LANGUAGES AND CULTURES: AN ECONOMIC AND EVOLUTIONARY ANALYSIS

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Abstract:

Languages and cultures are mediums of transmitting information. Their value rests on their ability to lower variable costs in communication. Lower variable cost systems in general entail higher fixed costs. Each culture or language has evolved to adapt to the local environment. As environment changes, however, different cultural systems may fare differently under new conditions. An analytical economic theory is applied to study the co-evolution of languages, cultures and social systems. Many problems about the evolution and diffusion of cultures and languages and how they co-evolve with the social and economic systems can be understood in a very consistent way.

Key Words: *culture, language, information, fixed and variable cost, thermodynamic theory of economics*

JEL Classification: *A14*

I. Introduction

There is a long debate about the impact of differences in languages on human societies. (Whorf, 1956; Pinker, 1994; Devitt and Sterelny, 1999) The ability to acquire languages is innate and universal (Chomsky, 1988). Written languages, however, appeared very late in the history of human evolution and independently originated only in very few places (Diamond, 1997). Our discussion will be confined to how the differences in written languages are related to other aspects of human societies.

Words in English, an alphabetic language, are linear combinations of twenty-six letters. Characters in Chinese, a logographic language, are two-dimensional pictures. Several thousand of these complex characters need to be memorised before one can read articles reasonably well. Therefore Chinese is much more difficult to learn than English (Hanley, Tzeng and Huang, 1999). For the same reason, Chinese is more spatially compact and visually distinct than English. A Chinese document is much shorter than an English document of the same content. The speed of reading in Chinese is higher than in English (Lu and Zhang, 1999). From an economic point of view, the fixed cost (learning a language) of Chinese, a logographic language, is high and the variable cost (using a language) of Chinese is low. The opposite is true for English, an alphabetic language. Its fixed cost is low and its variable cost is high.

The classification of cultures by context is analogous to the classification of languages by fixed cost. "In general, high context communication, in contrast to low context, is economical, fast, efficient and satisfying; however, time must be devoted to programming." (Hall, 1977, p. 88) This means that high context cultures are of high fixed costs and low variable costs. The opposite is true for low context cultures. The lowest-context cultures are probably Northern European and North American cultures, while "China, Japan, and Korea are extremely high-context cultures." (Anderson, 2000, p. 266, 267) It is easy to note the link between the context of a culture and the fixed cost of learning a written language. Chinese language is a logographic language. Japanese and Korean languages are mixture of alphabetic and logographic languages. The logographic composition of these languages makes them more difficult to learn than alphabetic languages. Since learning and using written languages are such important parts of our lives, and since written languages are relatively stable and written records accumulate over time, they have a strong influence on many aspects of cultures.

Cultures and languages are mediums of transmitting information, which is the reduction of entropy (Shannon, 1948; Bennett, 1988). The value of cultures (and languages) rests on their ability to lower

variable costs in communication. Lower variable cost systems entail higher fixed costs. In a homogeneous and densely populated society, people share common background and engage in communications frequently. It pays to spend more time to build up the context of the culture to reduce the variable cost of communication. In a sparsely populated society or a society with members of diverse background, it is more economical to keep the fixed cost of a culture low. Each culture has evolved to adapt to the local environment. As environment changes, however, different cultural systems may fare differently under the new conditions.

The performance of an economic system with respect to its fixed cost and variable cost has been studied with an analytical framework based on the thermodynamic theory (Chen, 2005, 2006). From this framework, it can be derived that as fixed costs increase, variable costs decrease rapidly in a low uncertainty environment and decrease slowly in a high uncertainty environment. The main insight from this theory is the trade-off between efficiency of high fixed cost systems in a stable environment and flexibility of low fixed cost systems in a fast changing environment. One of the major purposes of the researches on culture is to find out the relation between culture factors and economic development. However, the mixed statistical results often puzzle cultural researchers. One type of culture that is linked to high economic growth in one period often performs badly in another period (Hofstede, 1980). With this analytic framework, it can be analyzed in a straightforward way. Lower context cultures have advantages in fast changing environments and higher context cultures have advantage in stable environments.

