Prospects for the World Economy in 2035

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The record of long-term forecasting is not a glorious one. In a celebrated article the great English economist John Maynard Keynes, writing in 1930 about "the economic possibilities of our grandchildren," forecast that in a century's time the working week would be about fifteen hours long, thus creating a serious challenge of how to use our extensive leisure.[1] We have only fifteen years to realize that result. The trends point in the right direction, with shorter working weeks and longer paid vacations, but are substantially off in magnitude. In the early 1950s the Twentieth Century Fund published an ambitious projection of the world economy to the year 2000, in which it projected a world population of 3.25 billion, up from 2.4 billion in 1950, and concluded that the major future challenge would be how to feed so many people. In fact, the world population in 2000 was about 6.1 billion, and the average diet was significantly better than it was in 1950.[2] And of course many forecasts of world energy demand were made after the oil shocks of the 1970s, most of which proved wildly wrong.[3]

Despite this unhappy record, we can say something sensible about at least the next two or three decades, since most societies have a lot of inertia, such that the near future is not radically different from the near past, or can be projected from known factors. Start with demography. Most of the mothers of 20 years from now have already been born, or will soon be born. Barring radical changes in fertility in the next few years, we know

with high confidence roughly how many potential mothers there will be in 2035. We know with less confidence how many children they will bear, but we know something about recent trends in fertility, and about the influence of greater education and affluence on child-bearing behavior. Putting these factors together, the US Census Bureau projects a world population of 8.6 billion by 2035, and 8.9 billion by 2040. The distribution is at least as interesting as the totals. Almost all the growth will occur in today's poorer countries. The populations of Japan and Germany have already peaked; Italy and Spain and South Korea and especially Russia will be in serious decline; China will reach its peak around 2026 and India will have become the world's most populous country, although population growth there will have dropped below one percent a year.

The United States stands out as an exception among rich countries: fertility has fallen, although not as rapidly as in other rich countries; and net immigration continues to augment the population significantly, leading to a projected population of 370 million by 2035.

With over a billion more people, will we be able to feed them all? The answer is almost assuredly affirmative, thanks to rapid improvements in plant and animal genetics, permitting augmented yields, and possibilities in some parts of the world for extending irrigation, and everywhere for using water more efficiently. Grain yields vary greatly around the world, by a factor of eight with respect to maize, with the differences largely due to the use of chemical fertilizer and good quality seeds, features controlled by humans. Thus a move toward best practice could significantly increase total food production. This does not rule out local famines, but they will be due to low income and and/or governmental failures, not to a global shortage of food.

All countries will have aging populations, since longevity is increasing almost everywhere, although of course at different rates. The share of populations above 65 will grow dramatically in Europe and in East Asia. Table 1 presents projections of median ages (half above, half below) for the world and for a number of selected countries in 2010 and 2040. Median age in the world rises by seven years over this 30-year period. Japan remains the oldest country in 2040, but South Korea is aging more rapidly, as is China, by 12 years over the period. The United States is aging too, but at a much slower rate than other countries. This is partly due to the less rapid fall in birth rates in the United States, but also to a continued inflow of immigrants concentrated in young adults, which pulls down the rate at which the United States ages.

The third column of Table 1 illustrates a different point: with declining birth rates the number of young adults (concretely, aged 15-19 here) is declining, by over one percent a year in China, Japan, and South Korea, and not much less rapidly in some other countries. The United States stands out in the growing number of young adults, again largely because of immigration. Young adults are the best educated and the most mobile members of society these days, both geographically and occupationally. A decline in their numbers reduces the ability of economies to adapt to the continual changes in technology and in the pattern of demand that takes place in growing economies, reducing their ability to grow rapidly.

In addition to higher population, incomes will also be significantly higher – a reasonable guess is that the income of the median world citizen increase by nearly three quarters over the 25 years 2010-2035. That continues the rate at which global incomes grew over the past half century, and there is no compelling reason to believe that growth

will slow from rates we have seen, as one country after another attains the domestic conditions and the policies required to achieve and to sustain economic growth. We now know much about the determinants of growth: achieve social stability, above all security for the population from physical harm, adopt incentives for effort and risk-taking, and engage the economy with the rest of the world (since most economies are too small to sustain growth on their own for more than a few years). The pipeline of prospective new technologies is full, leading to innovation in the rich countries and rapid diffusion to poorer countries, these days called emerging markets. Education and productive investment are also critical, and will be encouraged by opportunity and the proper incentives for families. More and more poor countries, often after having tried alternatives that failed, have mastered the keys to economic growth, at present especially the world's two most populous countries, China and India, resulting in a rapid reduction in poverty; but also spreading throughout Southeast Asia, South Asia, and more selectively in Latin America and Africa. There will be setbacks and even perhaps reversals, but the process is inexorable at the global level, because it produces real choices and better chances for fulfilling lives for millions, indeed billions, of people.

