

## APPLYING NATURAL SCIENCES TO STUDYING HISTORY: Regarding the Example of England and the Industrial Revolution. Part I

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*In this work we outline a bio-ecological approach to studying history. We show that human societies from the first civilizations to our days are techno-ecosystems and do not differ much from the natural ecosystems of a lake or a forest that are also restricted by their supplies of food. Below we call them coenoses (sing. coenosis) – this word from Greek is used in biology to denote a mutually dependent community of life-forms. Historically, a succession of distinctive nestled geo-climatic zones was domesticated as the older ones became exhausted due to growing demographic pressures. In this context, evolution is not synonymous with competition. Cooperation of mutually dependent species is crucial for domesticating a new ecosystem. At specific moments in its lifecycle, competition intensifies, leading to speciation. The dominant technology of each growing society serves as its unique adaptation to its geo-climatic zone. Using it, a particular society, just like a biological species, gains an evolutionary advantage over its neighbors by opening access to a new, previously inaccessible resource or, in plain English, a new source of food. For example, thermoregulation of warm blooded animals opened up colder habitats. Or, the use of canals in the uninhabited swamps of Mesopotamia paved the way to the irrigation agriculture of the great rivers' deltas circa the V Millennium BC. It enormously increased both the grain yields and the population densities. The feeding chains that grew around the abundant grain evolved into the ancient egalitarian society, perfectly attuned to using mass labor. The 20th century, quite dissimilar in its technologies, customs, etc, unfolded according to the same master design. Oil deposits that, for millennia, sat around the world idly, turned into the foundation of the affluent consumer society, based on democracy. The car, along with the highways, suburbia and supermarkets became the symbol of modernity. Today, the amount of available food supplies is restricted by a single factor only, namely, the price of oil. Below, using an example from the Industrial Revolution, we will show that the process of utilizing a newfound resource by building a society around it is essentially cyclical. Social organisms evolve in regular and recurring patterns, not unlike birth, youth, maturity and death of biological beings. Each of these steps has its own functionality and must be lived through, much like the fact that one can't mother children until she reaches puberty. That is why this approach possesses significant predictive capabilities.*

**Keywords:** evolution, ecosystem, coenosis, technology, history.

*Iteikta 2006-01-16 ; priimta 2006-02-22*

## Biological Versus Social. The Bio-Ecological Concept

### Introduction

The popular belief in man's elevated stature stays contrary to the basic principles of humility preached by major religions. No wonder that it has been under attack for centuries. First to go was the man-centered universe, with the sun and the stars somehow positioning their tiny selves around the all-important Earth. In his 1530 work *De Revolutionibus* Copernicus proved that the earth rotated on its axis once daily and traveled around the sun once yearly: an implausible concept for the times. Then, there came the evidence of our ascendancy from the monkeys. According to Gallup polls, Darwin's 1859 work remains unaccepted by about half of Americans as yet another "theory", with creationism more up to their taste.

This work attempts to further lower the bar of our presumed uniqueness. Leaning on a rich array of related research, we show that historic human societies are but techno-ecosystems. The only difference that these particular *coenoses* have from those of lakes or forests is that animal ecosystems change internally, through genetics, while, for adapting to a new environment, human societies use external adaptations, namely, technologies. This speeds up the pace of changes, affecting neither their inner logic nor the related suffering.

The 6 *coenoses* under our consideration coincide with the 6 well-known periods of western history, from ancient *Mesopotamia to our days*<sup>1</sup>. We will show that these historic *coenoses* are represented by a series of long K-waves (Kondratieff, 1984)<sup>2</sup> rolling through history. People gradually domesticated a sequence of

nestled geo-climatic zones, whose resources became available as technologies matured. These historic human societies with their technologies and social structures presented specific adaptations to their unique natural habitats.

Just as deer need grass in order to survive and wolves control the deer populace, laborers depend on salary exchanged for food and other necessities, while entrepreneurs regulate the levels of production. Each of the many tiers of a successful *coenosis* has its unique functionality. Production takes place on the lower tiers. Control is performed by the higher tiers. A proper balance of the co-dependent strata on different hierarchical levels is essential for a *coenosis*' survival regardless of its being natural or *human*<sup>3</sup>. Along with the availability of adequate food resources within a niche this balance or the lack thereof delineates the fine line between complete disappearance, marginal existence or roaring reproductive success. Historically, civilization advanced by domesticating new, previously underutilized habitats. The **dominant technology or the fundamental invention** of any growing society is crucial, allowing it to survive by finding food where before there was found none. The social and power groups of a society rise as **hierarchical food chains around the novel food**.

We restrict this work to studying a single bio-sociological *clade* (Cowen, 1990), or, in plain English, western lineage, from the first civilizations to the mass society of our day. Other civilizations, such as the Chinese, Indian,

<sup>2</sup> In honor of the renowned Russian economist N. Kondratieff, who noticed the long-term regularities in price movements of the 19-20th Centuries.

<sup>3</sup> The necessity of multi-tier balanced ecosystems has been proven by many intended and unintended experiments. They range from the failure of the communist system that strived to exterminate the top tier of its entrepreneurs to the successful wolf-reintroduction to the Yellowstone National Park, where it improved both the diversity of species and their overall health.

<sup>1</sup> 1. The first civilizations, 2. The classic era of the ancient Greece-Rome, 3. The European feudalism, 4. The Age of Exploration, 5. The Industrial Revolution and 6. The modern mass societies.

