Energy, Money and Industrial Civilisation

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Oil and coal have fuelled the development of civilised economies since time began. But fossil fuels are finite. What resources will drive future economic growth?

Think back to 1975: very little of the industrial capital stock existing then can be traced to any resource discoveries other than that of coal and petroleum. The technologies incubated by those discoveries constitute the basis of almost all of the global industrial economy.

The discoveries of most industrial metals, such as iron, copper, tin, lead as well as silver and gold, occurred thousands of years ago. Whatever technologies (and productivity gains) resulted from those discoveries – such as crude carbothermic metal smelting, alloying (brass and bronze) and casting – were already established by the 16th century. The discovery of opium centuries ago led to some by-products (morphine, heroin) but not much else. Much the same can be said of the discovery of tobacco. The discovery of sperm whales led to a short-lived boom in whale oil, and the

near-extinction of the whales, but no significant technologies. There are plenty of other examples of resource discoveries that did not lead anywhere. The two exceptions, perhaps, were the discovery of natural rubber, which led on to rubber tyres, tubes and waterproof clothing and the discovery of radio-activity at the end of the 19th century, which led on to the creation of radium, nuclear weapons and a nuclear power industry.

Fuelling Industry

It is also a demonstrable fact that ever-cheaper and more convenient energy itself has been a major factor driving economic growth since the Industrial Revolution.
Money since Roman times, before the Industrial Revolution, was either gold, silver or copper coins, plus gold-backed “bills of exchange” for larger transactions. For example, the Spanish Empire made coins from the gold and silver looted from the Aztec and Inca civilisations, and later from the silver mine at Potosí in Peru (now Bolivia). Coining required only the simple physical process of melting, rolling and stamping. Spain did not use the new money for productive investments. Instead the gold and silver financed conspicuous consumption by the Crown and the Church and (mostly) their wars. This lack of productive investment left Spain behind its rivals when the gold and silver supply began to run out in the 18th century.

So, if it was not a new source of gold and silver, what financed the Industrial Revolution? Why did it start in England? Some modern scholars from developing countries argue that the Industrial Revolution was financed by profits from the slave trade. There is some, but not much, truth in this claim. Looking backward, it is easy to see that the Industrial Revolution – starting in England around 1776 — was largely financed by profits derived directly or indirectly from coal mining. Coal, by contrast with gold and silver, was not regarded as an inherent “store of value”. It could not be converted directly into money. It was not a convenient medium of exchange.

Coal Comes of Age

Coal had value only when put to use as fuel. It had to be dug up and transported to a user. As the mines burrowed deeper, they had to be drained of water. That simple fact, by itself, inspired and started the Industrial Revolution. The coal mining industry became a technology incubator. The

first steam engines, were specifically designed to pump water out of flooded mineshafts. Coal from the mine was the fuel required to make the steam. James Watt made the engine far more efficient, more compact, suitable for rotary motion and applicable to other uses. Those new uses included blowing air through a blast furnace, powering a boring machine to make cannon barrels (and the cylinders of steam engines), driving spinning machines and power looms, paper machines, printing presses and machine tools.

The market for coal and the availability of steam engines motivated the construction of canals and rails and locomotives on the rails to carry the coal. In 1803 the first self-propelled steam-powered traction vehicles – called locomotives − were built for coal mines, using new “high pressure” steam engines and wrought-iron rails. They were the basis of the first railways (1825). The growing railway system enabled the development of telegraphy. Telegraphy, in turn, later led to the telephone.

The use of coal (as coke) for iron production changed that industry and eventually (during the next century) led to the mass production of steel (Bessemer, 1860) and steel rails, steel ships, steel bridges and building steel pipes, steel wire and cables, and other things. Coal provided high temperature heat for making Portland cement, the basis of the construction industry. Coal was burned in large steam engines to make electric power (in places where there was no water power) and enable Edison’s invention of the first efficient dynamo which led to the first electric power system. The availability of electric power in large quantities enabled electric furnaces, to make steel alloys and other materials requiring very high temperatures; electrolysis opened the way to economic production of aluminum, chlorine and other chemicals. Aluminum, in turn, enabled the development of aircraft and today’s airline industry. The global cement industry, steel industry and the electric power industry still depend largely on coal or natural gas.

Coal as “town gas” was used for street-lighting and household lighting in the 19th century. It was replaced by natural gas in the mid-20th century. Coal tar from the coke ovens became a source of chemicals for the burgeoning aniline dye industry. Finally, gas from the coke-ovens of the Ruhr valley provided ammonia for nitrate fertilisers (and explosives) and gas to drive Otto’s first commercial internal combustion engines. All of this technology was “incubated” by the discovery of a natural resource that could not be converted directly into money: coal.

Black Gold

Similarly, the discovery of large reserves of petroleum (“black gold”) in the 19th century (initially because of a search for an alternative to whale oil for lamps) incubated a host of other new technologies. They started with improved drilling technology, fractional distillation and petroleum-based petrochemicals. Petro-chemicals like ethylene and propylene are the basis for all plastics and synthetic fibres. Petroleum also provides the liquid fuels that are needed today for the internal combustion engines that power all ground and air transport (except electrified railways), as well as off-road construction and agricultural machines.

Today it is quite evident to most governments and business leaders that sustainable economic growth in the future depends on the future availability of high quality energy at low cost. Most industrial countries now have cabinet-level departments responsible for assuring reliable energy supplies, with special emphasis on petroleum. Unfortunately, in my opinion, the economists who advise politicians under-estimate the importance of cheaper energy as a driver of growth.

It is generally assumed that the future energy supply will take care of itself, thanks to the magic of markets. The standard theory of economic growth, as taught in every major university since the 1960s, assumes that economic growth is essentially automatic, that “the economy wants to grow” (although it did not grow for thousands of years before the Industrial Revolution) and that economic growth does not really require cheaper energy or, indeed, very much energy. This last belief claims that the importance (technically, the output elasticity) of each factor of production must be exactly equal to its cost share in the economy. Since fossil fuels and sunlight are gifts of nature, there are no payments to “energy”, as such. There are only payments to coal companies and oil companies – that is, to “refiners”. But economic theory attributes those products to the capital and labour they employ. In fact, the “cost share” of energy is zero.

Although recessions have followed every oil price “spike” since 1973, standard economic theory still says that those recessions cannot be related to energy costs, because the cost share of energy is so small. It is still standard doctrine that economic growth can, and will, continue along an

historical trajectory (about 3.5 percent per annum for the U.S.), known as “the trend” even if energy prices continue to rise, or simply stop falling, reversing the two-hundred-year history of economic growth driven by declining costs and prices. I believe the “economics establishment” is dangerously naive about this.

Not only are fossil fuels essential to the functioning of most of today’s industry, they have incubated most of the technological building blocks of that industry, including electric power. True, the electronics industry and its step-child, the information technology industry, was not a direct consequence of large-scale electrification, or of telegraphy, telephones or radio. It began with the transistor (1946), based on a newly discovered physical phenomenon: semi-conductivity. Since that time science has become the “new” resource, and scientific laboratories financed by government, and industry, are the new incubators. Most of the new industries of the future, from nano-technology to genetic engineering, will come out of the proverbial test tube. But perhaps the single most important scientific challenge of the coming decades is to create renewable energy substitutes for the fossil fuels that have – in a very real sense – created the current industrial system, and its unwanted by-products.

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