguration of another.

The trend which reached its end was the “monetary ratchet”. Over time, a cyclical process had emerged in which excessively low interest rates created bubbles, and the bursting of each bubble led to another reduction in policy rates as central bankers sought to stave off recession. From 2008-09, this process ended because rates were now effectively zero.

The newly-emerging trend was “toxic asset transference” or TAT. When debts became too onerous to be sustained by borrowers, debt ‘black holes’ were transferred from customers to banks. When banks, too, became overburdened by toxic assets, governments stepped in, completing a process whereby bad debts had transitioned from borrowers, via the banks, to the state.

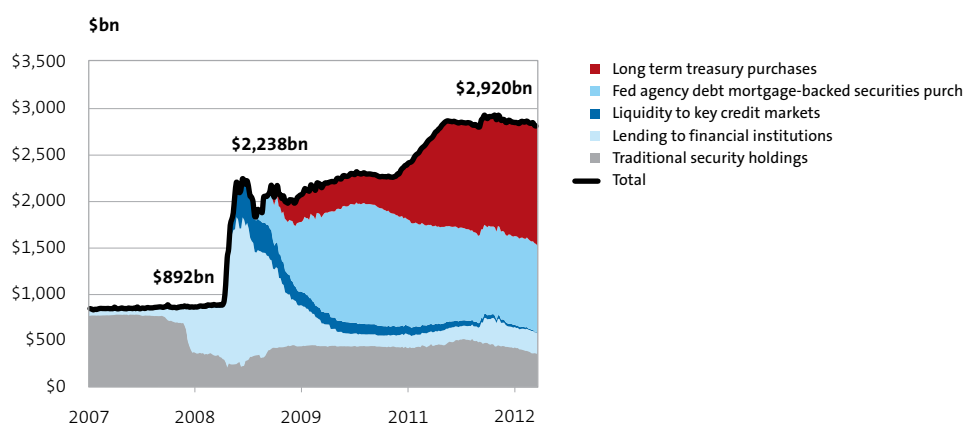
Though various shifts and sleights of hand are used to support claims that QE does not equate to the creation (“printing”) of money, the only real difference between the two is the claimed intention of reversing QE at some point in the future. To the extent that eventual reversal is intended, QE

can be portrayed merely as a balance sheet operation, but this defence is valid only to the extent that QE really will be unwound.

Logically, the next sequential stage – one which probably lies in the very near future – is a market realisation that the claimed reversibility of QE is nonsense. The idea that, say, the Bank of England can ever reverse £375bn of money creation seems extremely far-fetched.

If – or rather, *when* – the credibility of eventual reversal is lost, a dire chapter of recklessness is likely to end in money-printing, hyperinflation and collapse.

Fig. 3.6: The expansion of the Federal Reserve balance sheet, 2007-12*



* Source: Federal Reserve



compounding errors

Two further points are particularly worthy of note. The first of these is the way in which the West compounded its problems by pursuing gravely inefficient courses of action, and the second is the role that tightening energy resource constraints played in bringing down the Western house of cards.

As we have seen, the economic crisis in the West has been created, above all, by the way in which globalisation has driven a wedge between weakening production and soaring consumption, creating a gap which has been filled by a reckless accumulation of debt. But other mistakes, almost as serious, have contributed to a disastrous weakening of the Western economies.

These mistakes fall into various categories, of which the first has been a wilful ignorance of the competitive nature of the global economy. Fundamentally, the aim of economic management is to sustain and increase the well-being of an ever-increasing population on a planet whose resources, ultimately, are finite.

Since the implicitly competitive character of this situation is an obvious one, no great credit need be accorded to China and others for recognising it and acting upon it, most notably by endeavouring to convert the waning and dubious value of Western currency

holdings into physical assets in the form of natural resources. What is truly breathtaking is the way in which Western countries have overlooked the obviously-competitive nature of an ultimately-finite resource set.

The West seems to have been seduced by the philosophy of “comparative advantage” associated with the British economist David Ricardo (1772-1823). According to Ricardian logic, the general wealth will increase if all countries specialise in those activities in which they possess the greatest competitive advantage over others. This logic is valid if – but *only* if – the scope for growth is infinite. Unfortunately, an unlimited capability for growth can only exist if the supply of resources is infinite as well.

Based on the false assumption of an infinite capability for growth, the West has followed Ricardian rationale and ceded entire areas of economic activity to emerging economies, and has done little or nothing to compete for finite reserves of natural resources. Another by-product of the seductive logic of Ricardo has been a Western commitment to free trade, even when it has been clear beyond peradventure that other countries are not playing by the same set of rules.

Meanwhile, a second compounding error has been the way in which the West has been extraordinarily profligate with capital. Huge sums

have been diverted from productive investment and ploughed instead into inflating the value of nations’ existing stocks of housing. Houses – which, after all, are non-earning assets – have thus acted as capital sinks, denying investment to genuinely productive (and often vital) areas, most notably infrastructure. Just as it has been hugely wasteful of capital, property price inflation has fostered a ‘something for nothing’ culture which, in itself, has undermined economic productivity.

If this were not bad enough, the West has also diverted capital into vanity projects. Few Western countries have avoided the allure of building new sports stadia even as roads are crumbling and bridges are deteriorating. The neglect of the infrastructure has gone largely unnoticed just as gleaming new soccer, baseball and athletics venues have proliferated.

Labour efficiency has been undermined by gravely mistaken social policies. Whereas schools in China are tasked with identifying and nurturing those brightest children from whom future leaders in science, technology, innovation and government will be drawn, the West has deliberately eschewed all forms of merit selection, retaining parental affluence as the only basis on which any form of selectivity is allowed to operate.

Incentives have been skewed to the point at which the American higher education system produces 41 law graduates for each graduate engineer. The inflation of housing values has contributed to the impoverishment of Western nations' own young people. Immigration policy, which logically should aim to attract the brightest and most industrious people, has instead been characterised by a policy of oscillating sentimentality and populist toughness, tempered by incompetence.

Alongside wasteful investment allocation and disastrous labour market policies, the West has allowed the rise of two extremely damaging cultural norms. The first of these is the unchecked rise of consumerism, fostered by an advertising industry which spends close to \$470bn annually (and about \$143bn in the United States alone)⁶.

The second is a sense of entitlement, both at the individual and at the national level. Welfare systems, originally intended as safety nets, have been allowed to price Western workers out of international markets. Benefits systems, even if they are not (as is often claimed) "lifestyle choices" for the recipients of benefits, certainly have been exactly that for the armies of administrators that flourish in almost all such systems. The rise of welfarism has imposed huge social costs and taxes on businesses, placing

them at an ever greater competitive disadvantage which has been exacerbated by well-meaning labour legislation in which considerations of profitability and efficiency are also-rans when measured against supposedly 'progressive' social objectives.

Worst of all, Western countries and their citizens have behaved as though their affluent lifestyles are some kind of divine entitlement rather than the reward of productiveness.

energy takes away the punch-bowl

Though much attention has been paid to the role of the banking system in the creation of the post-2008 economic slump, there has been a widespread failure to appreciate the role that was played by the emergence of energy resource constraint. As emerging economies increased their production *whilst the West continued to ramp up its consumption*, demand for energy escalated to a point at which resource constraint became a major contributor to the unwinding of an always-unsustainable effort to use debt to put off the inevitable implications of a divergence between production and consumption.

Reflecting the combination of real growth in the emerging economies and debt-sustained consumption in the West, a surge in energy prices saw the annual average price of Brent crude oil rise from \$25/b in 2002 to

\$97/b in 2008. We estimate that the increase in the price of oil alone cost American consumers an incremental \$460bn between those years, of which more than \$300bn was accounted for by imports of petroleum. Between 2002 and 2008, meanwhile, OECD oil consumers' costs increased by about \$1.14 trillion, including an import component of around \$730bn (see figs. 3.7 and 3.8).

Of course, increases in the prices of other fuels (such natural gas and coal) exacerbated these huge liquidity drains, which were more than enough to stop the debt-consumption binge in its tracks.

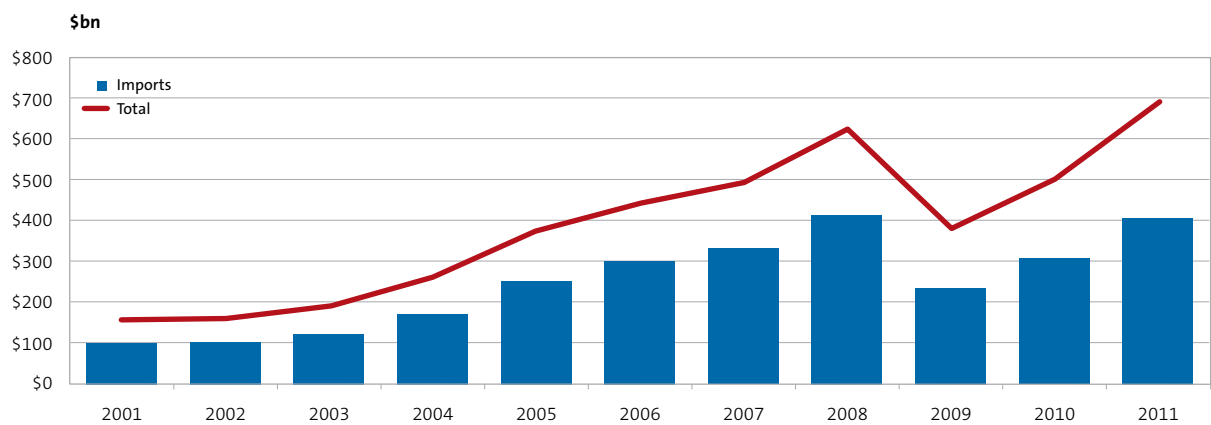
The role of central banks is – or should be – to stop excesses by being ready to "take away the punch bowl just as the party gets going", in the inimitable phrase of William McChesney Martin⁷. When central bankers duck this obligation, markets will do it for them.

Financial recklessness (including globalisation) and energy constraint are the two most important factors which have created the current economic slump, so it is perhaps fitting that it was energy markets which drove the first, disastrous wedge into the debt structure which had been created in an attempt to bridge the widening chasm between the West's diminishing production and its ever-growing propensity to consume.

⁶ <http://www.wpp.com/wpp/press/press/default.htm?guid={23ebd8df-51a5-4a1d-b139-576d711e77ac}>

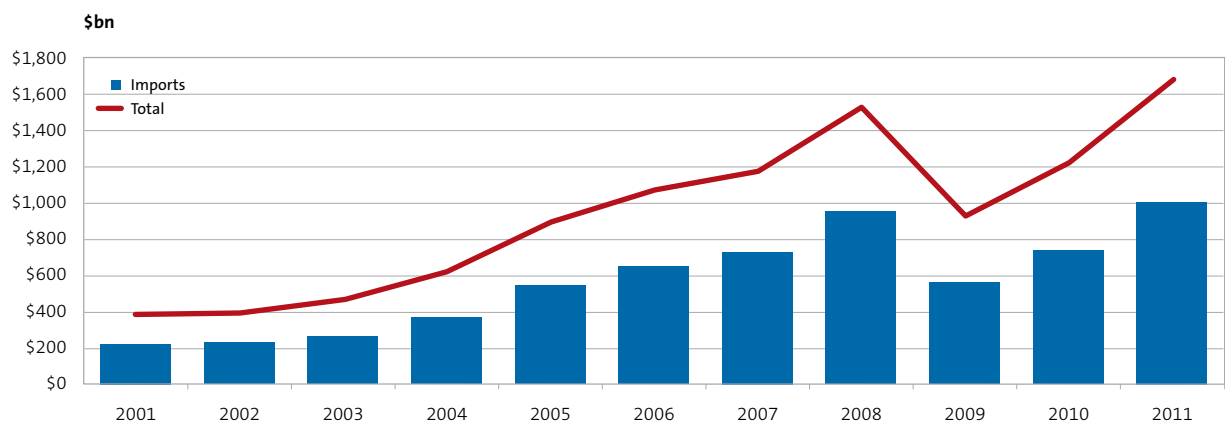
⁷ William McChesney Martin (1906-98) was chairman of the Federal Reserve from 1951 to 1970

Fig. 3.7: US oil costs*



* Source: Tullett Prebon estimates derived from data in the BP Statistical Review of World Energy 2012

Fig. 3.8: OECD oil costs*



* Source: Tullett Prebon estimates derived from data in the BP Statistical Review of World Energy 2012



part four:

loaded dice

how policies have been blind-sided by distorted data

summary

The reliable data which policymakers and the public need if effective solutions are to be found is not available. Economic data (including inflation, growth, GDP and unemployment) has been subjected to incremental distortion, whilst information about government spending, deficits and debt is extremely misleading.

This report describes an impending economic crisis. Although, and as we have already seen, the post-2008 slump is the denouement of the biggest financial bubble in history, this is, in many ways, the least of the problems faced by the global economy collectively, and by the Western economies in particular.

As we shall see in the final part this report, the fundamental problem is that the surplus energy dynamic which has propelled economic development since the Industrial Revolution is now unwinding very rapidly indeed. From a Western perspective, these trends have been exacerbated by the globalisation disaster, which has driven an ever-widening wedge between diminishing production and burgeoning consumption, and has then attempted to bridge this gap using ever-less-sustainable mountains of debt.