Muslim and Meso-American, are currently out of scope. In the West there were 6 major eras.

1. The first civilizations grew on the resource of **mass grain** and the technology of **canals** in the tiny areas of great rivers' deltas suitable to intensive irrigation agriculture (the Tigris and the Euphrates in Mesopotamia, the Nile in Egypt, the Yellow River in China and the Ganges and the Indus in India).
2. Then, the classic world of Greece and Rome blossomed on the larger and much drier area around the Mediterranean. While these newer territories couldn't support the earlier technology of irrigation, their inhabitants relied on their own unique advantage – their excellence in **mechanics** and engineering. Such simple machines as the olive and wine presses, the oar of the trireme and the human “wedge” of the pike-armed phalanx helped to mass produce, deliver, defend and market the nutritionally valuable supplements of **olive oil and wine**. This newly available food greatly enhanced the resource of grain supplied by the earlier habitats (Egypt and its likes + some ploughing in rain-fed areas). Thus, the much larger populaces of the classic world could be supported.
3. When the Roman Empire collapsed under the pressure of barbarians who also wanted their part while there was little to spare, civilization gradually “advanced” to the swampy forests of Europe. These generally fertile lands were of heavy clay and couldn't be mass cleared and tilled using Roman teams of oxen. Starting from the 4th century AD Germanic tribes brought **the horse** and the related 2-field rotation system, one field to feed the horse and another to feed the owner. Later on, bits, stirrups, heavy wheeled plough and other elements of the horse harness allowed mass clearances of forest lands opening access to a new resource – **a mix of grains (malin) and beans**. At the end of the feudal age the ecological catastrophe of over-populated and over-tilled deforested Europe manifested itself through the 1348 Black Death.
4. People were pushed to the inhospitable northern seas pursuing new sources of nutrition: **butter, whale-meat, cod and herring**. New means of soil drainage and reclamation greatly increased the overall amount of available food and jump started population growth. Along with the invention of frame-built **seagoing vessels** for sailing in inclement winter weather, this started the Age of Exploration, opening up the resources of the Americas.
5. The Industrial Revolution followed the English Agrarian Revolution of the 17th century. A medium-sized country strapped for food adopted the 4-field rotation of the Norfolk system. Nearly devoid of timber, then essential for iron smelting and ship building, England sorely depended on imports from the Northern Europe and, to a lesser degree, from Russia, and the American colonies. After the loss of the latter, in a desperate and wildly successful attempt to substitute timber, it learned how to utilize the next resource, coal. The lack of appropriate rivers was similarly alleviated by **industrial means**: first, by a system of canals, then, railroads. Using its railroads and the iron steamship, England grew into the dominant colonial nation. The system of land management and improvement well tested at home became the foundation of its global power. The temperate zone was settled by white colonists; while the tropical regions were drained of their resources by river-like tentacles of railroads, most of them English-built.
6. Similarly, the postwar blossoming of the only current superpower followed an entry into a new geo-climatic habitat. For the first time in history, its mighty machines broke through the previously impregnable barriers that for millennia restricted farming to the temperate zone. **The post World War II techno-geo-climatic zone encompassed**

**mass societies on both sides of the ocean – both the US and the USSR.** Its model of domesticating areas **beyond the temperate zone** depended on massive land use projects. The latter started in earnest in the midst of the 1930s Great Depression: the Hoover-dam, the TVA, the reclamation of the-Great-Plains-Turned-Dust-Bowl along with the desert-like environs of California and swampy areas of Florida. Construction and round the clock maintenance of such huge manmade environments didn't come cheap. In the 1990s the USSR folded under the weight of its grand undertakings completely paid for from the government's coffers. The US escaped this fate, despite its excesses of golf courts in deserts and condos in swamps. Thanks to its democratic institutes it remained solvent. The immense economic burden was redistributed among the members of its prosperous postwar consumer society. Currently, this model is being copied all over the world, stressing the importance of the dominant resource of **oil**.

Oil's growing scarcity as the rapidly industrializing countries, such as China, India and the Muslim world join in the consumption, signals the coming of a distinctly new era. If history is any guide, the world would rely on something completely new in order to alleviate the current energy demands, while dramatically increasing the available food supplies. The food chains that would form around this new resource would be as radically different from anything known, as our time of cars and democracy differs from the 19<sup>th</sup> century's time of railroads and fervent dreams of suffrage.

Within this approach history breaks into a series of distinct civilizations, each in its own geo-climatic and chronological niche, with unique social institutes and hierarchies molded to better use the niche-specific resource. For example, Britain formed its entire culture around coal and the machines powered by it, such as steam looms, locomotives and steamships.

The 6 cited historic *coenoses* show that each and every time, technological progress led to domesticating a new, previously underutilized zone, rich with its unique resource that might have been sitting around, without anyone noticing it, all along. These resources varied widely. 1. Mass grown grain in the case of the first civilizations (made available thanks to technology of canals that started as little more than extensions of existing natural waterways) (Nissen, 1988); 2. Olive oil and wine in the case of the classical civilization of the Mediterranean (the olive press); 3. A mix of grains (*malin*) and beans grown in the heavy clay of the feudal Europe (*harnessing the horse*); 4. Butter, herring and other nutritional add-ons in the Age of Exploration, products of the specialized economies of the North Atlantic (harnessing wind power: the sail ship and the mill); 5. Mineral coal for the industrial age (the steam engine); 6. Fossil oil for the modern mass society (the internal combustion engine).