The projection just sketched assumes that there is no major war during this period, nor a major economic depression, and that an open world economy is preserved – concretely that the major economies remain open to imports of goods and services from other countries – all of which conditions are likely to be met, although not with certainty and not without continuing vigilance and appropriate policies by governments.

Putting these projections of growth in population and in per capita income together implies that gross world product will increase by more than 80 percent in the

coming 20 years. That in turn implies higher demand for food, for fuel, and for much else. But it also implies higher production to meet these needs – indeed, gross domestic product (GDP) is a measure of production of all goods and services in an economy. Incomes, production, and demand will grow together. There will also be growing amounts of leisure (that is, waking time not involved in directly productive activity), although not as much as Keynes foresaw, because people will want higher material standards of living. Many more people will have real choices in life, and that will lead, if the past is any guide, to lower birth rates and more education, in a virtuous circle.

More people with higher incomes will put greater pressure on resources and on the environment. The prices of some resources will rise, creating incentives to conserve them, to find substitutes for them, and to innovate around the need for them, as kerosene was invented to replace increasingly scarce whale oil for illumination in the mid-19th century. Some activities will disappear in their current form, and new activities will emerge. Think of the rapid growth in computation and in communication during the past 30 years, largely unforeseen ten years earlier. We will have a growing ability to manipulate materials at the molecular level to achieve the attributes we desire, and that will reduce the growth in demand for many natural resources.

Growing economies will require growing amounts of energy, although less than proportionately on recent experience. Electricity is especially important, but so is motive fuel – for automobiles, trucks, aircraft, and ships. The latter has relied overwhelmingly on petroleum since the conversion of ships from wind to coal in the 19th century and from coal to oil in the 20th century. On projections by the US Energy Information Agency, assuming an annual growth averaging three percent in the world economy, demand for

energy will rise by 1.5 percent a year, or by nearly 50 percent over the period 2010-2035. Demand for liquid fuels will grow by 0.9 percent a year, or by 26 percent over the whole period, from 86.7 million barrels of oil a day in 2010 to 109.4 mb/d in 2035. China will reach the United States in its total oil consumption of over 18 million barrels a day. Global demand for coal, mostly by China and India, will grow even faster, by 1.3 percent a year.

These projections raise two important questions. Will the required supply of energy be forthcoming, and from where? And what will be the environmental impact of this significant increase in energy consumption?

Coal is abundant, especially in the USA, China, India, and Russia, but also more widely available, and can be extracted at low cost. But China's demand for coal has been growing so rapidly that even its large reserves could be exhausted within a few decades. The major exporters today are Indonesia, Australia, the USA, South Africa, and Colombia.

Oil is more problematic. Known conventional reserves are heavily concentrated in the Middle East and a few other places such as Venezuela. Advances in exploration techniques continually permit new finds, although at much higher extraction costs than those prevailing in the Middle East. The key questions are whether the high-reserve countries, most notably Saudi Arabia, will make the investments required to increase oil extraction by the required amounts, how much wealth the rest of the world will transfer to the oil exporters, and how the oil exporters will use their increased wealth.

Efforts to reduce dependence on oil will have to start soon if they are to have a significant impact two decades from now – such is the built-in inertia of our existing systems of transportation and other uses of oil.

The notion of "energy independence" has been part of the American political dialogue at least since the Nixon administration, over forty years ago. Now there seems to be some possibility that the United States will actually achieve energy independence, or come close to it, within the next 20 years – at least according to the recent world energy outlook to 2035 produced by the Paris-based International Energy Agency. Just a few years ago the United States imported nearly 14 million barrels of oil a day (roughly 700 million metric tons a year), over half US oil consumption. In 2013 imports were below 10 mb/d. How was this radical change possible?

The answer lies mainly in "shale oil," a term that was hardly known outside circles of specialists a few years ago. Thanks to advances in technology that have taken place over the past two decades – both in collecting and interpreting seismic information, and in drilling horizontally from deep wells –gas that has been locked in dense rock – and known about for over a century – has become economically accessible. The process is called "fracking," whereby a combination of water, sand, and certain chemicals is injected at high pressure into the shale, cracking it and releasing the trapped gas to flow up the well-pipe for human use.