In this situation, it seems self-evident that policymakers, business leaders and the general public alike have an

imperative need for reliably accurate data if they are to stand any chance of finding least-bad solutions. But this reliable data is precisely what they do not have. Both economic and fiscal reporting have been subjected to incremental massage and deliberate obfuscation to the point where policymakers, investors and the public really have no accurate conception of our economic predicament.

Data distortion can be divided into two categories. Economic data has been undermined by decades of methodological change which have distorted the statistics to the point where no really accurate data is available for the critical metrics of inflation, growth, output, unemployment or debt. Fiscal data, meanwhile, obscures the true scale of government obligations.

Much of the detailed analysis provided here is drawn from the United States, but this requires a cautionary note. It is **not** our contention that the US is

the worst culprit where misleading statistics are concerned. Rather, the raw data required for an unravelling of statistical distortion is more readily available in the US than in other countries which lack America's data transparency. Additionally, the United States is fortunate in that it possesses analysts willing and able to untangle the statistical mess (even if few policymakers are any more prepared than their overseas counterparts to listen to the uncomfortable conclusions resulting from these analysts' labours).

Concentrating mainly on the United States, we begin here by looking at how the principal economic metrics have been distorted over time, beginning with inflation before turning to growth, output and unemployment. We then examine fiscal accounts to reveal quite how misleading both government obligations and budget balances have become.

We should be clear that the debauching of US official data did not result from any grand conspiracy to mislead the American people. Rather, it has been an incremental process which has taken place over more than four decades.

In the early 1960s, the Kennedy administration tampered with unemployment numbers to exclude “discouraged workers”. The Johnson administration introduced the “unified budget”, which incorporated what was then a big Social Security surplus to hide part of the underlying federal over-spend. Richard Nixon tried, with only limited success, to peddle the concept of “core inflation”, an inflationary measure which excluded energy and food (the very items whose prices were rising most strongly at that time).

“Owner-equivalent rent”, a concept to be explained later, was introduced under Ronald Reagan. Convoluted changes to the measurement of CPI inflation, recommended by the Boskin Commission, were drafted under George Bush Sr. but implemented by the Clinton administration (and, as renowned strategist Kevin Phillips has remarked⁸, there is a certain irony to the introduction of “hedonic adjustment” by the Oval Office’s ultimate hedonist). A further four

million out-of-work Americans dropped out of the unemployment totals under a redefinition of “discouraged workers” introduced in 1994.

economic distortion #1 – the high price of understated inflation

Though the undermining of data quality has been widespread, few series have been distorted more than published numbers for inflation, and few if any economic measures are of comparable importance. In the United States, CPI-U inflation reported at 3.2% in 2011 probably masked real price escalation which was very much higher than that. This is hugely significant, because inflation is central to calculations of economic growth, wages, pensions and benefits. Moreover, understated inflation undermines calculations of the ‘real’ cost of credit as represented by interest rates and bond yields, a factor which, as we shall see, may have played a very significant role in the escalation of indebtedness during the credit super-cycle.

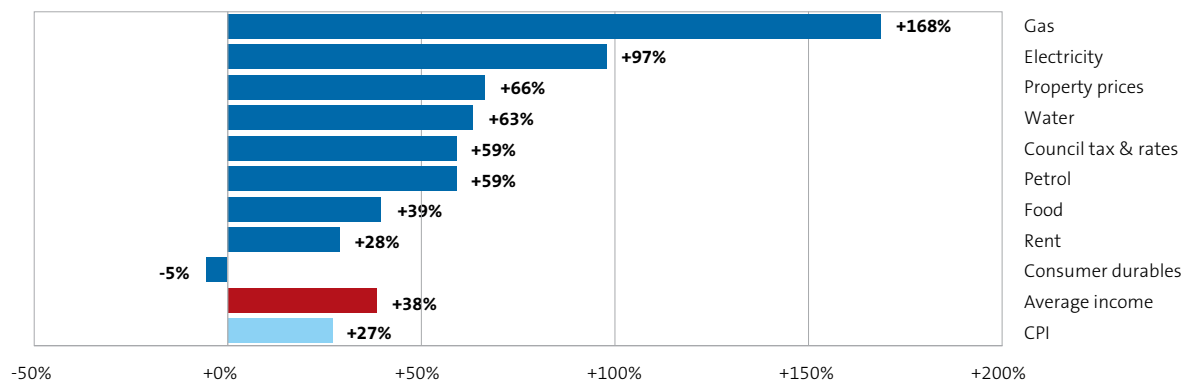
British inflation data, too, seems pretty optimistic. Between 2001 and 2011, average weekly wages increased by 38%, which ought to have been a more than adequate rise when set against official CPI (consumer price index) inflation of 27% over the same period

(fig. 4.1). But the reported rate of overall inflation between those years seems strangely at odds with dramatic increases in the costs of essentials such as petrol (+59%), water charges (+63%), electricity (+97%) and gas (+168%).

Those who question the accuracy of official inflation measures in Britain have nothing much more upon which to base their suspicions than intuition, experience and the known escalation of the prices of essentials. In the United States, this situation is quite different, and far greater data transparency has enabled analysts to reverse out the methodological changes of the last three decades. The scale of the distortions which have been identified is truly shocking.

The biggest single undermining of official inflation data results from the application of “hedonic adjustment”. The aim of hedonic adjustment is to capture improvements in product quality. The introduction of, say, a better quality screen might lead the Bureau of Labor Statistics (BLS) to deem the price of a television to have fallen even though the price ticket in the shop has remained the same, or has risen. The improvement in the quality of the product is equivalent, BLS statisticians argue, to a reduction in price, because the customer is getting more for his or her money.

Fig. 4.1: Beyond belief? UK inflation, 2001-11*



* Source: Tullett Prebon UK Economic & Fiscal Database 2012

A big problem with hedonic adjustment is that it breaks the link between inflation indices and the actual (in-the-shop) prices of the measured goods. Another is that hedonic adjustment is subjective, and seems to incorporate only improvements in product quality, not offsetting deteriorations. A new telephone might, for example, offer improved functionality (a hedonic positive), but it might also have a shorter life (a hedonic negative) and,

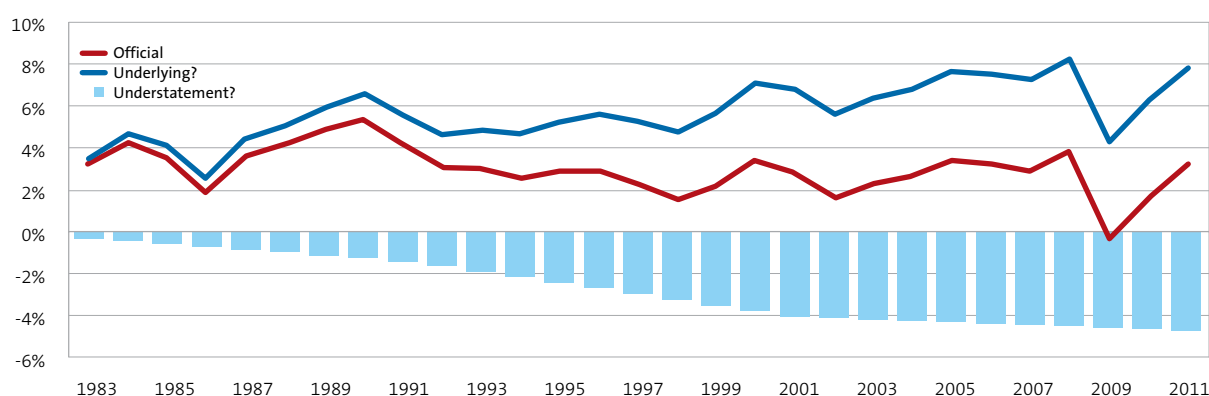
critics claim, the official statisticians are all too likely to incorporate the former whilst ignoring the latter.

The failure to incorporate hedonic negatives may be particularly pertinent where home-produced goods are replaced by imports, a process which has been ongoing for more than two decades. A Chinese-made airbrush might be a great deal cheaper than one made in America, but is the lower quality of the imported item factored in to the equation?

A second area of adjustment to inflation concerns 'substitution'. If the price of steak rises appreciably, 'substitution' assumes that the customer will purchase, say, chicken instead. As with hedonic adjustment, the use of substitution not only breaks the link with actual prices (a process exacerbated by 'geometric weighting'), but it also, as Chris Martenson explains, means that CPI has ceased to measure the cost of living but quantifies "the cost of *survival*" instead⁹.

⁹ Chris Martenson, *The Crash Course*, John Wiley & Sons Inc, 2011

Fig. 4.2: Smoke and mirrors – the distortion of US CPI-U inflation*



* Sources: Bureau of Labor Statistics and Tullett Prebon estimates

Geometric weighting, too, plays a significant role in the distortion of American inflation data. In any case, some of the weightings used in the official indices look strange, one example being medical care, which accounted for 16% of consumer spending¹⁰ in 2011 but is weighted at just 7.1% in the CPI-U.¹¹

Since the process of adjustment began in the early 1980s, the officially-reported CPI-U number has diverged ever further from the underlying figure calculated on the traditional methodology. Fig. 4.2 gives an approximate idea of quite how distorted US inflation data seems to have become over three decades.

Instead of the 3.2% number reported for 2011, for example real inflation was probably at least 7%. Worse still, the official numbers probably understate the sharp pick-up in inflation which America has been experiencing. A realistic appreciation of the inflationary threat would be almost certain to have forced very significant changes in monetary policy.

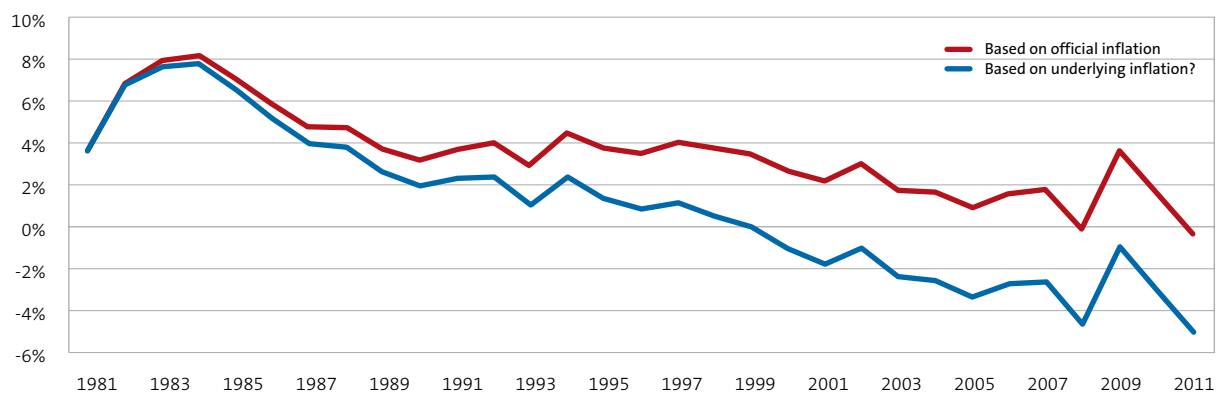
Taken in aggregate, the extent to which the loss of dollar purchasing power has been understated is almost certainly enormous. Between 1985 and 2011, official data shows that the dollar lost 53% of its value, but the decrease in purchasing power might stand at more like 75% on the basis of

underlying data stripped of hedonics, substitution and geometric weighting.

The ramifications of understated inflation are huge. First, of course, and since pay deals often relate to reported CPI, wage rises for millions of Americans have been much smaller than they otherwise would have been. Small wonder, then, that millions of Americans feel much poorer than official figures tell them is the case. By the same token, those Americans in receipt of index-related pensions and benefits, too, have seen the real value of their incomes decline as a result of the severe (and cumulative) understatement of inflation.



Fig. 4.3: The smoking gun – did *negative* real interest rates fuel the killer bubble?*



* Sources: Economic Report of the President, Bureau of Labor Statistics and Tullett Prebon estimates. Chart shows annual average real yields on 10-year Treasuries, based on official and on underlying inflation rates, see text



This process, of course, has saved the government vast sums in benefit payments. Rebasing payments for the understatement of inflation since the early 1980s suggests that the Social Security system alone would have imploded many years ago had payments matched underlying rather than reported inflation. In other words, the use of 'real' inflation data would have overwhelmed the federal budget completely or, conversely, might have forced government to come clean on what levels of welfare spending really can be afforded.

Another implication of distorted inflation, an implication that may

have played a hugely important role in the creation of America's debt bubble, is that real interest rates may have been negative ever since the late 1990s (fig. 4.3). Taking 2003 as an example, average nominal bond rates¹² of 4.0% equated to a real rate of 1.7% after the deduction of official CPI-U inflation (2.3%), but were almost certainly heavily *negative* in real terms if adjustment is made on the basis of underlying inflation instead.

Logically, it makes perfect sense to borrow if the cost of borrowing is lower than the rate of inflation. Whilst most Americans may not have been aware of the way in which inflation numbers

had been subjected to incremental distortion, their everyday experience may very well have led them to act on an intuitive understanding that borrowing was cheap. We believe that distorted inflation data may, together with irresponsible interest rate policies and woefully lax regulation, have been a major contributor to the reckless wave of borrowing which so distorted the US economy in the decade prior to the financial crisis.

¹² Annual average interest rate for 10-year Treasuries.
Source: *Economic Report of the President*, 2011 datasets

economic distortion #2 – grossly distorted prosperity

Gross domestic product (GDP) is usually accepted as defining the output of an economy. In 2011, the GDP of the United States was reported at \$15.1 trillion, a figure which most Americans probably assume consists entirely of ‘real’ dollars which can be counted. This is, in fact, very far from being the case, because close to 16% of the reported number consists of ‘imputations’. These imputations are dollars which do not really exist. Stripped of them, GDP totalled \$12.7 trillion in 2011, which automatically means that all debt ratios are a great deal higher than they look.

