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Growth and Dematerialization:
Why Non-Stick Frying Pans Have Lost The Edge

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The world's most successful economy in 1992 gainfully employed 121 million civilian members of its population, according to the US Statistical Abstract. That year, the largest single occupation category in the US was retail sales personnel (with 3% of total employment, at 3.7 million employees), followed by general managers and top executives (2.87 million). Right after that came janitors and cleaners (2.86 million). The US Bureau of Labor Statistics reckons that over the 13 years from 1992 through 2005 it is home health aides, human service workers, and personal and home care aides that will see fastest-growing employment (all more than doubling). Right after those, it is computer engineers, scientists, and systems analysts that are estimated to be the fastest-growing employment sectors.

Without proper qualification, such statistics could be almost meaningless. But they do accurately describe general tendencies. They highlight the rich diversity that underlies aggregate descriptions of economic growth and national economic performance. They emphasise that economic growth affects different sectors and different people differently. And they remind us that growth in the aggregate is made up of growth at different intensities in different areas.

This article looks at an important feature of such structural change and diversity as modern economies grow—what I will call the *dematerialisation* of economic activity. For modern industrial economies, growth cannot simply be a continuing advance in some abstract state of technological progress, nor the application of more and better factor inputs in an aggregate production. Dematerialisation has enormous implications for how economies should continue to evolve to be successful; for how wealth and incomes get distributed across and within societies; and for how prospects for economic success change through time. Without being aware of these implications, economic participants may never experience the elusive "feel-good" factor even as real prosperity continues to spread across society through the inexorable march of economic progress.

Dematerialisation

When, in the 18th century, economies switched from predominantly agricultural to manufacturing-based, ongoing scientific and technological improvements ushered in dramatic increases in labour productivity: much more output could be produced using ever fewer workers. Contemporary observers wondered if people would be forever displaced from gainful employment. Yet with hindsight, we know that economies and people adapted. Employment is now twenty times what it was when the Industrial Revolution began. This shift from agriculture to manufacturing, moreover, had been critical in generating the economic surplus that, in turn, fuelled further economic growth.

Such compositional changes, of course, continually occur—and the faster is aggregate growth, the more room there is for them. Successful economies like Indonesia, Malaysia, and Thailand have averaged, this decade, faster than 8% annual growth in aggregate income. In Malaysia, the agricultural sector fell from

17% of GDP in 1991 to 14% in 1995. By contrast, manufacturing increased from 28% of GDP to 33% over this same period. These transformations are large and rapid.

More advanced economies, however, no longer carry the structural characteristics to allow growth through improving the manufacturing sector. That happened 200 years ago. Instead, these countries show a different kind of structural drift, but one no less critical for ongoing growth.

In national income accounts, the traditional taxonomy of economic activity lays before us agriculture, manufacturing, and services. When observers note the drift in economies like the UK away from agriculture and manufacturing, they reason it must be towards services. And this move towards services, these observers conclude, means we are becoming a nation of shopkeepers, janitors, hair-stylists, gardeners, and hotel bed-makers.

But software developers do not manufacture—at least not in the traditional sense. Neither do purveyors of insurance and other financial arrangements that have helped us diversify risk, and thus have improved our welfare. Nor do designers of new biological and medical products through gene sequencing, inventors of encryption schemes for improved financial and communication security, or World Wide Web developers who have allowed rapidly disseminating information and ideas.

It is important to distinguish such high-tech activities from other components of the non-agricultural, non-manufacturing grouping. These activities obviously differ from haircuts. And, moreover, it is not high-tech that is the distinguishing characteristic. Dematerialisation is the more appropriate description. What do I mean by this?

It is easiest to begin by being (apparently) overly specific on details: it is the underlying principles that are important, and those principles extend quite generally. By dematerialisation, I mean that extreme situation where economic value is embedded in logical units—bits and bytes of memory (possibly computer, possibly biological, possibly chemical). The distinction to be made here is against the opposite extreme, that historical one where economic value manifests in concrete, physical, and material form.

It is helpful to have in mind clear examples of these polar extremes—of dematerialisation and its opposite. Consider computer software or gene sequences on the one hand; and titanium non-stick frying pans or oil super-tankers on the other. All four of these can be identified with the very latest in modern space-age technology. All four would have been unimaginable to earlier generations. All four have affected the well-being of most of the population in advanced economies. All, therefore, are instances of technical innovations that have taken advanced economies to the frontier of the technology envelope.