Shale gas now accounts for over a third of total US gas production, which has risen by a third since 2005 and is expected to rise by a further 30 percent by 2035. US production of petroleum liquids– a similar process can also produce oil from previously inaccessible formations, and some of the gas contains petroleum liquids—has risen by

over three million barrels a day since 2005, after having fallen for over a decade. The IEA expects the United States briefly to overtake Saudi Arabia as the world's largest producer of petroleum in the early 2020s, producing nearly 13 mb/d. Along with conservation, especially in automobiles, US imports of oil are expected to drop significantly, from 60 percent of total consumption in 2005 to 41 percent in 2012 to an estimated 34 percent by 2020.

In the United States over half the natural gas is used as a feedstock for the petrochemical industry. It is also used for heating and cooking, but its main use as a fuel is for generating electricity, where it has accounted for 77 percent of incremental power generation capacity since 1990. Much coal is also used for power generation, but in 2012 gas briefly reached coal as the major source of electricity for the first time. Over time the two fuels will compete closely on the basis of relative cost (possibly inclusive of CO2 emission charges in the future). More gas will help reduce pollution from power generation – although coal-fired plants are already subject to extensive environmental regulation. And gas releases only about half of the amount of carbon dioxide, an important greenhouse gas, as coal does for the same amount of electricity generated. US coal production may as a result decline, or alternatively it might be directed into foreign markets since it has become relatively cheap.

Thus "energy independence" in the US context does not mean that the United States ceases to import oil, which has been the main source of concern about security of supply, but rather that US exports of coal and natural gas will contain the energy equivalent of US imports of oil, which have already declined from their peak. It is possible, however, that US imports of oil in twenty years can be fully satisfied from

Canada and Mexico, both of which have unexploited oil resources. If so, North America as a whole would be self-sufficient in oil, and a net exporter of energy. US market prices, however, would still be tied to world oil prices, giving the United States a continuing interest in world oil developments.

In addition to substituting for coal in electricity generation, and thereby reducing air pollutants and greenhouse gas emissions, the shale gas revolution has a number of other implications. First, it will provide a cheap (and sometimes alternative to oil) feedstock for the petrochemical and plastics industries. Just how cheap will depend on decisions yet to be made about permitting the export of gas (beyond Canada and Mexico, which are covered under the North American Free Trade Agreement), and the investments required to do so. While only one liquefied natural gas (LNG) export facility has formally been permitted, it is likely that several of the other 20-odd applications will be approved, since failure to do so would open Americans to the charge of restricting exports in order to favor the domestic chemical industry, which would not be acceptable in Europe and other parts of the world. Export of gas, particularly to Northeast Asia, should be profitable, since prices there exceed $15 per million Btu (British thermal units, a unit for measuring energy), compared with $4 in the United States – more than enough to cover the $5-6 cost of moving the gas to the West Coast, liquefying it, shipping it across the Pacific, and re-gasifying it in the destination countries – Japan, South Korea, and perhaps China. With exportation, gas prices would rise in the United States, but still remain well below the effective prices in Europe and Asia.

Second, it is possible that cheap gas will substitute for expensive oil not only in home heating, where fuel oil is still extensively used, but also in transportation,

particularly where fleets of vehicles can be serviced in central locations, such as city buses, taxi cabs, and delivery and refuse trucks. It would take much longer for gas to substitute significantly for oil in individual passenger vehicles, although that too is technically possible (as demonstrated currently in Iran); and it could be accelerated by a charge on CO2 emissions and by introduction of small scale gas-to-liquid conversion plants. China is already substituting expensive LNG for diesel fuel in trucks and buses, to reduce air pollution.

Third, cheap gas will probably set back for a few decades the further development of nuclear power in the United States, given the serious public reservations about nuclear power on other grounds, re-enforced by the accident at Fukushima in Japan. Finally, cheap gas for generating electricity will also set back the development and installation of renewable sources of power (wind, solar, and biomass), except insofar as costs of those sources decline significantly, or subsidies are raised significantly, although wind (with current subsidies) will be competitive in some areas.

What of the rest of the world? Significant deposits of shale gas seem to be available in Russia, but if developed they would compete with conventional Russian gas which is already highly priced for delivery in Europe; indeed, the potential for exporting gas from the United States is already putting downward pressure on Russian gas export prices. China too seems to have extensive reserves of shale gas, perhaps the world's largest, although it is remote from the main consuming areas; and the heavy requirements of fracking for water may limit development in parts of China, where water is already scarce, even over the longer term.