The most important of these imputations are summarised in fig.

4.4. The largest single such imputation – worth over \$1.2 trillion in 2011 – concerns “owner-equivalent rent”. If a person owns his or her home outright, no mortgage or rent is payable, and no money changes hands in respect of the property. But the reporting methodology for American GDP assumes that such a property has a utility which a purely cash-based measure fails to capture. Therefore, GDP contains a sum representing the rent which the owner would have paid (presumably to himself) if he had not owned the property. Interest expense is backed out, but the net result remains a major, non-cash uplift to GDP. The replacement of actual expenditure with a notional (‘imputed’) rent applies not just to those Americans who own their homes outright, but also to

those with mortgages. For example, a person with 50% equity in his home is assumed to pay rent on 100% of it rather than, as is actually the case, mortgage interest on half of it.

The second-largest imputation concerns employee benefits (principally medical insurance, but also items such as meals and accommodation) which are provided to workers either freely or on a subsidised basis. A sum of \$601 billion was imputed in this category in 2011. Financial services (for example, checking accounts) which are provided free of charge by banks are treated similarly. Here, the imputation (of \$497 billion in 2011) reflects what the cost to the customer would have been if the bank had charged him for services which, in reality, were provided free.

Fig. 4.4: GDP – the impact of imputations*

\$bn	2006	2007	2008	2009	2010	2011
Reported GDP	\$13,377	\$14,029	\$14,292	\$13,974	\$14,499	\$15,076
Including imputations of:						
Imputed rental income	\$1,125	\$1,153	\$1,191	\$1,214	\$1,217	\$1,236
Financial services not charged	\$391	\$426	\$451	\$441	\$499	\$497
Employment-related imputations	\$543	\$565	\$581	\$592	\$601	\$628
Other imputations, net	-\$78	-\$50	\$9	-\$1	-\$32	-\$17
Total imputations	\$1,980	\$2,093	\$2,231	\$2,245	\$2,285	\$2,343
GDP excluding imputations	\$11,397	\$11,935	\$12,061	\$11,728	\$12,214	\$12,733
Imputations as % GDP	14.8%	14.9%	15.6%	16.1%	15.8%	15.5%

* Source: Bureau of Economic Analysis

There is a legitimate debate about the “production boundary”, which refers to the inclusion, or otherwise, of services provided free of charge, a good example being care provided to children, to the elderly and to the infirm by family members. But the sheer scale at which “imputations” are now used in the compilation of American GDP surely introduces grave distortions into the generally-accepted number for US economic output.

Moreover, non-existent (imputed) dollars obviously cannot be taxed, which means that imputations make the American incidence of taxation look a great deal lower than it really is. At \$4.7 trillion, general government revenue absorbed 31% of reported GDP in 2011, but this ‘tax take’ rises to 37% when imputations are stripped out of the GDP denominator.

economic distortion #3 – what growth, what jobs?

Understated inflation, then, has depressed wage growth, impoverished those in receipt of benefits, masked the decline in the purchasing power of the dollar, and probably contributed to a reckless monetary policy which has mired the United States in excessive debt. But it may also have resulted in economic growth being reported over

a long period in which the American economy has really been shrinking, not growing.

According to official figures, the GDP of the United States increased by 16.6%, in real terms, between 2001 and 2011. But these numbers are a function of two calculations which, as we have seen, are not in themselves reliable. First, the reported 2011 GDP number (of \$15.1 trillion) is highly questionable, because it includes non-cash “imputations” totalling \$2.3 trillion. Second (and much more seriously), since the way in which official inflation is calculated is open to very serious question, so, too, is the GDP deflator, the adjustment which is employed to back out the effects of inflation from changes in the nominal monetary value of economic output. Ritual claims that the deflator is worked out by comparing simple chained volumetric (that is, non-monetary) measurements of GDP need not be taken too seriously, as the reality is that it is impossible to de-link the GDP deflator from other measures of inflation.

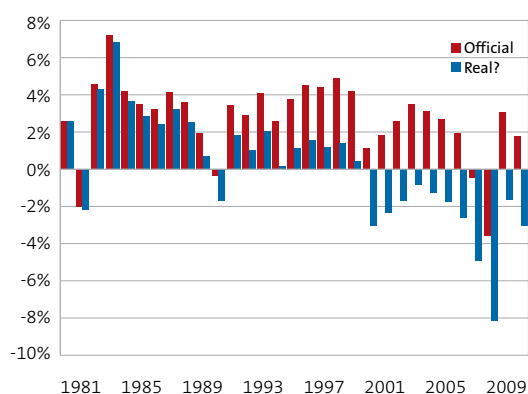
Once adjustment is made for the distortion of inflation, growth in American real GDP since over the last decade presents a gravely disturbing

picture (fig. 4.5). In effect, the United States has been in almost permanent recession since 2000, with real GDP falling year after year, and declining sharply over a ten-year period.

The growth-enhancing impact of distorted inflation has not been unique to the United States, of course. As we have seen, the prices of essentials have far out-stripped reported inflation in Britain, suggesting that underlying inflation may have been significantly higher than the reported number. Raising the annual GDP deflator by just 1.55% would have been sufficient to wipe out all reported economic growth in the United Kingdom between 2001 and 2011 (“growth” which, as we have seen, was essentially borrowed anyway).

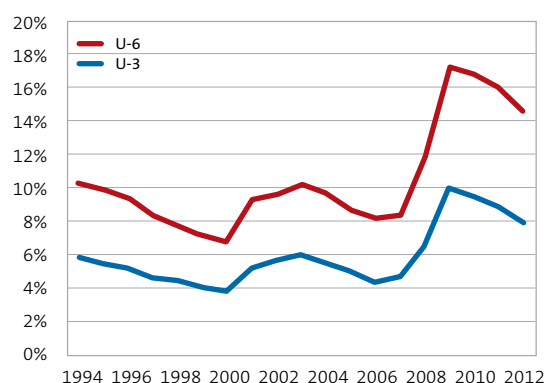
The picture of economic deterioration in the United States is reflected in the unemployment statistics or, rather, it would be, if these were not so heavily massaged by reporting methodologies. The official (U-3) number, currently 7.9%, excludes the millions of unemployed Americans who are defined as “discouraged workers”.

Fig. 4.5: What growth?*



* Sources: Bureau of Economic Analysis and Tullett Prebon estimates

Fig. 4.6: What jobs?*



* Source: Bureau of Labor Statistics

If these people were included, together with other “marginally attached” workers, and those who are in part-time work because they cannot find full-time employment, *the BLS itself* concedes (on its broader U-6 measure) that the unemployment rate would have been over 14% in October 2012, drastically higher than the 9.6% recorded ten years previously (fig. 4.6). Analysts who have unpicked all of the various methodological changes (including alterations to sampling techniques) argue that the real rate of unemployment is even higher, particularly where this is defined to include under-employment as well.

In the face of persistently high levels of unemployment (even on the basis of the understated U-3 definition), Americans have been asked to believe in the concept of “jobless growth” as a way of reconciling weak job data on the one hand with reported growth in GDP on the other. The real explanation is simpler. It is that the economic growth of the last decade seems to have been illusory.

fiscal distortion #1 – fast and loose

If statisticians (people of integrity who are at least nominally independent from government) have been drawn into the accretive distortion of

economic data, it will surprise no-one that government reporting all too often plays fast and loose with reality.

British citizens were treated to an example of this in April 2012 when the government, in taking over postal workers’ pension funds, used fund assets (of £28bn) to reduce reported debt (and the published deficit as well) whilst conveniently assigning the associated liabilities (£38bn) to off-balance-sheet “contingent liabilities”. The reality, of course, is that there is nothing remotely “contingent” about the liabilities of a pension fund to pay the sums to which it is contractually committed.

The International Monetary Fund (IMF) is not known for producing controversial analyses of its member governments' activities, but a report¹³ published in March 2012 shed a great deal of light on some of the ways in which government debts and fiscal deficits are massaged. Governments, the IMF said, "can be tempted to replace genuine spending cuts or tax increases with accounting devices that give the illusion of change without its substance".

"In retrospect," the IMF said, "it is clear that accounting devices contributed to the fiscal problems that many countries are now experiencing". The IMF report makes it clear that "hidden borrowing" has been rife, examples cited including Portugal, Austria, Denmark, France and Sweden, to which, of course, could be added the Private Finance Initiative (PFI) device extensively used in Britain to defer the cost of new hospitals and schools.

Portugal has done the same, at a cost (in annual payments) equivalent to 1% of GDP. At £8.7bn, British PFI payments in 2011-12 equated to 0.57% of GDP, or 1.5% of government revenue, and these payments are projected to rise to £10bn by 2015-16.

Between 2001 and 2007, Greece used swaps to hide €5.3bn of borrowing. Belgium, Italy, Germany and Poland have made similar debt-deferring use of swaps. Governments have also manipulated debt and deficits using sale-and-leaseback deals, whilst privatisation, too, can have a manipulative effect when future income streams are divested for a single payment which is booked immediately. Similarly, Greece securitised and sold lottery proceeds, air traffic control fees and, remarkably, European Union grants, whilst both Belgium and Portugal securitised tax receivables. During 2005-06, Germany – so often regarded as a model of fiscal

probity – securitised pension payments from Deutsche Post, Deutsche Postbank and Deutsche Telekom, receiving €15.5bn whilst at the same time eliminating purchaser risk by *guaranteeing future payments*.

Pensions payable to state employees constitute huge off-balance-sheet liabilities for many governments, including the United Kingdom (perhaps £1,000 bn, or 66% of GDP) and the United States (\$5.8 trillion¹⁴, or 38% of GDP). Just as important, annual increments to these obligations are excluded from reported deficits. Aggregate 2010 liabilities for selected governments are set out in fig. 4.7, which shows how massively Britain (in particular) is burdened by off-balance-sheet commitments. Importantly, this table excludes welfare obligations which, particularly in the case of the US, are enormous.

Fig. 4.7: Liabilities in 2010, selected governments*

% of GDP	Debt	Civil service pensions	Other liabilities	Total liabilities
Australia	14%	10%	8%	32%
Canada	37%	13%	8%	58%
New Zealand	36%	5%	25%	66%
United Kingdom	69%	81%	23%	173%
United States	62%	39%	12%	113%

* Source: IMF

¹³ *Accounting Devices and Fiscal Illusions*, IMF Staff Discussion Note, 28th March 2012

¹⁴ Source: *Financial Report of the United States Government 2011*

fiscal distortion #2 – vanishing acts

Governments are also well practised at the arts of making things disappear. In Britain, for example, the failure of Railtrack was handled in such a way that its successor company's debts were kept off the government balance sheet, even though Network Rail had no private shareholders. It was created as a company "limited by guarantee", a status which precludes the need to consolidate its debts into the government total. Current debt stands at £29bn, though borrowing plans (of £46bn) suggest that this total might expand very significantly. Network Rail's government guarantee is described as "unconditional", "irrevocable" and "unlimited", which gives the company's debts "the same credit ratings as the UK sovereign"¹⁵.

Large though it is, Network Rail's contribution to the British state's off-balance-sheet liabilities pales into insignificance when set against the guarantees which Britain (and other countries) provided to the banking system during the 2008 crisis. Official UK public debt (of £1,068bn, or 68% of GDP) rises to £2,169bn (138%) including financial interventions. Inclusive of banking support, Network Rail, PFI commitments (which we estimate at £170bn) and public sector pension obligations, the true scale of British government debt and quasi-debt probably stands at about 215% of GDP.

The commendable transparency provided by the government of the United States gives analysts a probably-unparalleled amount of insight into the true balance sheet position of a major government, though commentators still disagree about the true scale of Washington's indebtedness.

At the end of fiscal year (FY) 2011, official statistics¹⁶ showed debt "owed to the public" – that is, excluding debt held by other departments of government – at \$10,174bn, a figure which in itself reveals a huge increase over five years, since the equivalent figure was \$4,868bn at the end of FY 2006. But the reported number excludes two very material lines of quasi-debt. The first of these, included in the official balance sheet, is a \$5,792bn commitment to pay pensions to government employees. The second is a \$4,711bn pool of federal debt owed to other parts of government.

The significance of the latter number is that it forms the principal asset of the Social Security and Medicare systems, both of which have liabilities which far exceed their accumulated assets. At the end of FY 2009, net liabilities were stated at \$52.2 trillion in respect of closed system claimants, a figure offset by \$6.3 trillion which, it was assumed, will be the net positive contribution of future scheme participants. Within the \$52.2 trillion FY 2009 figure, \$33.5

trillion was attributable to Medicare and \$18.6 trillion to OASDI (old age, survivors and disability insurance), with the balance relating to railroad pensions (\$140bn) and black lung provisions (\$6bn).

During FY 2010, the outstanding Medicare liability was reduced by about \$15 trillion, reflecting the assumption that the Obama healthcare package will result in a very material reduction in future claims on Medicare. Whilst this is true, it is also somewhat disingenuous, in that the funding for healthcare will still need to be sourced from taxpayers, such that the future financial obligation has been shifted further off-balance-sheet, not eliminated altogether. At the end of FY 2011, net liabilities were \$46.2 trillion, offset by anticipated future receipts of \$12.4 trillion.