Cultures are often called multidimensional phenomena. Some of the primary dimensions of cultures are context, individuality, power distance and uncertainty avoidance (Hall, 1977; Hofstede, 1980). From the analytic framework proposed in this paper, it can be derived that all these dimensions are linked to one single factor, the fixed cost or context of a culture. Although cultures are often expressed in colorful ways, at core, they display highly consistent patterns. This is not surprising, for the function of culture is the same across different cultures, to reduce the cost of communication.

This analytical framework helps understand some of the long standing puzzles in linguistics and many problems in the evolution of language and societies. Why the ancient Egyptian language didn't take the "natural" step to evolve into an alphabetic language? (Diamond, 1997, p. 226) Was the logographic Chinese writing created independently or diffused from somewhere else? (Diamond, 1997, p. 231) Why are there so many low fixed cost alphabetic languages, but so few high fixed cost logographic languages, although all the earliest written languages were logographic? Is it a coincidence that Chinese, a logographic language, has the most native users? Why are most of the original Chinese characters, used three thousand years ago, still used today, with many of these characters having retained their original meaning, whilst over the same period of time, most alphabetic languages have changed considerably? Why was China the wealthiest country in the world during the long period of the stable agricultural society? Why could it not initiate industrial revolution despite its immense wealth? Why do democratic systems have a long tradition in the environment where alphabetic languages are used, while they rarely developed in regions that use logographic languages?

Many of these questions have been answered by many people in many different ways with various level of confidence. However, this theory will answer all the questions in a very simple and consistent way. The simplicity of the answers is not accidental. This is because the language, cultural and economic activities, which are thermodynamic processes, are directly modeled with an analytical thermodynamic theory. For any language, cultural or economic system, if it can help its hosts to extract more low entropy resources from the environment than the amount that dissipates, it will expand. Otherwise, it will contract.

This paper is organised as follows. Section II adapts the analytical framework developed in Chen (2005) for the completeness of exposition. Then we apply it to give a unifying analysis of different dimensions of cultures. In Section III, we make a detailed analysis of the evolution of written languages and how they affect cultural and economic development. Section IV concludes.

II. Basic theory and its application to cultural analysis

Living systems need to extract low entropy from the environment to compensate for continuous dissipation (Schrodinger, 1944; Prigogine, 1980). This process can be modeled by lognormal process, which contains a growth term and a dissipation term. Suppose *S* is the amount of low entropy or information of a social system, *r*, the rate of extracting low entropy or receiving information from external environment and σ, the rate of dissipation. The value of *S* follows the lognormal process

$$\frac{dS}{S} = rdt + \sigma dz . \tag{1}$$

Solving (1) for S yields

$$S = S_0 e^{(r-\frac{1}{2}\sigma^2)t+\sigma z_t} \tag{2}$$

in which S_0 is the initial value of *S*. From (2), the average growth rate of *S* is

$$r - \frac{1}{2}\sigma^2 . \tag{3}$$

This shows that the growth of a social system depends on the increase of *r* and decrease of σ. Cultures and written languages facilitate the transmission of information and reduce the noises associated with the information transmission, which increases *r* and reduces σ in a social system.

The production, transaction and transmission of goods, including cultural and information goods, involves fixed cost and variable cost. The variable cost is affected by the properties of this good. For example, if the demand for this good becomes highly uncertain, the variable cost will increase. So variable costs are functions of the value of the product. From Feynman-Kac formula, (Øksendal, 1998) the variable cost, as a function of *S*, satisfies the following equation

$$\frac{\partial C}{\partial t} = rS\frac{\partial C}{\partial S} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 C}{\partial S^2} - rC \tag{4}$$

Since the thermodynamic equations is of first order in temporal dimension, economic, cultural and language systems as thermodynamic systems are intrinsically evolutionary. Solving the equation (4) with proper initial condition yields the following solution

$$C = SN(d_1) - Ke^{-rT}N(d_2) \tag{5}$$

where

$$d_1 = \frac{\ln(S/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\ln(S/K) + (r - \sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

The function *N(x)* is the cumulative probability distribution function for a standardized normal random variable. Formula (5) takes the same form as the well-known Black-Scholes (1973) formula for European call options. (Chen (2005) provides the details of derivation.)