This progression of dominant societies, each of them an extension and an heir of the previous leaders, even while relying on its own resource and its unique technology for colonizing a previously inhospitable niche, provides the reason for the obvious but never explained **teleology** of the human history. It also takes away the Malthusian curse of the inelasticity of each and every known resource. Inasmuch rich, no supply of any resource can keep growing forever. Some day it too will get exhausted. But all is not lost – historically, while the society with an overstretched resource descended into the turmoil of misery and wars, a new *coenosis* was growing on the outskirts, waiting its turn as the next dominant force.

This understanding puts a new emphasis on the specific technology that opens up the next habitat. We define a **fundamental invention as a technology of such a great magnitude that it is discovered only once in a distinctive historic period, opening up a new resource that previously was of little or no use**. Thus, the ancient Mesopotamian canals would qualify – as

helping to produce a brand new source of food (grain) – but chariots, contrary to Graebner, the first to use this term, wouldn't (Graebner, 1911). The event of fundamental invention marks the starting point of every dominant civilization.

Rich with a newly available resource, an up and coming society experiences rampant growth of its population, organized within evolving hierarchical “food” chains. The latter consist of its distinct social institutes, including economy and prevailing norms and morals, all shaped up in order to optimize its main resource's usage. Each and every society thus evolves through a series of similar and quite necessary steps resembling birth, puberty and advancing stages of maturity. Inevitably, as soon as its main resource stops growing and thus loses the ability to accommodate and support the ongoing populace's growth, the related and still growing *coenosis* is hit by a series of severe crises.

So, while the discovery of a new resource gives a civilization its evolutionary advantage, it also starts a time bomb portending its future waning.

This society is not doomed and will not necessarily disappear physically, such as, for example, the Mayans. Things are rarely that dire – most cultures just stabilize, shrink to their initial zone, and stop growing, staying there as a foundation and gene pool for the future. The new dominants pile up on the top of their predecessors, forming with them an intertwined structure resembling an archaeological “tell”, – where the living city grows on top of layers of older civilizations. Thus the primordial clans survive in the guise of nuclear families. Nations shrink forming separate ethnic enclaves within a foreign city. The relics of the first civilizations can be still seen around the Euphrates – peasants water their plots with ancient-looking levers – now oftentimes motor powered.

Alas, this passage from zone to zone is far from being peaceful. Historically, the end of an era has been marked by wars and famines: from the 12<sup>th</sup> century BC Catastrophe of the Bronze Ages to the 1348 Black Death. This process is

essentially cyclical with its inner logic, where times of turbulence are followed by short periods of tranquility. Decoding it may allow us to explain the past and predict the future. We will demonstrate its logic below using the example of England and the Industrial Revolution.

## Review of Bibliography – the Main Milestones

The application of biological concepts to history has a lengthy and mixed record.

Malthus (Malthus, 1798), one of the most notorious proponents of using a resource-based approach to studying history, nearly discredited the very idea. In 1798, in the depth of recession, it was hard to share the earlier beliefs of Rousseau and Diderot in the limitless improvement of human conditions. Instead, Malthus believed in inherent human suffering. He argued that, since resources increase only in arithmetic progression and human population in geometric, then, sooner or later, there should be a correction. Population must fall, either voluntarily, due to the “positive” stimuli, when people stop procreating, trying to preserve their falling living standards. The “negative” means of control, vices and misery, include wars and diseases and reduce population directly.

Thankfully for us, our very survival until today proves that he was generally wrong. Since his times, we entered the era of the so-called sustained growth, with huge population increase with no major famines or cataclysms.

Malthus was also mean. Since, according to him, any rise in workingmen's salaries would only contribute to inflation, he was adamantly against it. (Charles Dickens portrayed him as Ebenezer Scrooge.) This belief too has been proven wrong – as we know, the rising standards of life became the very foundation of the thriving American consumer society. So, it would seem that Malthus has duly earned a place in the proverbial dustbin of history and his very name may be forgotten.

Don't we wish things were that simple? It is true that he made many conceptual, factual and even mathematical errors, but no one has yet disproved his main tenet – the intrinsic inelasticity of resources. Thanks to it Malthus' work became the very foundation of the evolutionary theory of both Darwin and Wallace, its independent creators.

That is why, despite occasional setbacks and an overall poor reputation, tainted by its unscientific use by the Nazis, the biological approach to history has never lost its appeal. Slowly but surely, it evolved, producing a considerable body of works. R. Pearl (Pearl, 1925), among the early trailblazers, asserted that population in animal (and, presumably, human) ecosystems grows according to a logistic curve, where the amount of available resources serves as the main variable. Graebner (Graebner, 1911) introduced the concept of **the fundamental invention** within his theory of concentric circles. According to him, inventions of such a tremendous importance as, for example, agriculture or chariot, appear only once, in a single geographic spot. Since they bestow a significant evolutionary advantage they spread rapidly, in concentric circles, to cover the *Oikumene*<sup>4</sup>. Following the same line of thought, W. Abel (Abel, 1934) and m. Postan (Postan, 1939) noticed the existence of demographic cycles in history, with population as a function of the available resources. In the early 1920s, a noted Russian economist, Nikolai Kondratieff (Kondratieff, 1987) discovered 3 cyclic waves of prices, each about 50+ years long, the so-called long or K-waves. Inflationary spikes followed deflationary troughs with amazing regularity. In their wake, they caused devastating recessions and wars on the background of rapid technological changes. For this finding (explained by him as self-corrections of the capitalist system through the evolution of technologies), he