What, then, is the true level of American federal government debt and quasi-debt? Inclusion of the entire off-balance-sheet liabilities associated with OASDI and Medicare would be excessive, because these sums are calculated on the basis of liabilities stretching 75 years into the future. Few governments (or other institutions) measure their commitments that far ahead.

If we apply standard net present value (NPV) techniques to the official net liabilities for FY 2009 but limit the

capture to 30 rather than 75 years, the quasi-debt total for closed scheme participants declines from the reported \$52 trillion to about \$41 trillion. This figure falls further, to \$36 trillion, based on the FY 2011 computation in which the Obama healthcare system is assumed to eliminate major forward Medicare liabilities.

This number, of course, is net of the assets held by OASDI and Medicare, comprising federal debt of \$4.7 trillion which OASDI, at least, is likely to start drawing upon in the near future. It also excludes forward pension and welfare commitments to federal employees.

Taken in aggregate, then, federal debt and quasi-debt can be put realistically at \$57.1 trillion, comprising debt owed to the public (\$10.2 trillion), debt held by other government agencies (\$4.7 trillion), pension commitments to employees (\$5.8 trillion) and the 30-year portion of net quasi-debt commitments (\$36.5 trillion)¹⁷.

Based on the official number for 2011 economic output (\$15.1 trillion), this estimate of federal debt and quasi-debt equates to 379% of GDP. If we strip out the non-cash “imputations” component of GDP (\$2.3 trillion), the federal debt and quasi-debt ratio rises to 449% of a smaller GDP denominator. Both numbers exclude private, corporate, bank and state debt, which total either 291% of GDP or

344%, depending upon whether the imputed component of GDP is left in or excluded.

Just as an assessment of federal off-balance-sheet commitments produces debt ratios large enough to scare small monkeys, much the same can be said of the federal deficit. This number was reported at \$1.29 trillion in FY 2011, equivalent to 8.6% of official GDP. But increases in quasi-debt commitments are running at an underlying rate of about \$2.7 trillion, meaning that the real deficit is arguably \$4 trillion, equivalent to 27% of official GDP, or 31% if imputations are excluded from the GDP denominator.

An underlying federal debt and quasi-debt total of some \$57 trillion, on top of private, bank, state and local government debt of \$44 trillion, could be used by America’s critics to argue that the United States is bankrupt. Any such inference, if not fundamentally mistaken, most certainly would be premature. America may be technically insolvent (in the sense that her collective liabilities far exceed any remotely realistic calculation of the net present equivalent of future income streams), but she is not illiquid.

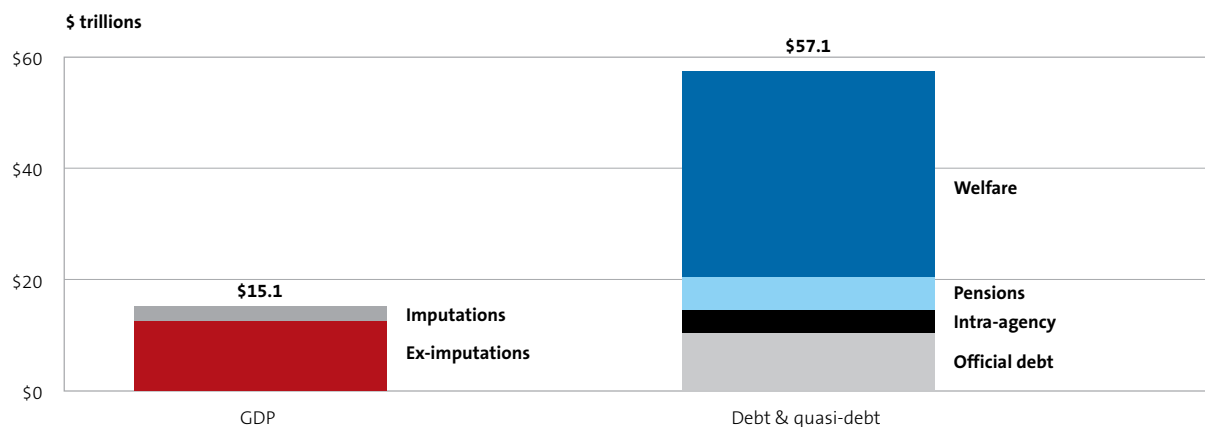
¹⁷ The detailed numbers are:

- debt owed to the public: \$10,174bn
 - debt held by other government agencies: \$4,711bn
 - pension commitments to employees: \$5,792bn
 - estimated 30-year portion of net quasi-debt commitments: \$36,472bn
- Total: \$57,149bn





Fig. 4.8: US GDP, debt and quasi-debt, 2011*



* Sources: Financial Report of the United States Government and Tullett Prebon estimates

The bulk of America's obligations are quasi-debts owed to the American people, which essentially means that forward welfare and pension commitments cannot be honoured (though few politicians are likely to admit this). In the nearer-term, the blue-chip rating of American government paper, reinforced by the reserve status of the US dollar, probably means that Washington can continue to live beyond its means for some years yet.

The broader point, though, is that the United States – and many other Western countries, most notably Britain – are not only burdened with

enormous official debt, but carry even larger, off-balance-sheet commitments as well.

Of course, these obligations are not, technically, the same as debt, in that they are political rather than contractual commitments which, in theory at least, can be cancelled by a simple vote in Congress or Parliament. This said, it is difficult to envisage a situation in which Congress tells contributors to Social Security or Medicare schemes that “we’re sorry, folks, but you’re not going to get paid after all”, any more than one can picture a British government publicly reneging on its public sector pension promises.

That these payments *will* be subject either to massive devaluation or to outright repudiation seems inevitable, in that the American, British and many other Western governments simply cannot afford to honour the promises made by their predecessors.

As we shall see, the deterioration in energy productivity alone almost guarantees that economies are poised to deteriorate. Where Western countries are concerned, there is the additional problem that they have crippled their own viability through the policy disaster known as globalisation.



part five:

the killer equation

the decaying growth dynamic

summary

The economy is a surplus energy equation, not a monetary one, and growth in output (and in the global population) since the Industrial Revolution has resulted from the harnessing of ever-greater quantities of energy. But the critical relationship between energy production and the energy cost of extraction is now deteriorating so rapidly that the economy as we have known it for more than two centuries is beginning to unravel.

If one asked a representative sample of the public what economics is all about, there is a very strong likelihood that the consensus answer would be “money”. The vast majority of economists do indeed frame the debate in monetary terms. The problem with this is that the economy is not, fundamentally, a monetary construct at all. Economics is really about the art of combining tangible components (such as labour and natural resources) to meet needs. Ultimately, money is a convenient way of tokenising this process. The process itself, on the other hand, is an energy equation.

The basic misunderstanding over this point – the treatment of money as the substantive challenge, rather than as the language in which that challenge

is expressed – lies at the heart of the current economic malaise. In essence, an ever-widening wedge has been driven between the monetary and the ‘real’ economies. A central argument set out in this report is that economic problems will remain insoluble for so long as policymakers concentrate on monetary issues rather than on the ‘real’ economy. We go further than this, arguing that the physical economy is, in essence, an energy system or, to be somewhat more precise, a surplus energy equation.

the commonality of energy

If one is to understand the essentially energy-based nature of the economy, it needs to be appreciated from the outset that all forms of energy – including food and work as well as such ‘obvious’ types of energy as oil,

natural gas, coal and renewables – are dimensions of the same thing. We term this vital concept *the commonality of energy*.

The fundamental fact of energy commonality is often obscured by the use of different units to describe and measure different forms of energy. For instance, food is measured in nutritional calories; work can be measured as kilowatt-hours (kwh); and fossil fuels tend to be expressed as gallons (of gasoline or distillate fuel), barrels or tonnes (of oil), cubic feet or cubic metres (of natural gas) and tonnes (of coal). But these differing calibrations should not be allowed to disguise the fundamental commonality of all forms of energy.



As an illustration of the commonality of energy, imagine filling the tank of a car with one gallon of gasoline, driving it until the fuel runs out, and then paying someone to push it back to the start-point. The ability of this person to do this depends, of course, upon sufficiency of nutrition, itself an energy equation. Obviously enough, the energy contained in food is converted by the human being into a capability for work, is exhausted, and requires continuous replacement. But this process is a circular one, in that the cultivation of food is a process which itself requires energy inputs, be they the labour of human beings (most simply in planting and harvesting), the labour of animals, the employment of machinery or the direct use of energy inputs such as fertilizers.

The exercise of putting one gallon of fuel into a car, driving it until the fuel runs out and paying someone to push it back to the start-point also illustrates the huge difference between the price of energy and its value in terms of work done.

According to the US Energy Information Administration¹⁸, one (US) gallon of gasoline equates to 124,238 BTU of energy, which in turn corresponds to 36.4 kwh¹⁹. Since one hour of human physical labour

corresponds to between 74 and 100 watts, the labour-equivalent of the gasoline is in the range 364 to 492 hours of work. Taking the average of these parameters (428 hours), and assuming that the individual is paid \$15 per hour for this strenuous and tedious activity, it would cost \$6,420 to get the car back to the start-point. On this rough approximation, then, a gallon of fuel costing \$3.50 generates work equivalent to between \$5,460 and \$7,380 of human labour.

One could come to a similarly-leveraged calculation of the energy cost-to-price mismatch by measuring the cost of employing workers pedalling dynamo-connected exercise bicycles to generate the energy used by electrical appliances in the typical Western home, and then comparing the result with the average electricity bill.

the great breakthroughs – agriculture and the heat-engine

The development of society and of the economy is, in reality, a story of how mankind overcame the limitations imposed by the energy equation. In the pre-agrarian, hunter-gatherer era (which lasted for at least 40,000 years), there was an approximate energy balance, in that the energy which each person derived from his food

¹⁸ http://www.eia.gov/kids/energy.cfm?page=about_energy_conversion_calculator-basics

¹⁹ 124,238 (BTU per US gallon of gasoline) divided by 3,412 (BTUs per kilowatt-hour) = 36.412 kwh per gallon

was roughly equivalent to the energy that he or she expended in finding or catching that food. Put simply, there was no energy surplus, and consequently no society. Each person had to be self-sufficient, or perish.

The first of the two great breakthroughs in human development was the discovery of agriculture. Farming seems to have begun in the “fertile crescent”, an area which stretched from the Upper Nile through modern-day Lebanon, Israel and Syria to the basins of the Tigris and the Euphrates in what is now Iraq, and to the upper coastal regions on both sides of the Persian Gulf. This region is also known as “the cradle of civilisation”. Evidence of cultivated grain suggests that the transition from a hunter-gatherer to an agrarian way of life may first have occurred in about 9,500BC, though millennia were to elapse before some of the staples of organised agriculture (such as crop rotation and the domestication of animals) were discovered.

From an economic standpoint, the significance of the development of agriculture lay in the liberation of surplus energy. If twenty individuals or family units could now be supported by the labour of nineteen, the twentieth was freed to undertake non-subsistence activities. He or she might

be engaged in making agricultural implements, bridges to improve access to fields, or mills which could grind grain into flour. Investment, properly considered, began when the energy surplus created by agriculture was deployed into the creation of capital goods instead of products for immediate consumption.

Of course, the energy surplus created by agriculture was extremely modest by later standards. It was sufficient to create a very limited range of specialist trades (such as smiths, millers and cobblers) and to provide rudimentary structures of government and law. The most complex organisations of the pre-industrial age – religious establishments, and the shipping and trading industries – were extremely simple by later standards, though trading companies did begin to point the way towards later corporate enterprises (in England, the East India Company and the Hudson’s Bay Company received their Royal Charters in 1600 and 1670, respectively, whilst the Dutch East Indies Company was established in 1602).

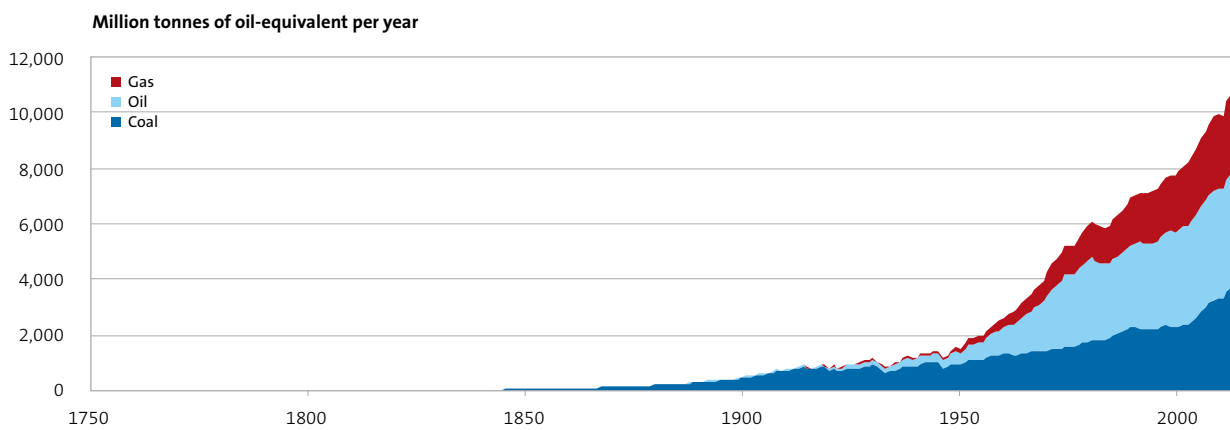
The importance of the discovery of agriculture lay in the creation of the first energy surplus, because it would be this surplus that would make possible the vastly greater advances

of the second breakthrough. As Daniel Webster put it, “When tillage begins, other arts follow. The farmers, therefore, are the founders of human civilization.”