In general, the value of a fixed asset rests on the ability to reduce the variable cost in production or information transmission. From (5), it can be derived that variable costs decrease when fixed costs are increased. However, the rate of decrease is a function of uncertainty. As fixed cost increases, variable costs, calculated from (5), decrease rapidly in a low uncertainty environment and decrease slowly in a high uncertainty environment. (Figure 1) So the payoff of building up the context of a culture is high in a stable environment. In a fast changing environment, low context culture, being more flexible and innovative, have more advantages.

Suppose the fixed cost of understanding a culture is *X*, the variable cost is *C* from (5). The volume of information transmission is *Q*. For simplicity, assume the value of each transmission is 1. Then the total cost of information transmission is

$$C(X,\sigma)Q + X.$$

while the total value of the information transmitted is *Q*. The rate of return of the information transmission is

$$\ln\left(\frac{Q}{C(X,\sigma)Q + X}\right) = -\ln\left(C(X,\sigma) + \frac{X}{Q}\right) \qquad (6)$$

Figure 2 is the graphic representation of (6) for different levels of fixed costs or contexts of cultures. Two properties can be observed from Figure 2. First, it takes higher volume of communication for the high context culture to break even. So it is more economical to keep the fixed cost of a culture low in a sparsely populated society. Second, higher context cultures have lower variable costs. In a densely populated and stable society, the volume of communication is high and people engaged in communication are relatively stable. The return of a high context culture is higher than a low context culture.

Cultures are often called multidimensional phenomena. Some of the primary dimensions of culture are context, individuality, power distance and uncertainty avoidance (Hall, 1977; Hofstede, 1980). We will discuss the relationships between these dimensions with the above framework.

"In general, high context communication, in contrast to low context, is economical, fast, efficient and satisfying; however, time must be devoted to programming." (Hall, 1977, p. 88) This means that high context cultures share large amount of common fixed assets among their members. Because of this, members in a high context culture will value collectivism more than those in a low context culture, who will value individualism more. From Figure 2, the return curve is steeper in a high context culture than in a low context culture. Power and wealth is more unevenly distributed in a high context culture than in a low context culture, which means high context cultures have higher power distances. From Figure 1, high fixed assets systems perform better in low uncertainty environment. So high context cultures entail a higher level of uncertainty avoidance than low context cultures.

Hofstede (1980) and Hall's (1977) works indicated that the values of these four dimensions of culture variation are positively correlated. Their correlation may even be higher than the statistical results because some formulas that calculated the indices may not adequately represent the defined meanings. For example, Singaporeans are generally considered very cautious. However, Singapore scored lowest on the Uncertainty Avoidance Index (Hofstede, 1980, p. 165). This is because this index is derived partly from employment stability and Singapore has a high job turnover rate. In a small and densely populated city state such as Singapore, changing jobs cause very little uncertainty. First, changing jobs rarely requires changing homes. Second, there are many firms crowded in a small place. It is often easy to find similar jobs nearby

This analytic framework also makes it easy to analyze the relation between cultural factors and economic growth. For example, Hofstede (1980, p. 205) found that the Uncertainty Avoidance Index is negatively correlated with economic growth in the volatile period from 1925 to 1950 while it is positively correlated with economic growth in the stable period from 1960 to 1970. From Figure 1, a system high in fixed

assets, (and hence a high need for uncertainty avoidance) performs well in a stable environment and performs poorly in a volatile environment.