<sup>4</sup> *The known world, in Greek.*

<sup>5</sup> p. 99. "Long waves and growth cycles are synchronized in a combined Kondratieff-Kuznets chronology."

earned a not-so comfortable place in the Gulags. There he perished, well before his prediction of the Great Depression and World War II proved to be so deathly accurate. His tragic death did not stop Western economists from being intrigued by the mysterious regularity of the *K-waves* (Schumpeter, 1939; 99)<sup>5</sup>. Independently, his findings were reaffirmed by a number of prominent historians, starting with Brodel (Brodel, 1984), Cameron (Cameron, 1989) and Ladurie (Ladurie, 1966), who also discovered cyclic regularities within other periods of history. Fischer (Fischer, 1999) tracked the so-called Great Waves as far back into the past as the 12<sup>th</sup> century and as close to our times as the 1980s. He attributed their rhythmic rises and falls to over-optimistic spurts of unsustainable demographic growth followed by merciless corrections.

Most recently, the bio-ecological, resource-based approach was used in geography and geology. Jared Diamond (Diamond, 2005), a noted professor of geography at UCLA and a bestselling author, researched historic case-studies, from Rwanda to the Dominican Republic and Haiti, in order to show that human societies either use their environments to their advantage or become their victims. Meanwhile, the fundamental nature of inelasticity of available resources was shown by Kenneth Deffayes, the disciple of a well-known geologist, King Hubbert. In his book, *Hubbert's Curve* (Deffayes, 2003), he argues that the availability of the world's oil resources essentially obeys a bell curve pattern. For example, from the 1850s to the oil shock of 1973–81, the USA was a leading oil producer. Meanwhile, as early as in the 1950s, Hubbert predicted that the production will peak out in the 1970s, which, as we know all too well, is exactly what happened. Of course, the following oil shock didn't portend our doom. US oil needs continue to be satisfied through global production. But, according to Hubbert's curve, global oil reserves aren't immune either. They will hit their peak, and, as Deffayes implies, indeed they already did, somewhere around 2004.

Shocks caused by the recent gas price hike, may be painful, but by no means are they lethal. They signal that the stage of resource retrieval is well past the bell curve's peak and its supplies can no longer be substantially increased at the old price level. What usually follows is a switch to another bell curve with a drastic increase in the price of the main resource. People must enter ever more dangerous areas, which previously could be ignored (oil resources in Africa and Alaska). The methods of production and distribution become more expensive. This creates a demand for new technologies able to stretch and substitute the dwindling supplies of the dominant resource. One of those will beget the next fundamental invention, creating, along with it, its own coenosis, which would not be fully dependent on the previous resource.

### The Inner Structure of the K-Waves

It should be noted that difficulties of the resource-based approach to history don't end on the conceptual level. The rather ambivalent nature of historic data presents an even trickier obstacle. As we move further into the past, information becomes scarce and is of an increasingly murky nature. In contrast, modern statistics regarding price movements and resource availability may be abundant, but they rarely present a clear-cut picture. Thus, no well-defined long waves were detected in the modern price series. Their dissolution can be attributed to the dollar's rapid inflation following the first oil shock of 1973 and the 1971 abandonment (caused by inflationary pressure) of the 1944 Bretton-Woods monetary *agreements*<sup>6</sup>. Fortunately, the data-related difficulties aren't insurmountable and may be mitigated by using other, less traditional, methods.

<sup>6</sup> The latter became the foundation of the postwar US dominance, creating a dollar denominated global currency system. For a time, the dollar was supported by its purported gold value, abandoned during the inflation of the 1970s.

Below, we will show that bell-curves represent the universal pattern of resource distribution, including, but not limited to oil. Indeed, this bell-curve shape lies at the root of the amazing regularity of K-waves. In fact, our concept is complimentary to several approaches to cyclic patterns in economics. Among them are: price-based Kondratieff waves (Kondratieff, 1984), investment related Kuznets-cycles (Kuznets, 1930) and inventory Kitchin-cycles (Kitchin, 1923), Schumpeter's interpretation of cycles in economics (Schumpeter, 1949), "long waves" in history (Fischer, 1996), "bubbles and Golden Ages" (Perez, 2002), "leading" countries and "leading" sectors, etc (Modelski, 1996).

The wavelike patterns are produced by a series of intense pulses as the food base rapidly expands or declines with an entry into a new niche or an exhaustion of the older one. Man's advance through sequential civilizations is an intricate process, which cannot be explained by mere technological progress, inasmuch important the latter. Thanks to this painstaking and often painful movement through eras and habitats there is no inevitability in the Malthusian inelasticity of resources. We will demonstrate this by analyzing the industrial era (the 2 long Kondratieff-waves of the 19<sup>th</sup> century)<sup>7</sup>. The Fig below shows the timeline.

Price shocks result in shrinking demand – deflations noticed by Kondratieff. Gradually, the current leader finds ways to adapt to its main resource's dearth by fostering a spurt of technological advance and gathering its resource from all over its Oikumene. After deflation, this starts yet another wave of inflation. Consumption goes up as more societies get involved due to the globalization of the resource procurement process. That is why K-waves always go in pairs.