At the same time, however, it should be apparent—if only intuitively—that the first two objects differ profoundly from the last two. The first two are dematerialised: they would retain their economic value independent of the physical medium containing them. The latter two are not: their economic values are the values that they are precisely because these objects have the physical manifestation that they do. Note that it is not the importance of an idea that distinguishes these: one could well have the idea of a nonstick frying pan or an oil super-tanker without such ideas ever becoming valuable. Not so the ideas of a slick piece of computer software, or of polymerase chain reaction, where it is a small step from ideas forming to their realisation in economic value. A good way to remember the distinction is that computer software and gene sequences are weightless; non stick frying pans and oil tankers are not. In the perspective developed by Nicholas

Negroponte and others, what is critical is that the first two are comprised of digital bits, while the last two of physical atoms.

Economic Properties

Weightless economies behave differently from those that are not dematerialised. How economic growth proceeds, and the resulting patterns of income distribution and mobility within societies will change with increasing dematerialisation. Why? Begin with infinite expansibility. An economic object is said to be infinitely expansible when its use by someone does not physically detract from its usefulness to someone else. Thus, the set of computer instructions underlying a word-processing package is infinitely expansible. If that software package were installed on a satellite server circling the Earth, my invoking its computer instructions from my LSE office for technical composition does not make those instructions any the less useful to someone else wishing to plug in to work on their creative writing.

A nonstick frying pan made of titanium will last for centuries. It is, however, not infinitely expansible. While frying eggs, that pan is useless for anything else. When a spinning jenny spins, it does so for a given quantity of material, and for that material alone. Physical constraints prevent its doing more. No such restrictions bind us, however, with dematerialised objects.

Infinite expansibility is related to the economic notion of a public good The two concepts differ in that infinite expansibility itself says nothing about the legal structure or property rights surrounding the economic object in question. A public good, by contrast, is not owned by any private agent. Modern theories of endogenous growth (e.g., Romer, 1990) have exploited this distinction to generate normative and positive implications for how already-developed economies can continue to grow. Because individual transactions in such goods bear social externalities, the natural economic equilibrium is often inefficient. Government policy can sometimes improve outcomes for growth.

But dematerialisation has other interesting economic implications, not just in the form of externalities determining the inefficiency or efficiency of aggregate growth rates. Dematerialised objects cannot be transferred, but merely replicated: the originating agent in a transaction cannot physically and credibly relinquish ownership of the object. For these commodities, trade is not exchange, but instead reproduction.

Academic economists are, actually, already familiar with such a model of exchange. When ideas are developed in a research paper, it is to the author's advantage to have those ideas widely-disseminated, freely, provided only that proper acknowledgment (costless, in this instance) is given in writings that develop further those ideas. What matters is not the initial handing-over of an idea, but its subsequent extensive use. The original author always continues to own the idea. This differs from trade where a farmer gives up leeks in exchange for corn: the farmer cares not a whit how the leek is subsequently used (if at all), only that he gets corn in return when he hands over his leeks.

Intellectual property is an instance of a dematerialised commodity. Yet, many models of intellectual property rights continue to carry a corn-leek mentality. In that anachronistic way of thinking, control of intellectual property means controlling its distribution—for commercial software, that would happen by imposing restrictions on its duplication.

For software, computer scientists have analysed alternative systems of exchange, similar to that I described above for circulating research ideas in academic

journals. Brad Cox (1996), following Japanese practice, calls these systems *superdistribution*. In such models, ease of reproduction of the commodity becomes a virtue, not the disadvantage that is taken as central in standard thinking on intellectual property. The product itself can be given away freely, but then pecuniary returns should accrue to the originator each time the product is used. That originator never relinquishes ownership rights on the product. In such a system, possession of the essential valueless physical medium differs from ownership of the software that is valuable therein—unlike, say, when one purchases a nonstick frying pan.

For software, such a system of exchange can be easy to implement when a particular communication system is in place: This already happens, for instance, for a large part of the music industry. Music publishers freely give away CDs to broadcasters in exchange for pay-per-play.

Software can easily keep track of how many times it is invoked. Provided that the software can communicate this information back to its owner, no difficulties arise for economic exchange. Over the Internet, this information transmission is trivial. Similar organisation of exchange and compensation apply naturally to other dematerialised commodities.

Such a system of production and exchange would work fine. It is a trading system different from that that many economists and other observers know well. A certain level of skills would be needed by everyone who wants to participate in such an economy, but that has always been true for all economic progress—the difference here is only a matter of degree.

More serious, perhaps, are the problems raised for governments that wish to continue to tax and spend. What is a national fiscal base when international trade in dematerialised commodities is not a matter of shipping wine and textiles from one country to the next, but of bouncing digital bits off satellites? Neither the economic commodity being handed over nor the corresponding payment can be measured: with packet switching as the dominant mode of bit-transmission, content—the only thing having value—of what gets bounced off a satellite need never be third-party observable. Economic value will have no clear points of physical entry and exit: international trade statistics become that much murkier and ambiguous—and, potentially, completely meaningless. Keeping track of international trade is no longer just going down to the nearest port and tallying up the bottles and bales that pile up on loading docks. As the current account goes, so goes GNP accounting more generally.

