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Guanzhong James Wen

Trinity College, JAMES.WEN@TRINCOLL.EDU

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Why Was China Trapped in an Agrarian Society--An Economic Geographical Approach to the Needham Puzzle

Guanzhong James Wen¹
Department of Economics
james.wen@trincoll.edu

Abstract

This paper argues that before the world started to globalize, the differences in the geographical endowments that different population faced were the most important constraints to their long-term production and consumption. The paper uses this central hypothesis to explain the sharp contrast between the flourishing Song and the stagnant Ming and Qing. During the Song dynasty, despite the fact that China lost a significant amount of arable land to invading nomads as its population peaked, China witnessed a higher urbanization level, more prosperous commerce and international trade, and an explosion of technical inventions and institutional innovations. However, after having significantly improved its man-to-land ratio in the period after the Song China only found itself induced deeper into the agrarian trap, resulting in reduced urbanization, withering foreign trade, a declining division of labor, and stagnant in technology.

Keyword: Needham Puzzle; Geographical Endowment; Heckscher-Ohlin Model
JEL Classification N 15, O 31, R 12

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I. Introduction

1.1 Why was Needham puzzled?

A question academically interesting but challenging at the same time was first raised by Joseph Needham (1981), which has mesmerized many scholars since. In his multi-volumed *Science and Civilization in China* Needham documents in great detail what China achieved in technology, as exemplified by its advanced agricultural technology, numerous inventions, highly developed mining, iron and steel production technology. China also was the first to learn how to manufacture sophisticated products such as porcelain, silk, and how to build large ocean-going ships equipped with magnetic compass. Needham concludes that China was the leading nation in technology over fourteen centuries prior to the 16th century (1981 p3).

Bewildered by his own findings about China's protracted technological domination and its sudden dissipation, Needham summarizes his famous puzzle in *Science in Traditional China* (1981):

"...the question [is] why modern science, the 'new or experimental' philosophy of the time of Galileo, had arisen only in European culture and not in Chinese or Indian....a second question hiding behind that first one: namely, how could it be that the Chinese civilization had been much more effective than the European in finding out about Nature

and using natural knowledge for the benefit of mankind for fourteen centuries or so before the scientific revolution?”²

A closer look reveals that the Needham puzzle actually contains four issues (hereinafter the Needham issues). First, why was China not a leading nation in the world before the 2nd century AD? Second, why did modern science or the experimental philosophy in Needham’s words, only emerge from European culture? Third, why did China become a leading nation only in the field of practical technique during the following 14 centuries? Fourth, why from the 16th century on, did China become a backward nation again even in practical technique? Because of the limited space, this paper will only address the third and fourth Needham issues.³

The dramatic rise and fall of China in its growth and development was also documented in Angus Maddison’s book entitled *The World Economy* (2001, Figure 1-4, p.42; p.117). Combining the findings of Needham and Maddison, we can conclude the following: First, from at least the beginning of the first century AD, until the beginning of the 19th century, China was the largest economy in the world. Second, from the second century AD to the 16th century China led the world in technology. Third, from the 5th to the 14th century AD, China led the world even in per capita income. It is interesting to ask why China lost all these titles during a period of about 300 hundred year, and by the beginning of 19th century, it had already become one of the poorest nations in the World?

1.2 Earlier explanations

²J. Needham, “Science in Traditional China”, Cambridge, Massachusetts: Harvard University Press, 1981, p3. There are numerous versions Needham puzzle phrased by Needham at different stage of his research. The above-mentioned represents the best phrased one at a later stage of his long life shortly before his health started to deteriorate in the mid-1980s.

³ Readers who are interested in my approach to the first and second Needham issues are welcome to contact the author to get a full-fledged paper through e-mail correspondence.

Various hypotheses were put forward over the years, trying to answer Needham's puzzle. One that remains influential even today was proposed by Elvin (1973).⁴ According to him, the steadily increasing population against fixed arable land led to worsening man-to-land ratio, shrinking social surpluses, resulting in declining price of labor relative to capital goods. This in turn deprived China of demand for labor-saving technology, slowed down China's technical progress, and led China to be confined by a high-level equilibrium trap.⁵ Although Elvin's hypothesis remains orthodox today, we will show in Section II that actually during most of the long period after the Song dynasty China saw improvement in its man-to-land ratio before the middle or late Qing, by then China already lost its lead in technology and per capita income. Therefore, Elvin's hypothesis seems difficult to explain Needham puzzle.