The period between peaks on odds and even waves unfolds within the natural habitat of the future dominant. It starts its life during the deflationary trough preceding the odd wave as one of several marginal countries serving the mature dominant. Each of them pursues its own version of development, mostly based on the end-stage

technology of the leader (so called technology-enabler, crucial for the next era). As the competition for the old resource intensifies, causing a price spike, they clash in a WWI-like event, rarely with a definite victory. Meanwhile, following it, one of the contenders acquires an evolutionary edge through its fundamental invention. Its cutting edge technological style is based on a new resource. Examples – assembly line for cars in the 1920s in the US (oil) or factories in 1820s England (coal).

At the start, reliance on this “leading industry” (Modelski, 1996) is narrow-based and may plunge the future leader into a deep depression, demanding a complete remake of its feeding

<sup>7</sup> *For the steam age its fully grown ecosystem existed between 2 inflationary peaks: from the end of the Napoleonic wars and the formation of the post-Napoleonic social institutes at the 1814 Viennese Congress and until their decline in 1860s, during the Franco-Prussian wars and Germany's unification. The consensus of stable Europe of “royals” was thus formed. This stabilized the status quo of the existing dynasties. Meanwhile, within this shell, we see the simultaneous stabilization of the social institutes related to the Industrial Age, completion of the Industrial Revolution in Britain (with the technological style of railroads and, later, steamships) and its expansion past “the channel” to Belgium and, most importantly, to Germany. For our age of oil this period lasted from the defeat of Germany in World War I (the Versailles Treaty of 1919) until the inflationary peak of two oil shocks (1973-81) and the end of the era of cheap oil in 1981. During that time, on the backgrounds of Ford's assembly lines, the consumer society in the US based on the car took its recognizable shape. The world was stabilized by the nuclear parity between the US and the Soviet Union. The Golden Age of this ecosystem coincides with the standardization of the technological style in the 50s-70s (highways and skyscrapers in the US). It stopped with the end of cheap oil – the Vietnam and Afghan wars and the demise of the Soviet Union (that resulted in a temporary huge influx of cheap oil). Following the dotcom boom of the 90s started the massive deindustrialization of the US through outsourcing of most of its industrial production abroad. In the 2000s, this caused an exponential growth of deficits, both of trade and budget, along with the renaissance of the single superpower, ruled according to the “preemptive strike” doctrine.*

chains and creation of a broad-based infrastructure for its nascent industry. Example – the Great Depression in the US and the New Deal of the 1930s or a similar event in the 1840s Britain.

In the trough of deflation between two K-waves, this causes intense global competition between the contenders, each pursuing a different economic and social model, based on their unique adaptations and the resources of their relative niches. A massive clash, homologous with World War II, ends with a definite victory and marks the “second coming” of the winning technology (Perez, 2002), a generally prosperous era of standardizing the winning lifestyle and radiating it to the close periphery. Example – mass society became the standard not only in the US and the so-called developed countries, but also in the USSR and its satellites. This victory marks the start of a massive technology transfer (the Marshall Plan, etc).

After the inflationary peak of the next even wave, the innate growth potential is exhausted. The dominant society has to reach beyond its native zone and collect its main resource from far and wide while radiating its technologies in exchange. Far from being unique for our times, globalization manifested itself at the end of each known historic civilization. Thus, the Romans lost their competitive edge after outsourcing most of their production to the outskirts of the empire, from Cologne to Damascus. After the 1860s, the English outsourced their industries overseas. Now, this is happening to the US.

Within any given civilization, periods of prosperity and equilibrium are short and transient. Since all successful *coenoses* reproduce and grow, sooner or later they are damned to reach the limits of their food base. In nature, then they face one of the three possible scenarios: 1. catastrophic extinction; 2. exit into another zone, with another resource or food base; 3. stabilization, by definition, in a precarious state of homeostasis. We will show that this applies to history as well.

Historically, different scenarios of survival were enacted on the backgrounds of the com-

plex interplay between future and current world leaders and their neighbors. Thus humanity, as a whole, always managed to find its way into a new *coenosis*. The new leader translated its unique ecological adaptation into access to a brand-new, untapped resource in order to create its unique food base. All social institutes – starting from the accepted forms of ownership to the prevalent ratios of cooperation/competition to the structure and composition of power groups and popular values – have risen as a means to optimize the food chains growing around its dominant resource.

## The Innate Logic of a Fundamental Invention

### The Lobe-Finned Fish Colonizes the Land

We start with an example from natural evolution. Awkward lobe-finned fishes *Latimeria Chalumnae* are still caught nowadays. While deep waters were swarming with the more traditional ray-finned fishes, their ancestors survived by colonizing shallow outskirts of seas. These swampy areas became attractive relatively recently to that time (the Devonian era), in the aftermath of land colonization by a growing ecosystem of plants and insects. This “led to a large increase of organic nutrients in and around shorelines” (Cowen, 2000; 134) creating a rich, formerly **non-existent** food source. The lobe-finned *Rhipidistia* multiplied as a local adaptation to exploiting the novel resources of the rising land ecosystem. Instead of thin rays they were armed with strongly muscled jointed lobes. But, just as bird feathers initially didn’t evolve for the purpose of flight, these precursors of limbs weren’t intended for locomotion either. At the start, lobe fins were used for propelling the fish in their shallow, obstacle filled habitats. By chance, and not by design, they could be used for driving after their prey through mud to the shore and occasionally even beyond. The cold-blooded *Rhipidistia* learned to use their

appendages for getting to the shore for basking. They greatly increased the rate of young fish survival by crawling out and laying eggs in shallow lagoons with few predators and plentiful insects. The fish learned to gulp surface air to maintain buoyancy in the oxygen poor swamp water. Mouth breathing led to the development of primitive lungs into true lungs.