Is this something only for the distant future? In 1995, the US Advisory Commission on Intergovernmental Relations estimated an annual loss of US $3.3 billion in state and local sales taxes in the US alone due to out-of-state mail order sales—while World Wide Web pages presenting business and products grew at 12% a month (Newman, 1995). Mervyn King (1996) has described further implications for fiscal and monetary analyses more generally—none of those seem, to this author, exceedingly remote in time.

It is in the dematerialised sectors that economies show the greatest capacity for unbounded growth. In 1949 when ENIAC—one of the world's first viable computers —was turned on, the streetlights in Pittsburgh would dim. By the beginning of the 1990s, anyone could walk into a local supermarket and purchase a Hallmark greeting card for two pounds sterling—embedded within that card is a computer chip that performs a reasonable rendition of Happy Birthday, and which contains within it more computing power than existed on all of planet Earth in the early 1950s. The production of no material commodity could show such rapid rates

of change. Without this kind of progress, economic growth will reach hard boundaries, and cannot be sustained in the long run—simply as a matter of physical logic.

Dematerialised commodities show no respect for space and geography. Urban sprawl will continue to exist, of course, but wealth creation and economic activity will occur in disembodied, dematerialised processes. Successful economic agents in the real world already recognise these possibilities, even if many economists still do not. Manufacture of the world's most valuable commodity is already location-blind:

> "Texas Instruments' high-speed telecommunications chip may look like any other semiconductor: But it's the product of a world's worth of effort. Conceived with engineers from Ericsson Telephone Co. in Sweden, it was designed in Nice with software tools the company developed in Houston. Today, the TCM9055 chip rolls off production lines in Japan and Dallas, gets tested in Taiwan, and is wired into Ericsson line-cards that monitor phone systems in Sweden, the U.S., Mexico, and Australia."[1]

Moreover, such physical dislocation is welcomed, rather than regarded as a problem.

> "While increasing numbers of workers will need ready access to wide-ranging information resources, optimal information sharing needn't demand one's physical presence in some corporate office complex. Tomorrow's interactions may depend far more on shared understanding than on sharing the same office corridor."[2]

Those interactions are how production occurs in dematerialised economies. And, as does value distribution in dematerialised economies, production happens, not by transportation, but by communication and transmission. Then, with an effectively infinite transmission bandwidth—most fibre optic cables that are already in place remain "dark", i.e., unused—the natural workplace for dematerialised production and the natural marketplace for dematerialised commodities are unbounded, not local.

What are the implications for thinking on economic growth and wealth creation? First, a high skill base for the economically active is critical. Second, systems of distribution and exchange will need to restructure. Some sectors will grow; others will no longer be economically viable. Such structural change is natural and good, and should be welcomed rather than feared. Economists need to understand this transformation better, and to communicate its implications to the public. Third, physical geography will become increasingly irrelevant, and without an understanding for how national fiscal and monetary systems operate in dematerialised economies, so might the nation-state become meaningless.

With dematerialisation, the natural marketplace is unbounded. Costs of production are all upfront fixed expenses; marginal costs of making more product are effectively zero. If, further, dematerialised consumption were to display

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[1] "The Global Chip Payoff" *Business Week* , 7 August 1995.
[2] Arno Penzias, *Harmony*, excerpted in *Fortune,* 12 June 1995.

network externalities—as we already observe when software to be effectively used requires training and collaboration with co-workers—first-niche advantages become paramount, and a single producer can end up providing for the entire market. Sherwin Rosen, studying a different economic structure but with related theoretical properties, called this the economics of superstars: Rosen used these ideas to explain why the income distribution across opera singers differs from that across shoemakers. A "winner-take-all" property holds here for sound, defensible economic reasons.

In dematerialised economies, such apparently unequal income distributions may be a good thing, rather than a bad one—and this by almost any reasonable criterion. The reason is that dematerialisation also lowers, relatively, the upfront costs of being successful. To become the winning superstar requires not inborn immutable talent as with opera singers, nor the massive metal and concrete surrounding a steel plant or automobile assembly line, but only encapsulating the idea within the trivial plastic of a CD-ROM, costing no more than a couple of pounds sterling. Put differently, the potential for income mobility—the originally poor overtaking rich, and in turn become the winners—increases, and with it the incentive for technical progress. Producers work hard on a software product to take over the entire marketplace—the rewards are immeasurably large—and can do so, with reasonable expectation, by pushing the envelope of ideas, not by minor tweaks on the same old idea.

With dematerialisation, no economy can sit back and try to copy the progress of another - there are no rewards for coming in second.

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(3088 words)

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