Following the discovery of agriculture, the second (and vastly greater) breakthrough in the development of society and the economy was the invention of the heat engine, which enabled mankind to access the vast energy resources contained in coal, oil, natural gas and other exogenous (non-human) sources.

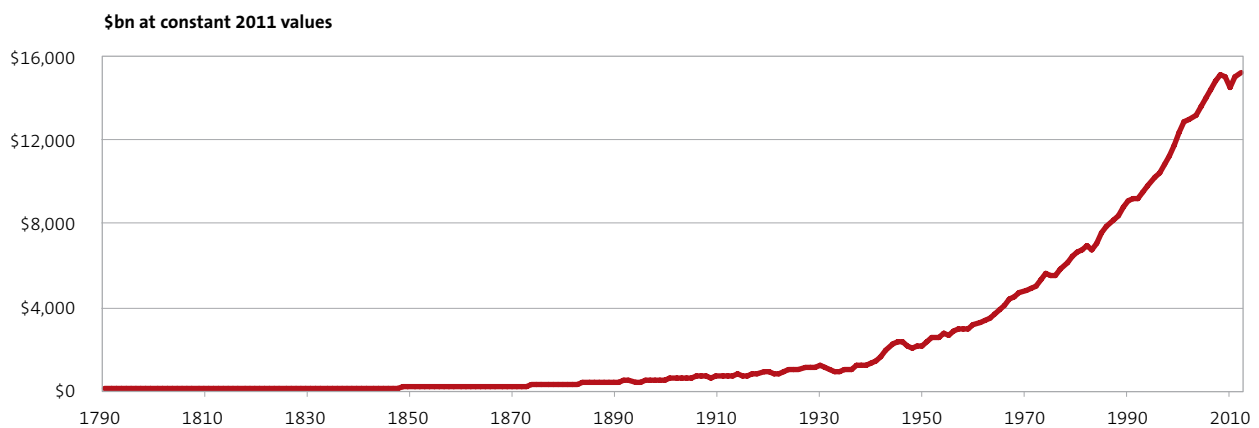
Although, in antiquity, Archytas of Tarentum and Hero of Alexandria seem to have played around with jets of steam – and gunpowder was discovered in China almost a thousand years ago – it is generally accepted that the invention of the true heat engine occurred in 1769, when Scottish engineer James Watt (1736-1819) patented his steam engine. Although it is arguable that the truly efficient heat engine did not arrive until 1799 – when English inventor Richard Trevithick (1771-1833) built a high-pressure steam engine, and applied it to drive the first locomotive – the industrial revolution was well under way by the end of the eighteenth century.

Fig. 5.1: World fossil fuel consumption since 1750*



* Source: Tullett Prebon calculations and estimates from various sources

Fig. 5.2: American real GDP since 1790*



* Source: Tullett Prebon estimates from various sources

The real importance of the industrial revolution lay in harnessing exogenous energy resources to apply vast leverage to the economy. Fig. 5.1 shows the truly enormous increase in the consumption of fossil fuels since the onset of the industrial revolution. Fig. 5.2 shows how, as typified by the United States, this expansion has been reflected in an equally-dramatic increase in economic output measured as real GDP.

As well as contributing to a massive quantitative increase in the economy, the energy dynamic has resulted in the extraordinary social and economic

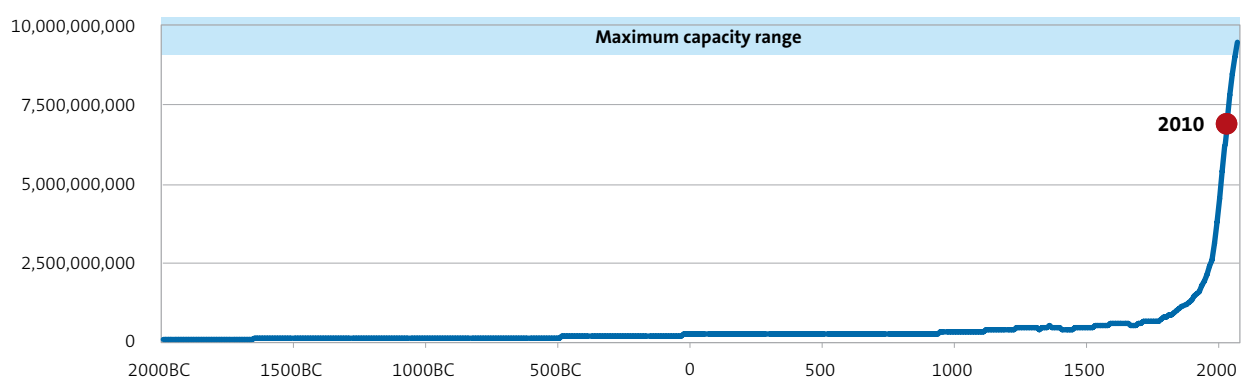
complexity and specialisation that are an accepted part of the modern economy. In the agrarian era, the overwhelming majority of people laboured on the land, and non-agricultural trades were not only few in number but, for the most part, were closely associated with farming. In today's developed economies, agricultural labour occupies only a very small minority of the workforce, with the majority engaged in an almost bewildering array of specialised occupations, trades and professions, the vast majority of which have no relationship whatsoever to agriculture.

exponential population, exponential energy

A glance at figs. 5.1 and 5.2 reveals a distinctive common feature, which is that the trajectories both of energy consumption and real economic output display clear exponential characteristics, something which is equally apparent in fig. 5.3, which charts global population numbers since 2000BC.

Historians estimate that the population of the world totalled about 27 million in 2000BC, and grew only very gradually thereafter, rising to 170 million two

Fig. 5.3: Exponential population growth, 2000BC to 2050AD*



* Sources: US Census Bureau & United Nations

millennia later. As recently (historically speaking) as 1400, the population of the world still totalled only 350 million, and did not reach the first billion until 1840, by which time the Industrial Revolution was well under way.

Thereafter, however, population growth accelerated very rapidly, reaching 2 billion by 1930, 3 billion by 1960, and 6 billion by 2000. The total recently passed 7 billion, should reach 8 billion well before 2030, and could be 9.3 billion (or more) by 2050.

If resources were infinite, this progression would be of little or no significance other than to sufferers

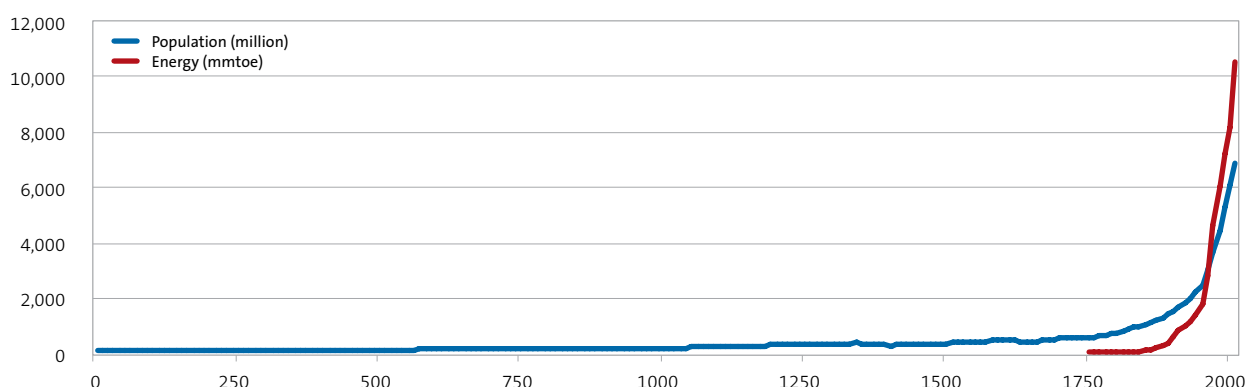
from agoraphobia. Since resources are not infinite, however, some experts postulate a maximum global carrying capacity somewhere within the 8.5 and 11 billion range shown on the chart (though others believe that, under certain conditions, even the lower end of this range may become wildly over-optimistic).

The striking feature of the exponential growth in the global population over the past two-and-a-half centuries is the way in which it parallels similarly exponential growth in the consumption of energy (fig. 5.4). Before about 1750, the consumption of energy was almost entirely untraded,

and therefore impossible to measure, but it was also too small to show up. In 1750, annual consumption of fossil-based energy (consisting at that time entirely of solid fuels) was about 3 million tonnes of oil-equivalent. (mmtoe), rising, pretty dramatically, to about 52 mmtoe by 1850.

Oil did not become a measurably-significant component of the energy total until 1870, by which time fossil fuel consumption had reached an estimated 142 mmtoe. Thereafter, this total escalated, to 200 mmtoe by 1880 and 400 mmtoe by 1895. The total exceeded 1,000 mmtoe in the late 1920s, reaching 2,000 mmtoe by the

Fig. 5.4: Energy and the population*



* Source: Tullett Prebon calculations from various sources

mid-1950s and almost 4,500 mmtoe by 1970. By the end of the 1980s – and despite intervening energy price shocks – consumption exceeded 7,000 mmtoe. Energy consumption broke through the 8,000 mmtoe barrier in 2000, and exceeded 9,000 mmtoe just four years after that. In 2010, and despite the onset of the economic slump in 2008, total fossil fuel consumption exceeded 10,000 mmtoe.

the subservient role of money

Though economists, policymakers, investors and the general public customarily think in terms of money, this conventional thinking is profoundly mistaken because, ultimately, the economy is a physical rather than a financial construct. Rather than being in any sense fundamental, money serves to tokenise output into a convenient form. After all, the world economy has survived the demise of an estimated 3,800 different paper currencies.²⁰

The roles of money can be defined as a medium of exchange, a unit of account and a store of value. The development of money paralleled the emergence of agriculture, the role of money being to tokenise the output of the economy into a convenient form. Obviously, the creation of money was a secondary stage in the economic process, as there was no point in having money

unless there were things that could be purchased with it, and the physical economy formalised by money was, as we have seen, an energy dynamic of inputs and outputs.

It is important to note that, in the agrarian age, anything that could be purchased with money was the product of human (or animal) labour, be that labour past, present or future. Purchasing, say, a plough amounted to paying for a product of past labour. Employing someone to plant a field involved payment for current labour. Commissioning someone to build an item of furniture meant paying for future labour.

As we have seen, however, the terms ‘labour’ and ‘energy’ are coterminous through the commonality of energy, so anything which could be purchased with money was the product of *energy*, past, present or future.

With the broader term ‘energy’ replacing ‘labour’, exactly the same relationship prevails in the industrial societies of today, except that exogenous energy inputs (overwhelmingly dominated by fossil fuels) now provide the vast majority of the energy used in the economy. So overwhelming is this preponderance that, in Britain today, human labour probably accounts for less than 0.5% of the aggregate human-plus-inputs

energy used in the economy. In other words, **all goods and services on which money can be spent are the products of energy inputs either past, present or future.**

The appreciation of the true nature of money as a tokenisation of energy also enables us to put debt into its proper context. Fundamentally, debt can be defined as ‘a claim on future money’. However, since we have seen that money is a tokenisation of energy, it becomes apparent that debt really amounts to ‘a claim on future energy’. Our ability, or otherwise, to meet existing debt commitments depends upon whether the real (energy) economy of the future will be big enough to make this possible.

Therefore, the viability (or otherwise) of today’s massively-indebted economies depends upon the outlook for energy supply. If one chooses to believe that the exponential expansion in energy use that has powered the growth of the economy (and the global population) since the dawn of the industrial age can continue into the future, debts may be serviceable and repayable out of the economic (for which read ‘energy’) enlargement of the future. If such enlargement cannot be relied upon, however, then the debt burden can only be regarded as unsustainable.

²⁰ See *Crash Course*, chapter six, <http://www.peakprosperity.com/video/222/playlist/153/chapter-6-what-money>

Where debt is concerned, individuals and businesses have only two possible courses of action – they can repay their debts, or they can default. Governments, however, have a third option, which is to repay debts using money newly created for the purpose. Instead of the ‘hard’ default of reneging on debt obligations, government can opt for the ‘soft’ default of ‘repaying’ their debts in a currency which has been devalued by inflation.

In any case, the real value of money is subject to a constant process of destruction as its value is eroded by inflation. According to official figures, even the US dollar – one of the most

resilient currencies that the world has ever known – lost 87% of its purchasing power between 1961 and 2011. To regard money as the building-block of the economy is profoundly mistaken.

at Hubbert's Peak?