Lin (1995) put forward a hypothesis on switching of mode of invention. According to him, before the 16th century, most technological inventions were experience-based, hence population size was the main variable determining the pace of inventions. As the most populous nation, China had the richest collective experience, and therefore should be expected to have an edge over other nations in technological breakthroughs. After the 16th century, technological innovation in Europe was experiment-based, and the frequency of experiments instead of population size became the main determinant of technical progress. China failed to switch to this new mode of invention, and has lagged behind Europe since then. Both of the invention modes rely on trial and error to find new knowledge. But the first mode does not use theories as guidelines. It depends instead on cumulative experiences, and population size matters for this reason. Under the second

⁴ See, for instance, in his 1998 book and 2006 article, Landes cites Elvin numerous times.

⁵ It is numbered Figure 4 in Elvin's 1973 book.

mode, where theories are used, breakthroughs can be made much more rapidly by raising the frequency of experiments to exclude ungrounded hypotheses or less desirable results. Therefore, the importance of population in invention is greatly reduced.

Lin's hypothesis is supported by Diamond (1997). He has established that only limited localities on earth had the carrying capacity to support a relatively large population cluster⁶ at the early stage of human evolution before the agricultural revolution. He has also established why a population cluster must be sizable before it could evolve into a civilization.⁷ What Kremer (1993) finds in his empirical test seems to provide ground to Lin's hypothesis. Using the population data of the period 1,000,000 B.C. to 1990 on a global scale, he finds that historically, "among societies with no possibility for technological contact, those with larger initial populations have had faster technological change and population growth."

However, Lin leaves a number of questions unanswered. First, why did the Greek civilization with a relatively small population size reach a level of technology and knowledge in almost all the fields of human activity much higher than nations with huge population size? Second, why did Europe succeed in finding the new invention mode around the 16th century while China failed? Third, when China's population size became much larger after the mid-Ming, and particularly after the mid-Qing relative to that of the

⁶ Population cluster or human cluster in this article refers to any autonomous community. It could be a group of people, an extended family, a tribe, a tribal union, a kingdom, a city state, or an empire.

⁷ According to Mokyr (1999), Diamond is talking about the importance of population density instead of population size. The two terms are not necessarily equivalent. If we assume the boundary of a civilization remains unchanged throughout history, then population growth automatically leads to rising population density and population size. If its boundaries are not stable, as is often the case in the real world, then the rise in population density is not automatically equivalent to an increase in population size. Losses of territory may lead to much raised population density as a result of an influx of refugees from the land lost to the invading enemy. However, territorial expansion into formerly sparsely populated area will decrease the nation's overall population density, but increase, however slightly, the total population size.

Song, why did China become so quiet in invention and innovation compared to the Song and earlier periods when China's population was much smaller?

1.3 The Organization of the Paper

Section II introduces the central hypothesis of the paper after discussing the economic implications of geographical endowments as economic constraints. Section III answers the third Needham puzzle by discussing the Elvin hypothesis and the technological explosion in the Song dynasty. Section IV answers the fourth Needham issues by showing why China was trapped in an agrarian situation. Section V concludes the paper.

II. Geographical Endowments and Long-term Economic Growth

2.1 Geographical endowments as important budget constraints

Economists have stayed away from this seemingly treacherous territory, except for a few such as Heckscher, Ohlin, and Krugman. The Heckscher-Ohlin (H-O) model uses the difference in natural endowments of various factors of production across nations to explain the origin of international trade. Among contemporary economists, Krugman most enthusiastically emphasizes the relevance of geography in economic studies. In his book entitled *Geography and Trade* (1991), he criticizes many economists to simply assume away the impacts of geographical factors because they are difficult to be quantified.⁸

⁸ See Krugman, 1991, page 99-100. Unfortunately, by assuming away impacts of geography, all economies, small or large, reduce to a single point. All distances disappear too when transportation cost is assumed zero, and flow of information is assumed perfectly smooth. Increasing returns to scale, one of the main sources of endogenous growth, is also often conveniently swept under the rug because it is difficult to incorporate into the traditional general equilibrium model, which is based on constant returns to scale assumption.

Let's see why geographical endowments were of great importance, especially at the early stages of human development. In economics, we assume that a decision maker, be it a person, a firm, or a community, has a utility function, a production function, and a number of budget constraints. We can argue that when the early Homo sapiens were migrating out of southeast Africa, there should not have been significant differentiations in their culture, preferences, technology, production, and social organizations, since these Homo sapiens had evolved in the same environment up to then. However, once they were re-settled by chance in different geographical locations, the geographical environments would have imposed various constraints on their patterns of production and consumption.