Most cultural and economic indicators are highly correlated with latitude (Hall, 1977; Hofstede, 1980; Parker, 2000). High latitude areas receive less solar energy. So bio-densities in general and human population densities in particular are lower in the cold high latitude areas than in low latitude areas, where there is abundant solar energy. In high density areas, people interact more. Therefore it is more efficient to develop high fixed cost communication systems that have lower variable costs. People in the warmer low latitude areas, such as Southern Europe, generally develop high context cultures. In low density areas, people interact less. It is more economical to keep the fixed cost associated with communication small. People in the cold high latitude areas, such as Northern Europe, generally develop low context cultures.

III. The evolutionary patterns of languages

It is more intuitive to map what we see into pictures than into alphabets. All the independently created written systems, from Sumer, China and Mesoamerica, are logographic languages. "The first Sumerian writing signs were recognizable pictures of the object referred to. … The earliest Sumerian writing consisted of nonphonetic logograms." Gradually, phonetic representation was introduced to write an abstract noun "by means of a sign for a depictable noun that had the same phonetic pronunciation". (Diamond, 1997, P. 220)

The first solution to a problem is often very complex. When a problem is known to be solvable, later solutions tend to be much simpler. As a writing system diffused to other regions, many logograms were gradually simplified to easy to write alphabets, especially the abstract nouns and grammatical items that are best represented phonetically instead of logographically. The earliest alphabets can be tracked to ancient Egyptian languages, which is probably influenced by the Sumerian language. But they kept the logograms in their language. This has puzzled some people. "The Egyptians never took the logical (to us) next step of discarding all their logograms …" (Diamond, 1997, p. 226) However, if we look at the patterns of innovation, the puzzle can be easily resolved.

Logograms, which are difficult to learn, contain high information content. They are of high fixed cost and low variable cost. To the people who already learned the logographic languages and hence already invested on the fixed cost, there is no incentive to convert the logograms into alphabets. It is for the similar reason that Japanese language, which is influenced by logographic Chinese language, retain many of the logograms. Only when the writing systems diffused further into new environments, the low fixed cost alphabetic system were gradually established. Semites familiar with Egyptian languages discarded all logograms and transformed the language into a pure alphabetical language. (Diamond, 1997, p. 226-227) This pattern is very similar to the innovation of new products. Many of the new ideas are initiated inside established large companies. However, it is often the new and small companies that implement the novel ideas.

The spread of writing systems is also an evolutionary process from logographic to alphabetic systems. This observation helps us resolves the puzzle whether the logographic Chinese writing was created independently or was diffused from Sumerian writing. (Diamond, 1997, p. 231) If the Chinese writing was diffused from Sumer, it would have been evolved into an alphabetical language over such a long distance and over such a long time.

Next we will apply this analytical framework to understand several properties of languages. First, since alphabetic languages are of low fixed costs, they are very easy to spread out. That is why there are many more people using alphabetic languages instead of logographic languages. Because of the simple structure of alphabetic languages, it is easy for them to mutate into new forms to adapt to local dialects. That is why there are many more alphabetic languages than logographic languages and most of the alphabetic languages have a relatively small number of users. Because of the high fixed cost, a logographic language is difficult to get established and to sustain itself. That is why there are few logographic languages left today although all the earliest written systems were logographic.

Why has the Chinese language survived while all other logographic languages were eventually replaced by alphabetic languages? "China's long east-west rivers ... facilitated diffusion of crops and technology between the coast and inland, while its broad east-west expanse and relatively gentle terrain, ... facilitate north-south exchanges. All these geographic factors contributed to the early cultural and political unification of China." (Diamond, 1997, p. 331) The same geographic factors also help the Chinese language to spread out quickly and gain large number of users. A logographic language has to be used by many people so that the low variable cost can offset its formidable high fixed cost. Chinese, a logographic language, has more than one billion native users, which is the highest among all languages.