More energy will mean more pollution, and greater forcing of climate change through emissions of carbon dioxide, a greenhouse gas. Most pollution will be local or regional. As incomes rise, local pressures for cleaner air and water will increase. Just as Europe and America now experience much less pollution than they did forty years ago, China and other middle income countries will take effective steps to reduce air and water pollution – after it has worsened further in the near future.

Carbon dioxide emissions are another matter. On the projections by the US Energy Information Agency, global CO2 emissions will rise from 31 million metric tons in 2010 to 44 mmt in 2035, a rise of 40 percent rather than the decline required if we are to limit climate change. The incentives for individual countries to reduce these emissions are low, since CO2 is a colorless, odorless, generally benign gas. But rising atmospheric concentrations of CO2 have undesirable effects. It remains to be seen whether the important emitting countries – which include both China and the United States, the two largest emitters – can agree on and implement effectively a collective arrangement for substantial reductions of CO2 emissions. Such an agreement would have to reduce significantly the world's growing dependence on oil and especially coal, or else find ways to scrub CO2 out of exhaust or remove it from the atmosphere. Such techniques exist, but they are largely untested on a commercial scale, and they may be costly, thus provoking political resistance to their adoption.

Due to growing greenhouse gas emissions, the world's climate will be changing during this period, but the change will be gradual, not dramatic, in the period to 2035. No doubt major weather developments will be attributed by some to climate change, and occasionally such attribution may even be correct. The world community will be

grappling with climate change in the meantime, and may well have found a satisfactory solution to restraining emissions by 2035, but its main impact will occur later.

How will economic development affect the political balance by 2035? The world economy will be larger, but countries are expected to grow at different rates, so their relative importance will change.

Most attention has been focused on China. On the EIA projections, adjusted to allow for a one percent annual appreciation of China's currency, China will account for nearly 24 percent of world output in 2035, up from nearly ten percent in 2010 (see Table 2). Chinese will be much richer than they are now – over five times richer. China will have economic capacity to do many things in the world, for good or ill. But the American economy will not stand still, and will still account for 20 percent of world output in 2035, down from 25 percent in 2010. It will remain much richer than China, with only one quarter of China's population.

China's leaders will be different in 2035 than they are now – a generalization that applies to almost all countries (although recall that Fidel Castro came to power in Cuba in 1959, and Qaddafy in Libya in 1969; Castro has relinquished the presidency but still influences policy; Qaddafy was only removed after over half a century of rule). They will have been born after 1965 and spent their entire adult lives in a period of growing prosperity, so their expectations and aspirations will differ from China's leaders of the present and recent past, who have focused their prime efforts on assuring economic growth.

One sometimes sees much larger figures for China, even the claim that China overtook the USA in economic size in 2014, as announced at the World

Bank/International Monetary Fund meetings in late 2014.[4] These claims are based on using so-called purchasing power parity exchange rates to convert the GDP of China, the USA, and other countries into common units. This is not the place for a technical discussion of the merits of purchasing power parity calculations and their appropriate uses. But there are both conceptual and measurement objections to using purchasing power parity conversion rates for a discussion of the economic and political interactions of countries in the world economy based on GDP. Re-calculations of China's purchasing power parity rates a decade ago reduced them by more than 40 percent, for instance (and India's by 50 percent), and while both the methodology and the collection of cross-country price and expenditure data have improved, there is reason to suspect even the new calculations. Suffice it to say that for comparison of market economies, which China largely is, it is more appropriate to use conversion rates related to market exchange rates for most purposes. However, it is well established that as poor countries develop their currencies appreciate in real terms relative to richer countries – the so-called Balassa-Samuelson effect – which can be achieved either through nominal appreciation, as in the case of China since 2005, or through higher relative inflation. To allow for this, I have somewhat arbitrarily assumed an annual real appreciation of one percent a year for both China and India from 2010 to 2035, along with the actual 30 percent appreciation of the yuan from 2005 to 2010, both incorporated into Table 2.

India's share of world output also grows, from 2.3 to six percent, exceeding Japan, but India remains much smaller than China even though it will have surpassed China in population. The shares of Europe and Japan each decline significantly, by ten percentage points for Europe, four percentage points for Japan– largely as a result of demographic

developments. Russia remains roughly the same, at 1.6 percent, despite a significant decline in population.