Hence, it is safe to assume that all human clusters at this early stage had similar utility and production functions. What made them different were the different budget constraints they faced. Among the explicit inputs in a production function, including capital, land, labor, and technology, land was the most important. This is because at very low productivity, there should not be significant differences across human clusters in accumulations of human and physical capital. Lack of social surplus precluded the emergence of a leisure class who could afford to devote time and resources to accumulating knowledge. At this early stage, even the size of population was mostly determined by the initial carrying capacity of the land. Therefore, at least two important arguments in a production function, i.e., land and labor, were actually geographically determined at first.

In this paper the term "geographical endowments" is used to capture many implicit factors that the term "land" does not convey, such as topography, ecology, fertility of

land, climate, location, and underground minerals.⁹ Since these implicit factors are all related to geography, and affect a population's production and consumption costs, they should be included in budget constraints. It is mainly the differences in these geographically based budget constraints that shaped the path of development of particular human clusters. Therefore, information about geography is highly relevant in projecting the long-term development trajectory of particular population clusters and the limitations they faced.

These geographical constraints must have shaped the way an early human community consumed, produced, and behaved.¹⁰ Each human community would have been induced or forced by geographical conditions to embark on a certain path of social, economic and cultural evolution. In this sense, the differentiations in culture, preferences, tastes, technology, behavior, organizations, and institutions must have developed at a much later stage, and been shaped by silent but dominating geographical factors. The different geographical factors, the ultimate exogenous variables, explain to a great extent, although not deterministically, why the same Homo sapiens eventually evolved into different peoples with different collective preferences, cultures, technology, behavior, organizations, and institutions.

2.2 New light shed by the H-O model and the Rybczynski Theorem

The H-O model is mostly used in international trade, but actually has deeper implications relevant to endogenous urbanization and growth, and to the Needham puzzle. The model

⁹ This list is certainly not exhaustive. For example, whether a plain was covered with or grasses could be important in determining why the Chinese civilization emerged much later than the Middle East civilization.

¹⁰ They would choose herding if living in grassland, hunting if living in a forest, fishing if living close to water, gathering and later farming if living on a fertile plain, trading if living in a strategic locality, or warring if living in a barren environment that was next to a rich but vulnerable target.

is mainly based on the geographical fact that natural resources are not evenly distributed across the world. Comparative advantage comes from the differences in factor proportions, or in factor availability across nations. Within this framework, Rybczynski proves that when an economy loses a certain amount of its endowment of one factor of production, the sector that does not use this factor intensively will expand at the expense of the sector that does use this factor intensively.

This theorem has interesting implications. Assume an economy has two sectors, one labor-intensive (say urban) and the other land-intensive (say agriculture), and for some reason the economy loses some of its land. The immediate effect is a worsening man-to-land ratio, which leads to the decline of the land-intensive sector, in our case, agriculture. Meanwhile, the labor-intensive sector, in our case, the urban sector, will expand by gaining land and labor at the expense of agriculture. The expansion of urban sector is endogenous here. As a nation's urban sector expands and benefits from the agglomeration effects, the nation is more likely to see acceleration of accumulation and spillover of human capital, technical progress, and institutional innovation (Lucas 1988 and 1993; Barro 1990 and 1998; Yang and Ng 1999).

The opposite holds if a nation for some reason acquires new land, causing an improved man-to-land ratio. Population will disperse to newly acquired land, causing the expansion of the land-intensive sector, in this case, agriculture, and the contraction of the labor-intensive sector, in this case, the urban sector. This implies that existing urban centers will decline, and as the consequence of losing some of the agglomeration effect, part of the factors such as acceleration of accumulation and spillover of human capital,

technical progress, and institutional innovation that are conducive to endogenous growth will be lost too.

2.3 China's problematic land data

By using geographical endowments and their changes, we also can circumvent the serious problem caused by inconsistency in the Chinese historical data on cultivated land. For example, it is well established that the Sui dynasty was significantly smaller than the Tang in terms of territory (Tan 1982, Vol. 5), and it started in the Tang dynasty, a dynasty after the Sui, that the land in South China started to be reclaimed. However, according to Liang (1980),¹¹ an authority on cultivated land in ancient China, the Sui had more cultivated land than the Tang dynasty. We also know for sure that the territory of the Qing was much greater than that of the Sui (Tan 1982, Vol 5 and Vol. 8). However, according to Liang, the cultivated land in the late Qing was less than half of that of the Sui. Such obvious mistakes can be avoided by using geographical boundaries instead of historical data on cultivated land.