Second, alphabetic languages, with low fixed costs and simple structures, can create new words easily and absorb words directly from other languages. Logographic languages, with high fixed costs, are more conservative and change less. Most of the characters Chinese used three thousand years ago are still used today, and many of these characters retain their original meanings. Over the same period of time, most alphabetic languages have changed considerably. New words in Chinese are formed by new combinations of existing characters. Since each Chinese character carries distinct meanings that are very stable, it is often difficult to create proper words to represent really novel ideas, which delays the understanding and adoption of new ideas. When the Japanese language absorbs a new word from other sources, the sound will first be represented by the alphabetic part of the language. If the word becomes popular, people will gradually create a logographic word with a distinct meaning to represent it for easier communication. (Harigaya, 2001)

Since societies using logographic languages are more stable, people there will value past experiences and are more conservative. Since societies using alphabetic languages change fast, a forward looking perspective is more valuable.

People using an alphabetic language spend less time learning the language, their common property. So they value individualism more. People using a logographic language spend far more time learning the language, their common property. So they value collectivism more. Hofstede (1980) found that those Chinese-majority regions "Taiwan, Hong Kong, and Singapore score considerably lower on individualism than the countries of the western world." He attributed it to a particular Chinese philosophy. (p. 215, p. 231) We find that language, by itself, offers a clearer explanation.

Third, economically, regions using logographic languages will do well in a stable environment because of the low variable cost in communication. During the stable agricultural society, which occupied most of the past two thousand years, China was the wealthiest country in the world. However, the high fixed cost Chinese language makes it difficult to initiate new changes. Instead, changes are initiated in the regions of diversified alphabetic languages. An alphabetic language, with low fixed costs, is more flexible and more innovative, which enjoys advantages in a fast changing environment. Regions using alphabetic languages have been leading the innovative changes since the beginning of industrial revolution several hundred years ago.

The difference in performance is not only reflected in world history but also in industries at different stages of maturity. Regions using alphabetic languages, such as USA, are dominant in new technologies. Regions using a mixture of alphabetic and logographic languages, such as Japan, absorb and perfect the advanced technologies. China, the region using logographic languages, is the main manufacturer in the mature industries.

Fourth, in a logographic language environment, if one manages to learn this language, one can acquire a huge amount of information at high speed. But the process of learning this language is difficult. Those who fail to master it may be left behind. The difference in payoff is drastic. In an alphabetic language environment, the result is not that drastic because of the low fixed cost, or low barriers of entry. (Figure 2) So one would expect the logographic language environment to be more elitism oriented and the alphabetic language environment to be more pluralism oriented. Indeed, democratic institutions have a long tradition in the environment where alphabetic languages are used, while they rarely developed in regions that use logographic languages.

IV. Concluding remarks

In this work, an analytical thermodynamic theory of economics is applied to languages and cultures to offer a unified understanding of the co-evolution of languages, cultures and social systems. Written languages and cultures, which are created by human beings, in turn, exert great influence on the path of human development.