This persistent pattern repeats again and again throughout history– **the fundamental invention causes a cascade of related adaptations. Coagulating together, they form a unique technological style causing speciation.** Note, that those very lungs morphed into swimming bladders for all “true” fishes. Our heroes, the lobe-finned fishes, lived on, strange creatures at the margins of the dominant ecosystem of their times, the seas.

Much later, they were pushed out of their swamps by a dramatic event, possibly, a prolonged draught. A cataclysm that killed many other life-forms created an opportunity for this one. In the event of **exaptation** (*Gould & Vrba, 1982*)<sup>8</sup>, an already existing **adaptation**, the lobe fin, was used within a novel functionality – land locomotion. The fish gradually morphed into amphibians, out to populate a brand new ecosystem of terra firma, rich with food resources. After some time, they evolved true feet, thus entering the stage of **implementation**. **The new technological style of air breathing and land locomotion provided a crucial edge, opening up a new ecosystem with its virginal resources. The four-legged creatures colonized the land, creating their own full-fledged ecosystem on the go.** Plants and arthropods, the lower tiers coming from an earlier ecosystem, now supported new food chains of animals, both prey and predators. In a similar scenario, feathers have risen as a local adaptation, presumably for mating displays or body temperature control.

<sup>8</sup> *Gould & Vrba, who introduced this concept of changes in functionality as the reason for creating new forms, cite such examples as penguin wings, which started to be used as fins for swimming.*

Afterwards, they powered the wing – the basis of a new air-based ecosystem of birds.

**The three steps of adaptation, exaptation and implementation present a stable and recurrent pattern of a fundamental invention, capable of opening up a brand new ecosystem. The latter is reshaped and accommodated in order to suit the interdependent food chains. Topped by the winning species they proliferate around its unique food source.** The well noticeable though as yet unexplained **teleology of evolution** is but a direct consequence of colonizing ever newer, previously inhospitable habitats.

This pattern also works for human *coenoses*. Every historic fundamental invention, such as the canal, the oceangoing ship or the steam engine, opened up an entry into a new *coenosis* with its unique resource. Historically, populations grew by domesticating a sequence of such *coenoses* complete with their own resources. Occasional famines and devastating wars were followed by more spurts of growth. Both the former and the latter occur at special points (min max) on the bell-curve of the main resource, during specific stages of the related pair of K- waves that comprises a single *coenosis* (Fig).

## England and the Industrial Revolution

**England's fundamental invention, the steam engine, was the end result of its local adaptation. It evolved into the exaptation of the industrial revolution, and, after that, into the implementation of its unique industrial style of smokestacks and railroads along with a bundle of related technologies.** In this sense it was no different from the muscular fins of the lobe-finned fish, the distant ancestor of animal-populated terra firma. We date this adaptation circa 1600–1780, between the two inflationary peaks of the previous *coenosis* of the Age of Exploration. The leaders of that time, first the Netherlands, then France, generated a massive flow of technological innovations along with increases in demand. This led to the Agrarian Revolution of the 17<sup>th</sup> century.

England, an island nation, was nearly devoid of important natural resources, namely forests and rivers, plentiful in France. **The British answered with their unique adaptation. First, they used homegrown cottage industries, then, increasingly, machines, up to the steam engine of the Industrial Revolution.** The species-forming exaptation transpired during the deflationary trough between the last inflationary peak of the Age of Exploration (1780) and the first peak of the industrial era (1812) – the Napoleonic wars after the loss of the American colonies. The **implementation** of the industrial *coenosis* took place between its two inflationary peaks (1812–1870), while its unique technological style of smokestacks and railroads coalesced in the second half of this period: from the trough of the 1830s–40s to the peak of the 1870s (Fig)

England's entrance into the industrial age allowed it to gain an upper hand in the harsh conditions of global competition with its much stronger neighbors: the Netherlands and France, the leaders of the previous *coenosis* of global seafaring and national markets. Starting from the 19<sup>th</sup> century, mineral **coal** acquired special importance, outweighing timber, at that time essential for ship-building and iron smelting. Note that before, the inelastic resources of a *coenosis* (grain/oil) could often be consumed “as is”, directly, as food. Starting from the Age of Exploration and the rising significance of timber, sources of energy became increasingly more important. This trend accelerated since the industrial revolution – the leadership position of a country, its wealth, its consumption level and even its production of food are now restricted by a single indirect factor only – its energy resources.

The industrial revolution came as the end result of a long and painful process. The story told by demographic numbers is *amazing*<sup>9</sup>.

For centuries, the island had fewer than 5 million people. This is less than 1/10 of the current English populace and about 1/5 of the population of France at that time. Compare it with the fact that the current population of

France is only thrice its feudal levels. Nowadays, the populations of these two countries are comparable, both at about 60 million people. At the same time, French is the 11<sup>th</sup> most popular language in the world, with 77 million French speakers. Meanwhile, English is either the official language or holds a special status in 75 countries populated by more than 2 billion people. This is mind boggling reproductive success.