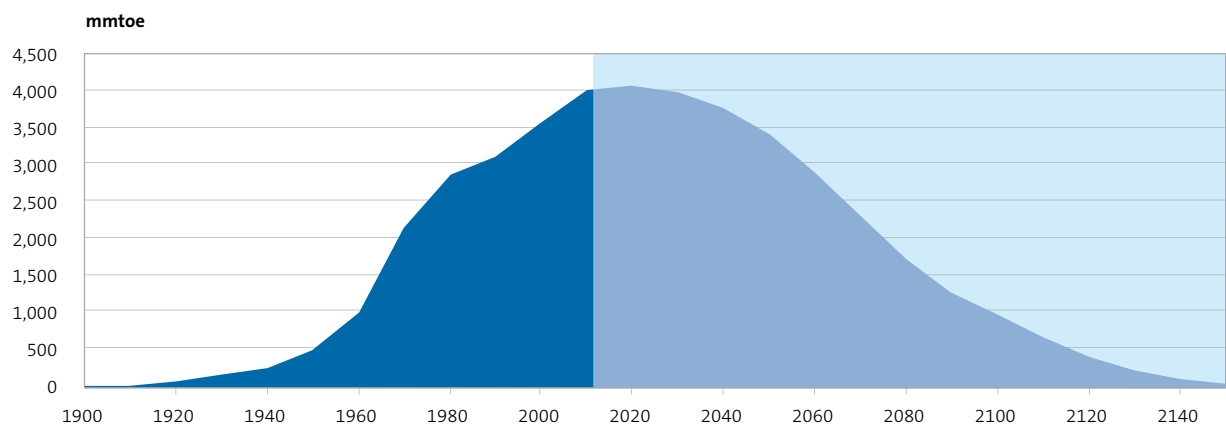
As we have seen, then, the economy is, in reality, an energy dynamic onto which has been grafted not just a system of monetary tokenisation but, much more seriously, a system of anticipatory finance which is viable if (but *only* if) it can be assumed that there will be no significant check to the process of exponential economic growth. Of course, the most obvious

threat to this anticipatory economic system would arise if the availability of energy were to diminish (or even simply cease to increase in the way that anticipatory finance necessarily assumes). Since the 1950s, this threat has acquired a name – “peak oil”.

This peak oil concept – pioneered by M. King Hubbert and accordingly known as ‘Hubbert's Peak’ – contends that, at some time in the relatively near future, we will have consumed half of all originally-available reserves of oil. This concept is illustrated in fig. 5.5, which combines past consumption data with a representative subsequent downwards curve.



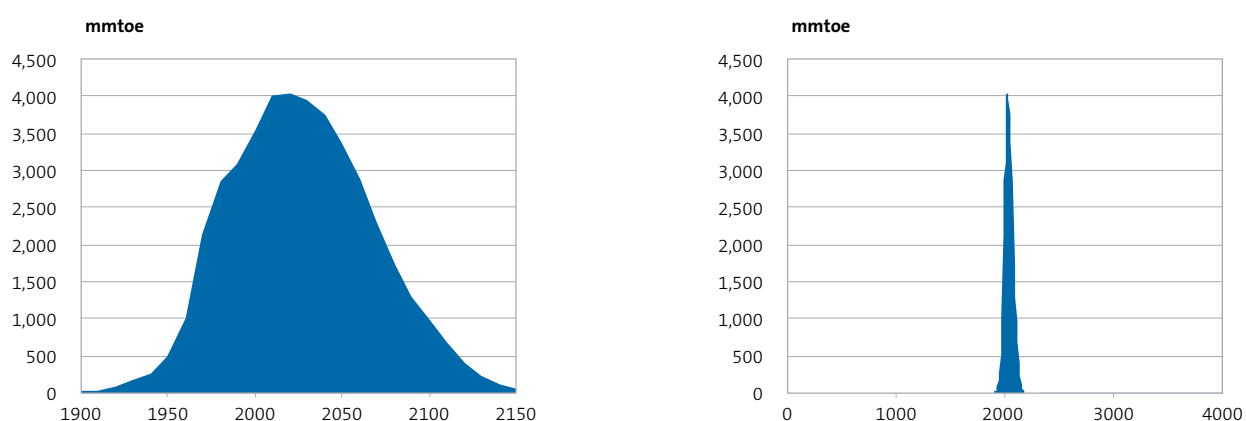
Fig. 5.5: The concept of peak oil*



* Source: Tullett Prebon estimates from various sources, see text



Fig. 5.6 & 5.7: Oil – feature ...or blip?



* Source: Tullett Prebon estimates from various sources, see text

At that point, Hubbertians argue, the supply of oil will decline, in pretty much a mirror-image of the increase in consumption which has taken place since the 1850s. Much the same, they argue, will eventually happen to supplies of natural gas and of coal, with depletion of these sources accelerating as a result of substitution from oil.

The peak oil process can already be discerned in the context of individual provinces such as the UK North Sea, or of multi-province plays such as the Lower Forty-Eight (L48) States of the US. Annual rates of petroleum discovery in America peaked in 1930, and peak production occurred forty years later, in 1970, since when output

has declined relentlessly. Since the global peak discovery rate occurred in the mid-1960s, it has been argued, a similar time-lag implies that global peak oil is now imminent.

Advocates of the peak oil interpretation argue that, seen on a timescale of social evolution, the era of the petroleum-based society is not so much a manageable trend (fig.5.6) as a one-off event (fig.5.7, which depicts *exactly the same data* as 5.6, but extends the time-scale from two hundred to four thousand years). Again, it has been argued that this same interpretation applies to other fossil fuels such as coal and natural gas, and that the current chapter in economic history amounts to nothing

more than a one-off event in which mankind has squandered a multi-million-year energy inheritance in an evolutionarily-brief moment of history.

As we have seen, a distinct exponential pattern links global population, energy consumption and, it should be added, a host of other linked parameters including economic output and food supply. If the availability of energy is the critical exponential driver in this agglomeration, might a reversal in the energy exponential bring all of the others crashing down?

To be sure, reversing any of the critical exponential progressions (be it energy availability, economic growth or population expansion) will be painful.

Indeed, society has absolutely no prior guide to how to manage successive (and perhaps rapid) decreases in population and in economic output. A mass collapse of exponentials could be catastrophic.

The classic Hubbertian argument is that oil production must soon enter an inexorable decline, because half of the world's originally-recoverable petroleum has already been extracted. The first flaw in this argument is that it is simply not true. The application of the Hubbert thesis at this point implies that reserves were of the order of 2,200 bn bbls (billion barrels). Ample evidence exists to suggest that the originally-recoverable reserves base was at least 3,000 to 3,500 bn bbls, and very possibly much larger. The Hubbertian case has considerable merit if it is applied to conventional oil, by which is meant light, sweet crudes which can be extracted relatively easily. But there is seemingly incontrovertible evidence that huge quantities of unconventional oils remain to be extracted.

In North America, tar sands reserves in Canada are estimated at no less than 170 bn bbls (billion barrels), whilst shales in the US alone may hold as much as 1,400 bn bbls of oil, though the extraction of much of that oil may be, to put it mildly, problematical. In South America, reserves of very heavy crudes in Venezuela are thought to be well in excess of 350 bn bbls. To be sure, there seem to be many cases of

overstatement where conventional reserves are concerned, most notably in OPEC countries, where, for many years, the quota allocation process incentivised the over-statement of reserves. But the overall picture is one of relative abundance of reserves of oil of all types.

The second error within the Hubbert's Peak theory is that it tends to ignore economics. A scarcity of oil would cause prices to rise massively. As we have seen, a US gallon of gasoline costs about \$3.50 but, in energy terms, displaces human labour worth perhaps \$6,400. Scarcity-induced price escalation could be expected to change this equation in at least two material respects.

First, a dramatic escalation in prices would reduce demand by causing greater frugality in the use of oil. As world-leading energy expert Robert Hirsch argued (in a thesis that essentially leant towards the concept of an oil production peak), there is a great deal that can be done to mitigate the economic impact of oil shortages, always presupposing that action is taken at least ten years ahead of the event²¹.

A society threatened by oil scarcity would be required to change fundamentally. Suburbs – the quintessential characteristic of a car-based society – would be replaced by denser forms of habitation in a

move that might yet be rendered necessary anyway by environmental considerations. The thirstiest vehicles (such as SUVs²²) would be consigned rapidly to the scrap-heap, and private car ownership would be displaced by public transport. The second effect of very high oil prices would be to incentivise exploration for, and development of, resources currently rendered uneconomic by their geological nature or their inaccessible location.

These arguments – and the apparent scale of remaining recoverable reserves – have generally enabled peak oil sceptics (sometimes known as 'cornucopians') to counter the Hubbertians and thereby, in general, to win the public debate.

In so doing, they are providing the right answers to the wrong question. The critical issue with peak oil does **not** hinge around remaining reserves. Rather, the critical issues are **energy returns on energy invested** (EROEI) and **deliverability**.

The best way to illustrate the deliverability issue is to compare oil sands reserves in Canada (about 170 bn bbls) with conventional reserves in Saudi Arabia (about 270 bn bbls). Given that Saudi production capacity is about 12 mmb/d (million barrels per day), one might, on a simple pro-rata basis, expect Canadian oil sands output to reach perhaps 7 mmb/d. But the reality

²¹ See Robert Hirsch et al, *Peaking of World Oil Production: Impacts, Mitigation, and Risk Management*. This groundbreaking report was written for, but then largely rejected by, the US Department of Energy

²² Sports-Utility Vehicles

is that output is most unlikely to reach even 3.5 mmb/d. Deliverability from the Canadian resource, will, then, be less than half of that attained from conventional reserves in Saudi Arabia.

Not surprisingly, and for perfectly logical economic reasons, oil reserves have been 'cherry-picked', meaning that the cheapest, highest-quality and most accessible reserves have been exploited first. What this in turn means is that, even if reserves remain substantial, production levels might hit a ceiling in the relatively near future. It also needs to be remembered that net changes in output represent a two-piece equation – substantial new sources are needed each year simply to

replace natural declines from already-producing fields. As the industry moves from higher- to lower-deliverability fields, maintenance of existing production levels, let alone growth, becomes ever more difficult.

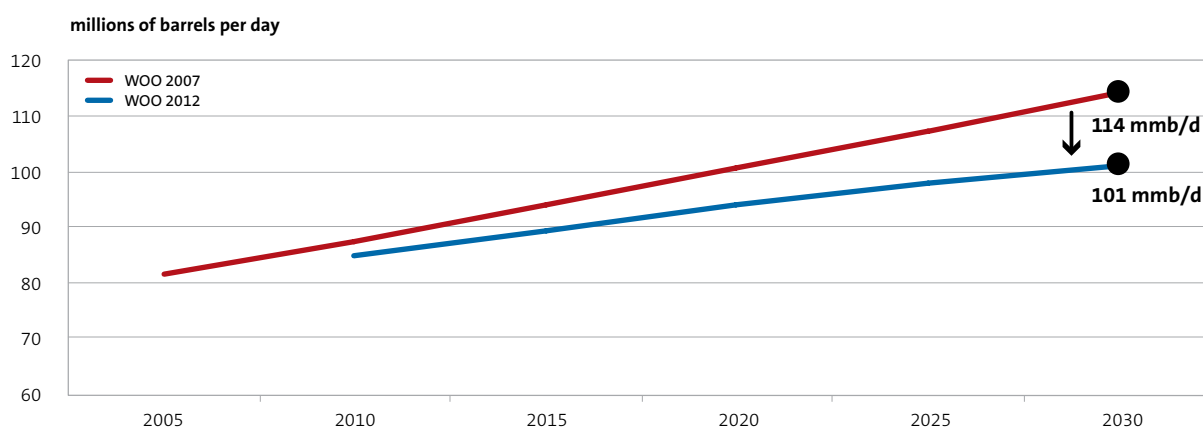
In the 2007 issue of the *World Oil Outlook*, OPEC predicted that global consumption of oil would rise to 114 mmb/d by 2030, amounting to a 31% increase over expected 2010 demand of 87.5 mmb/d. Five years on, the demand projection for 2030 had been reduced from 114 mmb/d to 101 mmb/d, whilst consumption in 2010 turned out to be a lot lower (84.9 mmb/d) than OPEC had expected in 2007 (87.5 mmb/d)²³ (fig. 5.8). The

significance of these figures is that the downgrading of OPEC's future demand forecasts resulted from the sharp lowering in economic growth expectations that occurred between 2007 and 2012.

Though appreciably lower than the cartel's estimate five years ago (114 mmb/d), the current projection for oil demand in 2030 nevertheless represents a big (19%) increase from the outturn in 2010 (84.9 mmb/d).

Is this achievable? We doubt it, not least because supply from existing sources of oil is declining by about 6.7% annually. On this basis, an overall supply increase of 14.4 mmb/d

Fig. 5.8: Oil demand – falling expectations*



* Sources: OPEC, World Oil Outlook, 2007 and 2012 versions. Demand shown in millions of barrels per day, net of processing effects

between 2012 and 2030 would require the development of new sources delivering 76.4 mmb/d (more three quarters of all output) by the latter date (fig. 5.9). This seems extremely improbable, not least because of the deliverability issue described earlier.

Moreover, future supply projections assume that a large proportion of all future net gains in production will have to come from OPEC countries. This might be difficult to achieve, particularly given that Saudi Aramco admits that it is injecting 13 mmb/d of treated seawater, most of it to sustain production at its giant (but ageing) Al Ghawar field, historically

the source of about half of the kingdom's production.