These changes in relative economic importance are significant, but not earth-shaking. China will have replaced the USA and the European Union to become the world's largest economy; but the European Union, presumably more politically coherent then than now, will still be significant. And US economic developments will still be a dominant determinant of world economic developments.

In recent decades international trade has grown more rapidly than output, as have international financial transactions, resulting in greater economic interdependence among countries. Those phenomena are likely to continue, assuming they are not thwarted by a major reversion to protectionism. The Chinese market will be the major one for many more countries, even more important than it is today, and much critical attention will therefore be paid to China's trade policies, just as was the case with Japan in the 1980s.

This projection is a benign one. It assumes that there are neither major wars nor a major economic depression. I opened with the observation that past long-term forecasts have not been distinguished by their prescience. This one will certainly be wrong in many details, but its broad outlines are highly plausible. It is nonetheless worthwhile to ask what could go so seriously wrong as to alter greatly this trajectory. Many serious disturbances are certainly possible, some even plausible, that will be very troublesome to contemporaries. But in the end the recuperative capacities of economies and of the international economic system may re-establish the trajectory after a period of turbulence. Arguably the world economy is in such a period in mid-decade, with full recovery from

the US financial crisis and subsequent deep recession still incomplete, and with oil prices at near $100 a barrel, up from under $20 early in the last decade.

Other major disturbances could be a global disease epidemic, another serious terrorist attack, or conventional wars among neighboring countries. In each case there would be worldwide repercussions; the period of turbulence would depend on the magnitude of the disturbance, but even more on the public and political reaction to it. Over-reaction is entirely possible in response to public anxiety, but could be far more damaging than the precipitating event(s). It is not inconceivable that migration and trade could be sharply curtailed following an epidemic or a terrorist attack, long enough to threaten the trajectory sketched above. Thus its realization depends among other things on political leaders maintaining cool heads during periods of stress.

Leisure will no doubt increase with rising incomes, and indeed some allowance has been made in the growth assumptions for growing leisure, particularly in developing countries. But it is unlikely that Keynes' 1930 forecast of a 15 hour week in Britain and other rich countries will have been achieved by then; enough new and better goods will become available to keep households around the world wanting to spend.

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[1] Originally published in 1930, reprised in Lorenzo Pecchi and Gustavo Piga (eds.), Revisiting Keynes, Cambridge, MA: MIT Press, 2008.
[2] W.S. Woytinsky and E.S. Woytinsky, World Population and Production, New York: Twentieth Century Fund, 1953.
[3] See the reviews by Vaclav Smil, Energy at a Crossroads, Cambridge, MA: MIT Press, 2003; and Clark Abt in R. Cooper and R. Layard (eds.), What the Future Holds, Cambridge, MA: MIT Press, 2002.
[4] See for example Robert Fogel, Foreign Affairs, July/August 2007.

Table 1: Demographic Trends

	Median Age (yrs)		Growth of young adults (%) 2010-2040
	2010	**2040**	
World	28.8	35.7	4
China	35.2	47.1	-32
India	25.9	34.7	3
Europe	40.4	47.5	-18
USA	36.8	38.9	22
Brazil	28.9	37.7	1
Russia	38.5	47	-28
Japan	44.6	54.1	-34
Germany	44.4	49.5	-15
Italy	43.2	49.7	-7
Korea,S.	37.8	51.2	-42

Source: US Census Bureau

Table 2

Projections of Real GDP (trillions of 2005 dollars)

	2010	2035	Growth Rate (%)
USA	13.06	24.09	2.5
Canada	1.2	2.06	2.2
Mexico/Chile	1.1	2.65	3.7
OECD Europe	15.68	23.99	1.7
Japan	4.65	5.58	0.6
South Korea	1.02	2.33	3.3
Australia/NZ	0.95	1.66	2.2
OECD Total	37.64	62.36	2
Russia	0.91	1.95	2.8
Other Eurasia	0.66	1.61	3.5
China	4.99	28.61	6.7
India	1.21	7.25	7.1
Other Asia	2.18	6.22	4.3
Middle East	1.24	3.27	3.8
Africa	1.73	5.15	4.5
Brazil	1.1	2.51	3.4
Other Cen & South America	1.23	2.62	3
Non-OECD Total	15.25	59.2	5.1
World	52.89	121.56	3

Source: International Energy Outlook 2014 by US Department of Energy, plus author's adjustments as i
text.