Instead of appreciating their island's quirks, the English tried their best to escape its natural poverty. First, in the customary Viking way, they put a claim to the French *throne*<sup>10</sup> and tried to conquer their more fortunate neighbors. Hence the Hundred Years War – 1337–1453. The English nearly won, thanks to the Welsh bowmen, whose arrows easily pierced the French armor (Crecy, Poitiers, Agincourt). This chain of victories was interrupted by Joan of Arc: a saint for some and a witch for others. The power of her prayers was greatly enhanced by French cannonballs, and the old fashioned Welsh arrows proved to be no match. The advantage of the cannon, along with the tactics of guerilla warfare newly adopted by French commanders such as Bertrand du Guesclin, put an end to English merrymaking across the Channel paid for by the unwilling hosts.

For other sources of easy wealth, the British also looked to their close neighbors, the Welsh, the Irish and the Scottish. But they were not rich and fought hard against the English intruders,

which, in the end, didn't save them. Then, there was the "pie" overseas discovered by Columbus. Despite their tardiness, the English managed to get choice tidbits off the Spanish table. In 1573, while on a privateering business trip, in the service of the good queen Elizabeth, Sir Francis Drake circumnavigated the Earth (60 years after Magellan, the first seafarer around the globe). The queen's half surpassed a yearly state budget, earning Drake a knighthood (Roger, 1997).

However, England needed more stability than provided by such, one-time only wind-falls

### Farewell to the Past

During the so-called "long" 16<sup>th</sup> century (Brodell, 1984) (1450–1780) Europe turned toward seas. This started as an attempt to break up the eastern trade monopoly held by Constantinople (important status symbols: steel, silk, brocades, and expensive small-volume food items, mostly spices, for food preservation, first of all, fish).

After the 1453 fall of Constantinople the pull of seafaring was increased. *The Basques*<sup>11</sup> started a revolution in shipbuilding. Their frame-based ship presented a break with the millennia-old tradition of the shell-built ship with a frame "thrown in" at the end, as an afterthought. This **fundamental invention** started the Age of Exploration by allowing for much cheaper and stronger ships. The frame-built ship was capable of "true" ocean going as opposed to the earlier island-hopping. (Georgetti, 2001:43-44)

Further improvements harnessed wind power. One of the early success stories in this newer generation of ships, the Portuguese caravel, could sail under adverse winds thanks to its innovative combination of square European sails

<sup>10</sup> *The Black Prince, Edward III, was the only direct grandson of Philip IV (Fair) of France, albeit on the hearth's side. The cunning French claimed their adherence to the ancient Salic law of inheriting through the male lineage only*

<sup>11</sup> *Or, in some accounts, the Genoese (Paine, 2000).*

9

Year	Events	Britain	France
1066	The Norman Invasion	1.1 mil	(850 ) 7 mil
1215	The Magna Carta	2.5 mil	( 1226)16 mil
1348	The Black Death	3.75mil	20,200,000
1350	After the Black Death	2.5 mil	(1400 ) 16.6 mil
1700	After the 1666 London Fire	5.5 mil	21 mil
1765	Prior to the French Revolution	6.5 mil	(1789) 28 mil
1801	The First English Census	8.9 mil	(1811 )–30 mil
1821	After the Inflationary Peak	14 mil	31,578,000
2001	The Census of 2001	59 mil	(2004) 60 mil

with slanted Oriental ones. But well before its advent, the northern seas were navigated on-board the awkward but roomy cog. Replacing the earlier trade in luxuries, it became economical to trade in bulk, by transporting relatively inexpensive large-volume goods.

This completely changed the very objective of trading. Regional and transatlantic trade greatly improved the food availability in shore-side localities. First the Hanseatic League, then the Portuguese, the Spaniards, the Dutch and the French entered the sea race. Gradually, with the growth in tonnage came the need in more popular trading items. In addition to bulk freight, such as Eastern European grain, skins and herring, newer manufactured goods, especially textiles, gained in importance.

The English, on their poverty-ridden island, proved to be adept at catching choice tidbits falling off the table of this growing *coenosis*. The islanders were expert seafarers. Their privateers, in the service of crown, took their share of the Spanish gold and silver galleons and, occasionally, even laid siege to cities. Soon enough, the English found a more stable source of income, in the lower tiers of the textile trade then dominated by the French and the Dutch. Of course, the English were no match to the French, the noted experts of luxury trade.

But there were also the Dutch, who produced sturdy fabrics for commoners. The English were only too happy to serve as their suppliers. They had a valuable resource, English sheep, which were being improved from Roman times, but faced stiff competition from softer Spanish merino wool. Starting from the 1530s, about a century after the end of the Hundred Years War, the English got the upper hand, benefiting from the introduction of the so called New Draperies and “worsted”. These less bulky, more affordable and thus much more popular fabrics, which required longer fibers, increased the demand for the sturdy English wool. So, in the case of England, adaptation meant coming to terms with its loss

of overseas riches and building a competitive economy by finding adequate resources from within.