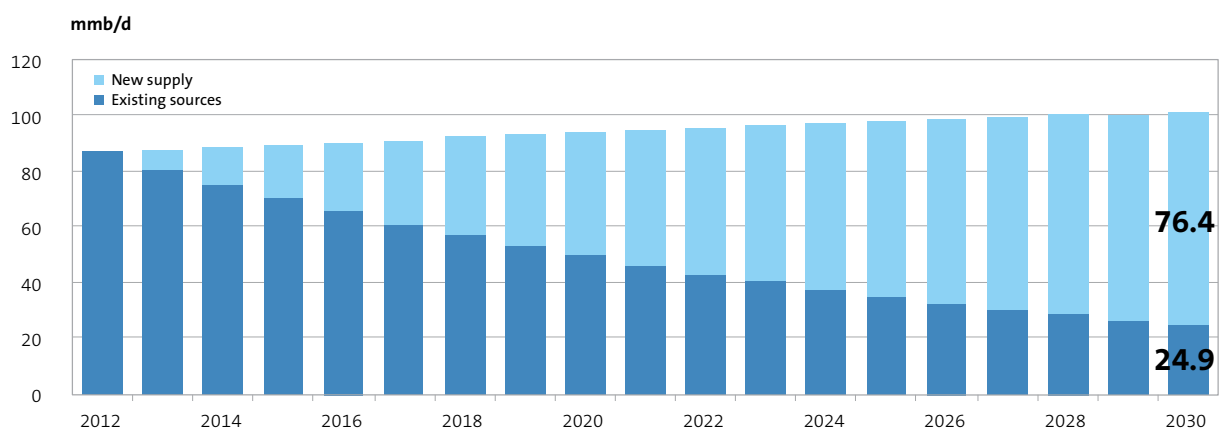
Another way to look at the deliverability issue is that reserves need to be quality-weighted. We may have used up much less than half of the world's originally-recoverable reserves of oil, but we have, necessarily, resorted first to those reserves which are most readily and cheaply recovered. The reserves that remain are certain to be more difficult and costlier to extract.

Production may not 'peak' just yet, but a new concept (which we term 'resource constraint') may soon kick in, implying that an economic model

based on abundant and ever-increasing hydrocarbon inputs might be running out of road.

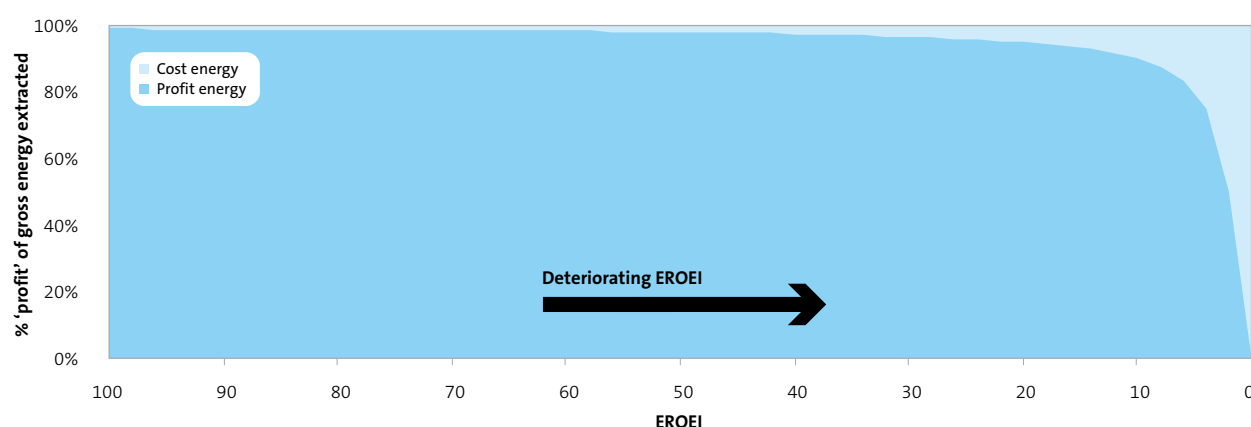
Neither should policymakers be fooled by the cornucopians' argument that technology will necessarily ride to the rescue. As remarked earlier, this argument is essentially equivalent to the statement that, if one locked some boffins up in a bank vault with enough cash and a powerful enough computer, they would eventually materialise a ham sandwich. Technology is not the Seventh Cavalry, poised to ride to the rescue.

Fig. 5.9: The oil supply challenge*



* Source: Tullett Prebon estimates from various sources

Fig. 5.10: The energy returns cliff*



* Source: Tullett Prebon estimates, see text

energy returns – the killer equation

An absolute decline in available energy volumes, serious though that would be, is *not* the immediate concern. The truly critical issue is the relationship between energy extracted and the amount of energy consumed in the extraction process. Known as the Energy Return on Energy Invested (EROEI), this is the 'killer equation' where the viability of the economy is concerned. Put very simply, there is no point whatsoever in producing 100 barrels of oil (or its equivalent in other forms of energy) if 100 barrels (or more) are consumed in the extraction process.

Though described earlier as an energy equation, a more precise definition

of the economy is that it is a *surplus* energy dynamic, driven by the difference between energy extracted and energy consumed in the extraction process. As we have seen, society and the economy began when agriculture liberated the first energy surplus. Subsequent economic history has been a process of increasing that surplus by harnessing ever-larger quantities of surplus energy.

The mathematics of EROEI are pretty straightforward. If the EROEI is 50:1, this means that 50 units are extracted for each unit invested in the extraction process. The division here is 50:1 between 'profit' and 'cost' energy, meaning that the net 'cost' of energy is 1.96% (1 divided by 51). Similarly, the

'energy cost of energy' is 0.99% (1/101) at an EROEI of 100:1, 3.8% (1/26) at 25:1 and 9.1% (1/11) at 10:1.

The best form of graphical presentation of EROEI is the "cliff chart" (fig. 5.10). The horizontal axis shows EROEI as a multiple, running in this instance from 100:1 to zero. The vertical axis divides gross energy produced into "profit" (the dark, lower area on the chart) and "cost" energy (the light area). At an EROEI of 100:1, the picture is overwhelmingly one of "profit", in a profit-to-cost percentage ratio of 99:1. The percentage ratio remains very strong (98:2) at 50:1, and is still robust (96:4) at 25:1.



Below an EROEI of about 15:1, however, the “profit” element falls off a cliff, because there is an exponential increase in the “cost” component, which rises from 4.8% at an EROEI of 20:1 to 6.3% at 15:1, 9.1% at 10:1 and 16.7% at 5:1. This process of “cost” escalation is illustrated in fig. 5.11, which shows that energy cost is yet another addition to the collection of exponential progressions (including population, energy consumption and economic output) which dominate the world as we know it. This time, however, the exponential progression is a negative one.

It is important to emphasise that the cliff chart depicted in fig. 5.10 is not time-linear. Even so, and as fig. 5.12 makes clear, the progression in energy sourcing is moving unmistakably and inexorably towards ever-lower EROEIs.

Oil discoveries in the 1930s offered EROEIs well in excess of 100:1, whereas this ratio had declined to about 30:1 by the 1970s, and few discoveries today offer an EROEI of much better than 10:1. In the heroic pre-War days of the oil industry, the ratio was high, because a small energy investment (often consisting of little more than rudimentary onshore drilling and wellhead equipment) could access extremely large oil fields. By the 1970s, these ‘easy’ (low-cost) sources were well on the way to being exhausted, and the industry was developing fields

which were both smaller and costlier, an increasing proportion being offshore.

The petroleum industry has shown enormous resourcefulness in developing techniques such as water- and gas-injection, horizontal drilling, remote production and various forms of advanced oil recovery (AOR) as discoveries have become ever more technically and geographically challenging, but the underlying trend has been a relentless deterioration in EROEIs as costs have risen and average field sizes have declined.

Believers in peak oil have seen this progression as an indication of ever-growing reserves stress, which indeed it is. But the real economic significance of this progression lies in a rapid deterioration in EROEIs rather than in an exhaustion of absolute reserves. The overall EROEI of the North Sea today may be no higher than about 5:1, a far cry from ratios in excess of 100:1 yielded by the pioneering discoveries in the sands of Arabia.

Much the same applies to other fossil fuels such as coal and natural gas. Where coal is concerned, fuel quality has deteriorated just as costs have risen. Almost all of the world’s original reserves of anthracite (the best coal in terms of energy content per tonne) have already been exhausted, pushing miners into ever greater reliance on

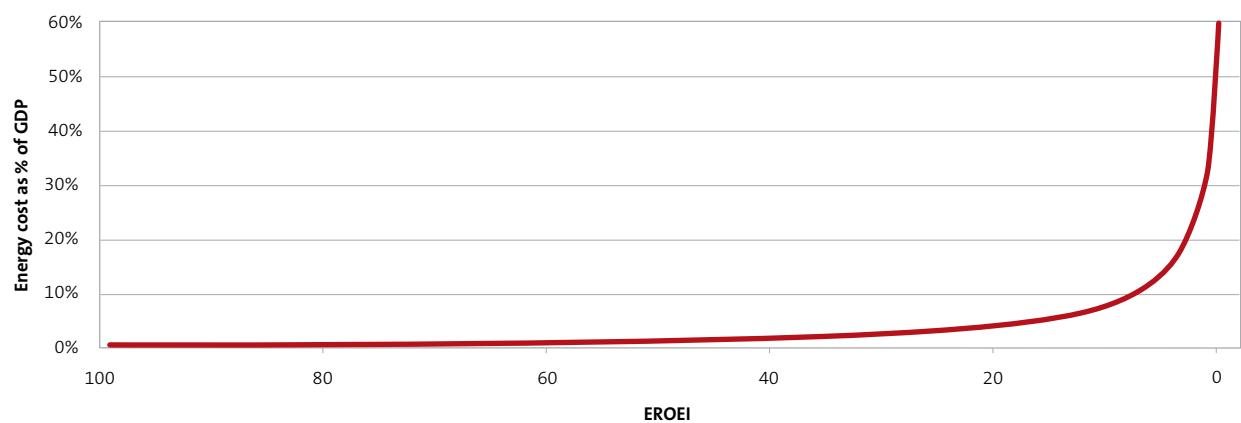
bituminous and even sub-bituminous coals, the latter offering barely half the energy content per tonne of bituminous coal.

Newer energy sources display a similarly disturbing trend. At first glance, the claimed EROEIs for onshore wind power look pretty reasonable at perhaps 17:1. However, the returns claimed for wind seem to make some pretty heroic assumptions about the longevity of generating plant and, in any case, wind turbines produce electricity, not the highly-concentrated transport fuels upon which the economy depends.

Other energy sources look even worse in EROEI terms. Biofuel EROEIs seldom exceed 3:1, and some are negative. The much-vaunted “hydrogen economy” is a myth, because hydrogen acts as a store (not a source) of energy, and is very inefficient in the way in which it converts energy obtained from conventional sources. About 40% of the initial energy is lost in conversion, perhaps another 15% is lost in the collection process and, if the hydrogen energy is reconverted into electricity, the process losses mean that one finishes with barely 15% of the energy put into the process in the first place.

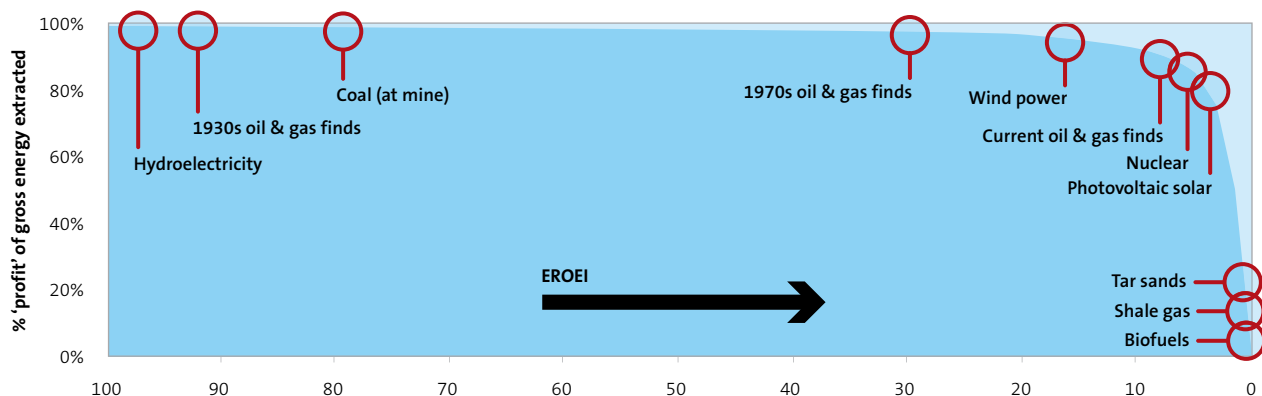
Policymakers who pin their hopes on unconventional hydrocarbon sources are guilty of a quite extraordinary degree of self-delusion.

Fig. 5.11: EROEI and energy costs*



* Source: Tullett Prebon, see text

Fig. 5.12: EROEI and energy sources*



* Source: Tullett Prebon, see text

The EROEI of surface-mined tar sands is probably little better than 3:1 (if that), and those sands (accounting for about four-fifths of the total) which cannot be surface-mined can only be extracted using massively energy-intensive techniques such as SAGD (steam-assisted gravity drive), such that EROEIs are minimal, or even negative.

The latest fashion in collective delusion concerns shale gas and oil. These may indeed exist in vast quantities, but EROEIs of barely 5:1 should make it abundantly clear that shales most emphatically are **not** the quick-fix that many governments (and their electorates) might like to suppose.

where are we now?

As we have seen, then, there is an unmistakable trend towards lower energy returns on energy invested, with EROEIs falling within the fossil fuels slate just as society is turning both to renewables (such as wind power and biofuels) and to unconventional sources of hydrocarbon energy (including tar sands and shale gas). The critical question (though it is one to which scandalously little official attention has been devoted) has to be that of where the world is in terms of the overall EROEI, and where this critical equation may be heading.

