CLIMATE CHANGE AMIDST GLOBAL CHANGE: FIN-DE-SIECLE THEN AND NOW
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Let us close with a thought experiment about the climate question as it might have arisen in the 1890s. Toward the end of the last century the Swedish geochemist Svante Arrhenius (1896) published his classic article projecting a warming as high as 5oC for doubling of CO2. Suppose this came to the attention of the leading governments…

The Swedes contacted the British, French, and Germans, who were deeply concerned. An enormous, populous, coal-burning nation loomed on the far shore of the ocean. Called the United States, it was building railroads, steel mills, and power plants at a furious rate. Its population had soared from 5 to 80 million in the 19th century. Emissions would surely rise rapidly.

To prepare memoranda for governmental use, the European Panel on Climate Change (EPCC) was created. The rest of the world did not count scientifically. The British assumed the chairmanship. They selected for the role the world's foremost expert on economic growth, Alfred Marshall, author of Principles of Economics (1890). Marshall had excelled in his advisory capacity with the Royal Commission on the Depression of Trade and Industry in 1886.

Marshall assembled leading experts from diverse fields. From France came Henri Poincare, to assess the mathematics; Antoine Becquerel, to consider energy; and Gabriel Tarde, specialist on the diffusion of innovations. From Norway came oceanographer Fridtjof Nansen, from Russia fluid dynamicist Alexander Lyapunov, from Austria-Hungary the geologist Eduard Suess, and from Italy sociologist Vilfredo Pareto. Marshall added fellow Englishmen in physics, William Thompson (Lord Kelvin) and John Strutt (Lord Rayleigh), and statistics (Francis Galton). Germany contributed engineer Karl Benz, climatologist Vladimir Koeppen, and zoologist Ernst Haeckel, inventor of "ecology."

The EPCC considered energy and emissions. About 65 percent of world energy came from coal and about 30 percent from wood and hay. The geological community asserted energy was not a question: coal was king. Oil was a novelty that would soon be depleted. Coal consumption was 500 million tons in 1890 and emissions 340 million tons. The growth rate of emissions 1850-1890 had been 4.7 percent.

The "business-as-usual" forecast was troubling. If the rate of emission growth and airborne fraction were maintained, the atmospheric concentration of CO2 would rise from the 290 ppm recorded currently at the observatories to double that level by the year 2000.

Poincaré was alarmed about chaotic behavior of the climate system, Nansen worried that the ice caps would melt, and Suess pointed out that such changes had not occurred for millions of years. Koeppen and Haeckel feared that vegetation would be mismatched with the new atmosphere and the intricate web of life destroyed. Anxious letters kept arriving from water expert John Wesley Powell, head of the United States Geological Survey. In short, catastrophic and irreversible developments were underway.

Marshall himself was sensitive to the fact that England imported many of its food staples from poor, unstable regions such as Ireland and the Ukraine. "Corn laws" to protect domestic farmers

and prevent dependence on foreign food supplies had caused massive political crises earlier in the 19th century. Gross domestic product per capita in Western Europe in 1890 had reached $1,000 per capita and gross world product $1.4 trillion ($1985). Who would responsibly jeopardize this achievement?

But, Lord Rayleigh was unsatisfied with the energy balance in Arrhenius' model, and Lyapunov was concerned about the stability of the equations and missing feedbacks. Galton questioned the reliability of the data and insisted on the need to state the confidence with which conclusions were stated. Becquerel and Benz asserted that innovations in energy and transport were sure to come. Tarde and Pareto insisted societies would adapt; the social and economic transformation of European societies in the 19th century was surely more rapid than what added sunshine would bring. And, after all, Europeans were competing madly to colonize tropical territories.

Marshall set out to define a compromise. An eager consumer of statistics, Marshall noted that economic growth since the start of the industrial revolution had averaged about 3 percent. If emissions rose at this rate, which assumed advances in efficiency and fuels, then concentrations would reach about 355 ppm a hundred years later. The atmosphere would warm by at least 0.6oC, and possibly as much as 2oC, depending on the climate's sensitivity. Earth would still be the hottest it had been for 1000 years. This seemed a reasonable case to consider.

As an economist, Marshall sought to reckon how much income the world should forego to stay at 290 ppm. To answer, he wondered what would be the gross world product in 1990 if Earth warmed and if it retained the climate of 1890. Working with an actuary, Marshall laboriously calculated what the next 100 years might bring. Assuming the established rate of long-term growth continued, the result was that between 1890 and 1990 world product would grow from $1.4 trillion to $20 trillion, and income per capita from $1,000 to $10,000 dollars in Western Europe.

Marshall was astonished. Both adaptation and mitigation would be affordable. In fact, the 0.6oC warming would be lost in the noise of such massive change. Provided there was genuine development, neither would emissions rise at a reckless rate, nor would climate threaten human survival.

Marshall circulated a draft report with his prognosis for global change. Almost the entire panel was disbelieving. Lord Kelvin's copy came back with derisive marginal annotations about prospects for technical progress: "Heavier than air flying machines are impossible" and "Radio has no future." Marshall was suddenly called to work on urgent near-term issues of unemployment. Tensions between the European powers worsened. The report of the EPCC was forgotten.

Marshall, of course, was right.

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