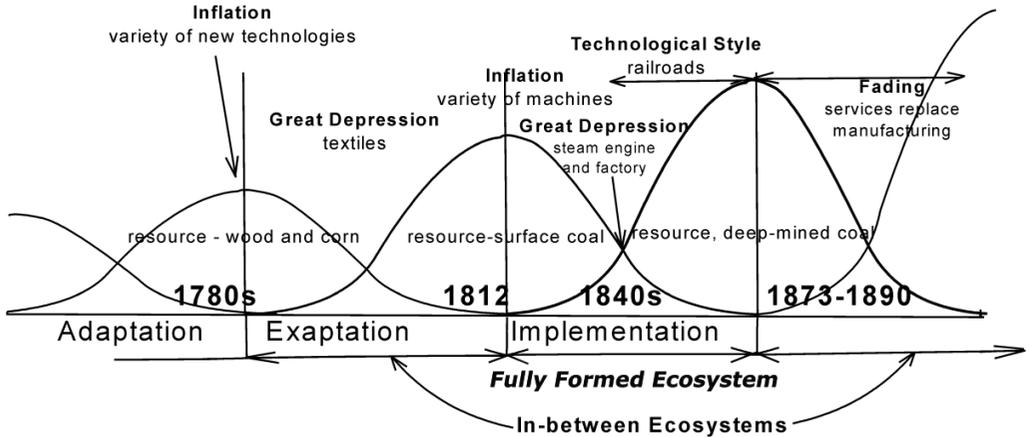
About the same time, in 1533, the infamous divorce of *Henry VIII*<sup>12</sup> produced another important development. The 1534 Act of Supremacy declared the independence of the young Anglican Church from the Holy See. The break with the Catholic world was further enhanced by a series of English-Spanish conflicts, the loss of the Great Armada and Drake’s exploits, which coincided with the first inflationary peak of the Age of Exploration, around the end of the 16th Century.

Simultaneously, starting from the rule of Henry VIII and his minister, Thomas Cromwell, England drastically reformed its economy. The new model presented an outright about-face and a growing adaptation to local conditions. The former church lands sequestered by Henry VIII were sold, strengthening a rising class of gentry. The newborn Anglican Church, under the king, was relieved from paying taxes to Rome. The Puritan revolution of the first Cromwell ended with the regicide of Charles I and the civil wars of 1640–1649 under the second Cromwell, Oliver – the Lord-Protector of Britain in 1651–1658 and a distant relative of the first one. However, a growing preoccupation with domestic problems never meant a loss of interest in others’ properties.

Charles II was crowned in 1660. Besides granting civil rights – taken already anyway, he had to marry Catharine Braganza, the Portuguese heiress. In her dowry came Tangier and Bombay, cornerstones of the future British Empire.

Nonconformist England stood out among its neighbors like a sore thumb. Reversing a trend quite pronounced in France, where one’s income came from one’s position in the court or with the government, the English were promoted because of their wealth<sup>13</sup>. From the

<sup>12</sup> He started his rule traditionally, with 1511 unsuccessful campaign of Holy League allies against France.



Two long Kondratieff-waves of the 19<sup>th</sup> century

rule of Henry VIII and up, the Lord Chancellor proudly sat on a woosack, disregarding the derisive sneers of continental neighbors, who made fun at the nation of “shopkeepers”.

Though the reforms were initiated from the reign of Henry IV and well advanced around the times of Elizabeth the Great, only the Glorious Revolution made them irreversible. The country staked its future on its unique adaptation – domination of private property. From now on, the clocks could not be turned back. As a write-off of its “inglorious” past, this moment may qualify as the most important step in the long path that shaped England into the dominant colonial power of the 19th century.

## Conclusion

The English Revolution meant farewell to the past and an entry into the uncharted waters of modern economy. The rise of manufacturing was but the next logical step in its unique adaptation to the environment. Starting as the second tier producer for the dominant manufacturing powers of the time,

such as the Netherlands and France, the Great Britain managed to outcompete them both.

Unfortunately, description of the detailed mechanics of this process exceeds our allotted space. It will be discussed in the next article, devoted to the English adaptation, exaptation and implementation: from the growth following the Glorious Revolution and until the start of the next coenosis. At the end, the fading colonial empire was gradually eclipsed by the young US. The new leader grew into a global power starting from the WWI and came to its full might after the WWII.

<sup>13</sup> Until 1838 MPs were required by law to have an annual income of L.600-300 depending on one's district.

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## GAMTOS MOKSLŲ TAIKYMAS STUDIJUOJANT ISTORIJĄ: ANGLIJOS INDUSTRIJINĖS REVOLIUCIJOS PAVYZDYS. I DALIS

Lucy Badalian, Victor Krivorotov

*Straipsnyje istorija tyrinėjama bioekologiniu požiūriu. Žmonių visuomenė nuo pirmųjų civilizacijų iki šių dienų yra technologinė-ekologinė sistema, kuri iš esmės nesiskiria nuo natūralios ežero ar miško ekosistemos. Vartojamas terminas „coenosis“ apibūdina gyvybės formų tarpusavio priklausomybę. Istoriskai naujos geoklimatinės zonos buvo apgyvenamos veikiant demografiniam spaudimui. Evoliucija netapatintina su konkurencija. Tarpusavyje priklausomų ryšių sąveika labai svarbi kuriantis naujai ekosistemai. Kiekvienos tobulėjančios visuomenės vyraujanti technologija padeda adaptuotis jai prie geoklimatinės zonos. Panaudodama ją konkreti visuomenė, kaip biologinė rūšis, įgauna evoliucinį pranašumą savo kaimynų atžvilgiu. Ji geba panaudoti naujus, iki tol neprieinamus išteklius arba maisto šaltinius. Pagal pramoninės revoliucijos pavyzdį parodomas visuomenę sutelkiantis naujai rastų išteklių panaudojimo procesas.*

**Reikšminiai žodžiai:** evoliucija, ekosistema, coenosis, technologija, istorija.

*Įteikta 2006-01-16; priimta 2006-02-22*