In an excellent discussion published in 2010, analyst Andrew Lees suggests that the overall EROEI, having declined from 40:1 in 1990 to 20:1 in 2010, might fall to as little as 5:1 by 2020²⁴. Though Mr Lees does not cite sources for these numbers, his figures for 1990 and 2010 accord pretty closely with our own estimates.

Policymakers must hope that he is very wrong indeed, however, about the global average EROEI in 2020 because, if this ratio does indeed decline to just 5:1 over the coming seven years, the economy as we know it is finished. It is as simple as that.

The cost point here is critical. At the 40:1 ratio cited by Andrew Lees for 1990, the theoretical cost of energy would have been 2.43% (1/41) of GDP. If the correct figure for 2010 was indeed 20:1, then the ratio in that year would have been 4.76% (1/21), a painful increase since 1990 but, nevertheless, a ratio at which the surplus energy economy can still function.

At a ratio of 5:1, however, energy would absorb 16.67% (1/6) of GDP, meaning that energy costs would have increased by 250% (16.67 compared with 4.76) over just ten years. Put very simply, and ignoring (for now)

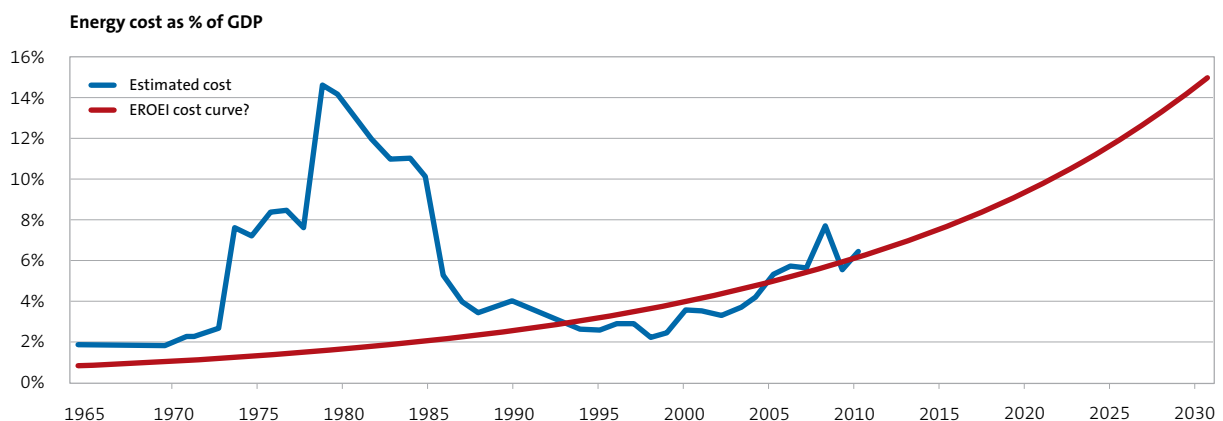
intervening inflation, this would be equivalent to the annual average reference price of Brent crude oil having soared from \$79.50/bbl to almost \$280/bbl.

Our own analysis begins with an estimate of the overall cost of energy as a percentage of global GDP, which is plotted for the period since 1965 in fig. 5.13. Energy costs, historically very low before 1973, were driven to extremely high levels by the oil crises of the 1970s before falling back markedly in response both to demand destruction and to the incentivisation of previously non-commercial sources of supply.

As a result, energy was remarkably cheap during the 1980s and 1990s, averaging perhaps 3.1% of GDP between 1986 and 1999, compared with an estimated peak of almost 15% in 1979.

Of course, and as we have seen, the value and the cost of energy are very different concepts, and short- and medium-term cost oscillation can be created by political and economic events largely unrelated to underlying fundamentals. Even so, we believe that there is sufficient alignment over the longer term in the relationship between EROEI and cost for us to plot

Fig. 5.13: The underlying trend of EROEI?*



* Source: Tullett Prebon estimates, see text

an estimated EROEI trend (in its cost-equivalent form) on a 'best-fit' basis.

Remember that what is being measured here is not the value of energy, but its cost as a proportion of the value that we derive from it. Cost and value could only be the same if no surplus existed, which would also mean that the economy could not exist either.

Our assessment of the trend in EROEIs is shown as the red line in fig. 5.13. On this basis, our calculated EROEIs both

for 1990 (40:1) and 2010 (17:1) are reasonably close to the numbers cited for those years by Andrew Lees. For 2020, our projected EROEI (of 11.5:1) is not as catastrophic as 5:1, but would nevertheless mean that the share of GDP absorbed by energy costs would have escalated to about 9.6% from around 6.7% today. Our projections further suggest that energy costs could absorb almost 15% of GDP (at an EROEI of 7.7:1) by 2030.

Though our forecasts and those of Mr Lees may differ in detail, the essential conclusion is the same. It is that the economy, as we have known it for more than two centuries, will cease to be viable at some point within the next ten or so years unless, of course, some way is found to reverse the trend.

This point requires further explanation.

EROEI decline – the road from wealth to poverty

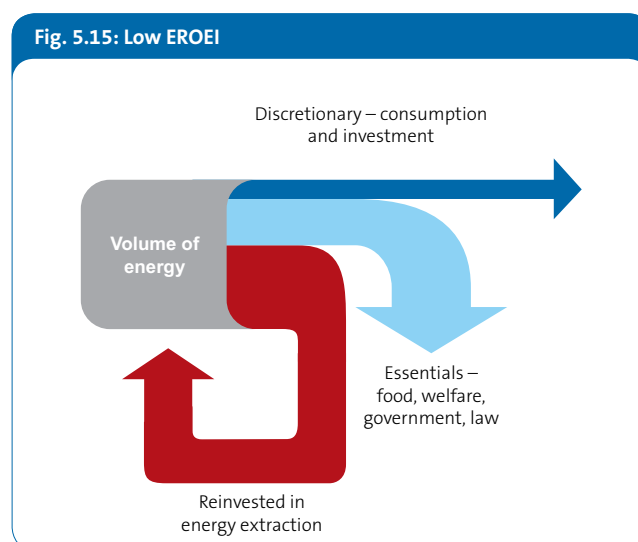
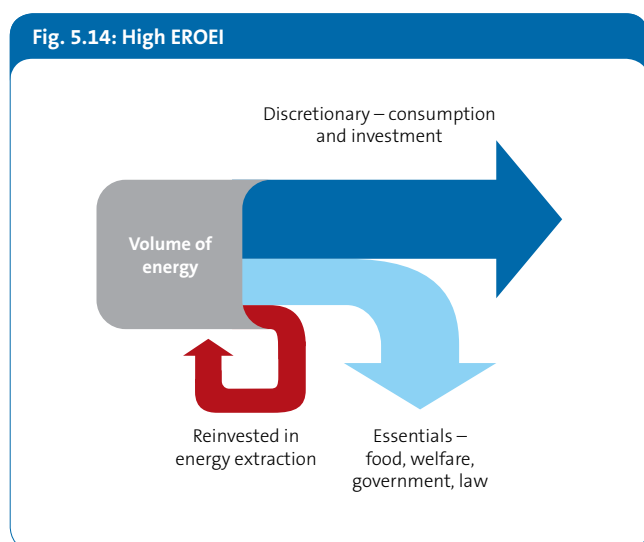
When looking at how a sharp decline in EROEI affects the economy, we need to take note of two key points. The first of these is that the slump in energy returns means that an ever-higher share of total output will be absorbed by the cost of energy, meaning that less value remains for all other purposes. The second is that energy is central to the entire economy, and that its effects go far beyond the obvious ‘costs’ of energy-related activities such as transport and the generation of power.

Let’s start with the straightforward EROEI equation by comparing a high- and a low-EROEI economy, represented here by figs. 5.14 and 5.15. Each chart subdivides the totality of produced energy into three streams. The red component is the proportion of the extracted energy which has to be reinvested into the extraction process, whether as infrastructure (capital) or in extraction (operating) expense.

In a high-EROEI economy (fig. 5.14), the reinvestment requirement is small, leaving most of the produced energy to be used to power the economy. Of

this, some – shown in light blue – is used for essential purposes, such as food production and the provision of healthcare, law and government. The remainder, shown in dark blue, powers *all* discretionary activities, including all other forms of consumption and investment.

If EROEI falls sharply, as in fig. 5.15, much more of the gross energy is consumed in the extraction process, resulting in a corresponding squeeze on the energy available to the economy. The essentials may still



* Source: Tullett Prebon estimates, see text

be affordable, but the leverage in the equation is such that energy available for discretionary uses diminishes very rapidly indeed. There, through the EROEI squeeze, goes the car, the holiday, the bigger home, the MP3, the meal out, toys for the children, the afternoon at the golf club or the soccer match. **If EROEI falls materially, our consumerist way of life is over.**

There are two *really* nasty stings in the tail of a declining EROEI. First, net energy availability may fall **below** the amount required for essential purposes including healthcare, government and law. It is hardly too much to say that a declining EROEI could bomb societies back into the pre-industrial age.

Indeed, a decrease in net energy below subsistence levels is an implicit consequence of EROEI decline beyond a certain point – one which is difficult to estimate, but is likely to occur within the next decade – which means that this is when the nastiest results of all start happening.

Second, of course, a decline in net energy availability could (indeed, almost certainly will) result in conflict driven by competition for access to diminishing surplus energy resources.





an unfolding collapse?

As we have seen, energy is completely central to all forms of activity, so the threat posed by a sharp decline in net energy availability extends into every aspect of the economy, and will affect supplies of food and water, access to other resources, and structures of government and law.

The story of modern agriculture is one of feeding an ever-growing global population from an essentially-finite resource base. At the time of population theorist Thomas Malthus (1766-1834), it would have seemed inconceivable that the world population could increase from 870 million in 1810 to 6,900 million in 2010. That this has been achieved has been solely due to the application of exogenous energy to agriculture, a process which has created an expansion in food production which has exceeded the 7.9x increase in human numbers over the same period.

Essentially, there are two ways in which agricultural output can be increased. The first is to bring more land into production, which has indeed happened, but virtually all viable farmland was under cultivation by 1960.

The second is to increase output per hectare, which is what the “green revolution” has achieved – between 1950 and 1984, for example, global grain production increased by about 250%.

The snag with this, of course, is that the green revolution has, overwhelmingly, been the product of energy inputs. Most obviously, planting, harvesting, processing and distribution have been made possible by fossil fuels, principally oil. Fertilizers have been sourced from natural gas, whilst most pesticides are made from petroleum. The impact of energy inputs on agricultural productivity cannot be calculated exactly, but some estimates suggest that these inputs have increased output per hectare by at least 85%. The apparent implication – which is that food production might decline by almost half if these inputs became unavailable – is almost certainly a severe understatement, because it ignores both the leeching of naturally-occurring nutrients and the conditioning of the land to input-intensive monoculture.

It seems highly probable that recent food crises are directly linked to rising energy costs, and that escalating food prices owe at least as much to energy

constraint as to continuing increases in the global population. Of course, the cultivation of crops for fuels worsens the squeeze on food availability and, as we have seen, offers such low EROEIs that it is a wholly futile response to the squeeze on energy supplies.

The knock-on effects of energy constraint go far beyond food issues, serious though these are. The production of most minerals would be uneconomic without access to relatively inexpensive energy. The giant Bingham Canyon mine in Utah, for example, produces copper at concentrations of about 0.25%, which means that some 400 tonnes of rock must be shifted for each tonne of copper produced, a process that is hugely energy-intensive. Most plastics are derived from either oil or natural gas. Desalination is extremely energy-intensive, which means that any sharp escalation in energy costs will undercut an increasingly important source of fresh water. Current plans call for the quantities of water produced by desalination to increase from 68 mmc³ (million cubic metres) in 2010 to 120 mmc³ in 2020, a plan which looks wildly unrealistic if the availability of net energy is declining at anything like the rate that our analysis of trends in EROEI suggests.

The logic of a deteriorating EROEI suggests that investment in energy infrastructure will grow much more rapidly than the economy as a whole in a process that has been called ‘energy sprawl’. In essence, declining productivity means that the energy infrastructure must increase more rapidly than the volume of produced energy, and this process is clearly under way, though principally in the emerging economies (where energy demand continues to increase) rather than in the developed world. This is most evident in the massive investment that is being poured into all aspects of the energy chain in China.

The calculations here are daunting. If we assume (for the sake of simplicity) that real GDP remains constant over a ten-year period in which the overall EROEI declines from 20:1 to 10:1, energy costs must rise at a compound

annual rate of 7.4% whilst the rest of the economy shrinks by 0.5% per year.

knowing the score

Where the surplus energy equation is concerned, one question remains – how will we know when the decline sets in?

The following are amongst the most obvious decline-markers:

- **Energy price escalation.** The inflation-adjusted market prices of energy (and, most importantly, of oil) move up sharply, albeit in a zig-zag fashion as price escalation chokes off economic growth and imposes short-term reverses in demand.
- **Agricultural stress.** This will be most obvious in more frequent spikes in food prices, combined with food shortfalls in the poorest countries.

- **Energy sprawl.** Investment in the energy infrastructure will absorb a steadily-rising proportion of global capital investment.
- **Economic stagnation.** As the decline in EROEIs accelerates, the world economy can be expected to become increasingly sluggish, and to fail to recover from setbacks as robustly as it has in the past.
- **Inflation.** A squeezed energy surplus can be expected to combine with an over-extended monetary economy to create escalating inflation.

With the exception (thus far) of inflation, each of these features has become firmly established in recent years, which suggests that the energy-surplus economy **has already reached its tipping-point**.

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