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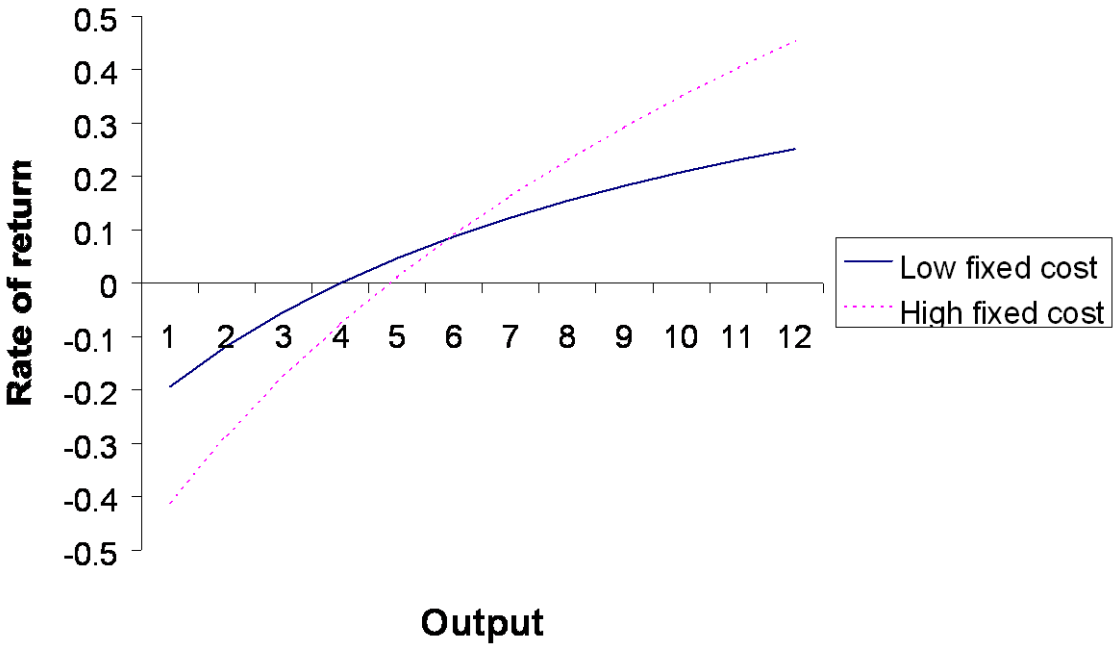
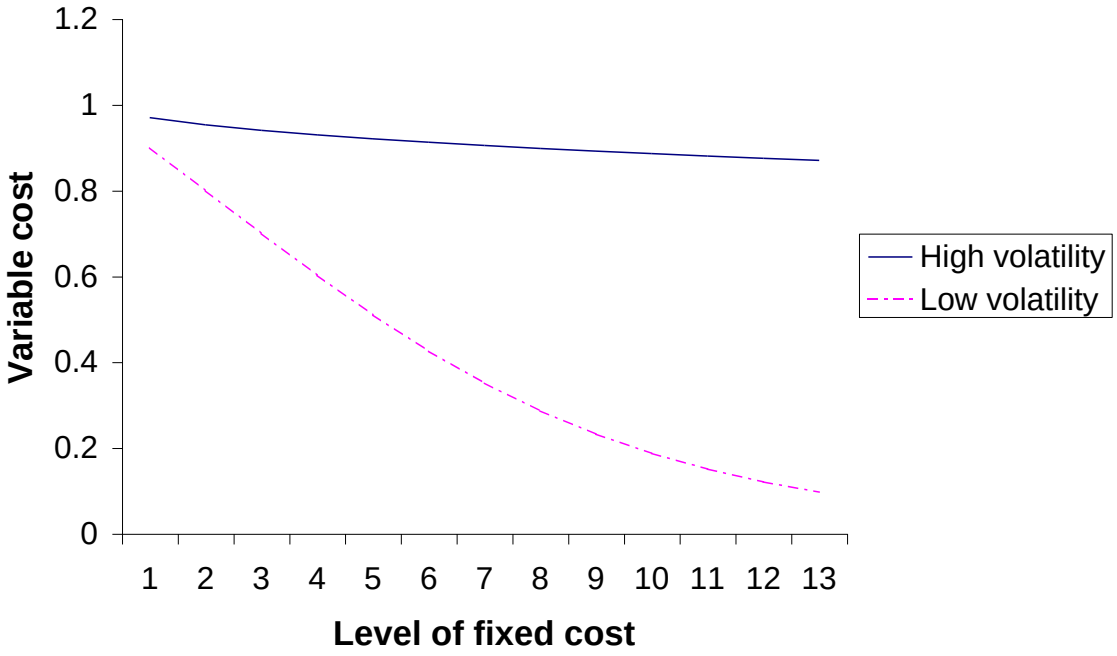
Figure captions

Figure 1. Uncertainty and variable cost
Figure 2. Output and return with different levels of fixed costs




1.2
1
0.8
0.6
0.4
0.2
0
Variable cost
1 2 3 4 5 6 7 8 9 10 11 12 13
Level of fixed cost
High volatility
Low volatility