2.4 Main hypothesis and the definition of geographical endowments

The central hypothesis of this paper is as follows. *The Needham puzzle can be explained by the differences and changes in geographical endowments that different civilizations faced in the pre-globalized world.*

This paper emphasizes the role of geographical factors in economic development and technical progress, but its approach is very different from the traditional geographic determinacy for the following two reasons. First, in this paper geographical factors enter

¹¹ I appreciate Liang's effort to comb through all the historical documents in order to get the data on China's cultivated land, and realize that in response to different tax policies under various dynasties, people could underreport their land to evade land taxes.

production and consumption through a nation's long-term budget constraints. Second, since geographical conditions of a specific area determine the initial carrying capacity of a land, and in turn the initial size of a population living on that land, population itself is an endogenous variable. As Lin (1995), Kremer (1993), Diamond (1997), and this paper show, population's size and growth can in turn affect many other factors including technical progress, transportation costs, and communication costs in dealing with neighboring societies. Therefore, while geographical factors cannot be deterministic forces in the formation of culture, institutions, or technologies, because the latter are contingent on many other factors, the geographical factors greatly reduce the range of possible outcomes in these domains. Using Mokyr's term "constrained contingency" ((2002), geographical factors serve exactly as such constraints by restricting the range of potential outcomes available to a society in a specific geographical location. For example, it is much less likely for a Pacific island nation to independently invent a steam engine than for China or India.

Based on such a constrained contingency, we still can argue that certain combinations of geography, topography, location, and climate are more conducive to the emergence of certain cultures, institutions, attitudes, world outlooks, and behavior. They in turn are more conducive to knowledge accumulation, technological breakthroughs, resulting in faster economic growth and development.¹²

¹² Sea-locked Japan evolved in a relatively more isolated environment than China until it came in contact with the Chinese civilization via the Korean peninsula. In contrast, the continental nature of China's geography exposed it to frequent invasions by the nomadic nations from the north and west, but never from the south, an area populated by agrarian nations. Imagine what would have happened had India and the Southeast Asia been grassland or Gobi desert, but north to China been fertile land with sufficient rainfall and big rivers.

III. Geographical endowments and the successive rise of ancient civilizations

3.1 Middle East—the key to the first Needham issue

The answer to the first Needham issue, i.e., why China was not a leading nation in technology before 200 AD, is largely geographical. Using the three criteria of civilization (evidences of a writing system; of urban centers; and of a hierarchical social structure), we immediately see that although the prehistory of China can be traced back to very ancient times, based on the dated evidence of the writing system, the Chinese civilization emerged much later than Sumer and Egypt in the Middle East.

According to Diamond (1997) and Cook (2003), the sequencing of the emergence of civilizations is not a pure accident, but due to geographical reasons. The Middle East as a favorable habitat was the first stop for Homo sapiens on their way out of Southeast Africa. The combined effects of the local climate and soil made this area the cradle for first sustained agricultural revolution and largest population concentration during the late Neolithic era, earlier than any other area on Earth. A larger population accelerated the early emergence of civilization through the positive chain reactions described in Lin (1995), and in more detail in Diamond (1997). The Middle East was not only the first to launch an agricultural revolution, but also the first to enter Bronze Age, about 5000 years ago, at least 1500 years earlier than the Yellow River Valley. The Middle East also entered the Iron Age 3200 years ago, about 700 years earlier than China (Cook 2003 p28). In terms of technology, the Chinese civilization could not have been a leading nation throughout this long period.

3.2 Unique Greek geography

Before answering the second Needham issue, i.e., why modern science only emerged from European culture, we first must ask what conditions are conducive to the rise of science, and we find that geography again provides clues. The spontaneous curiosity

about Nature and logical reasoning, criticisms of conventional wisdom, and challenges to norms and authorities, could happen among all cultures,¹³ but most cultures would not provide the right environment to encourage such critical thinking and rationality.

Ancient Greece was an exception. As Huff (1993) points out, "...the foundations of modern science, both cultural and institutional, are to be found precisely in those areas outside of science where men speculate about the nature of the cosmos, in its deepest and most mystical sense, and where the human imagination forges the institutions that allow individuals to perpetually enjoy *neutral space free* from the incursions of political and religious censors."

The freedom and tolerance that ancient Greeks enjoyed were related to Greek geography to a great extent. Located on the Balkan Peninsula known for its deep mountainous inland, Greece did not have vast plains and big rivers to support a large agrarian population. However, the small and scattered plains along its shores were ideal for the emergence of competing city-states (Cook 2003). None of them had a population large enough to rise quickly to dominate other cities. The unique Mediterranean climate combined with small and scattered plains was not particularly conducive to farming, especially not for grain, a typical land-intensive product.

However, the Greek geography has the following merits. First, the location of Greece was strategic for the exchange of goods and knowledge with the nearby highly matured civilizations in the Middle East at a time when the Greeks were rising out of obscurity.¹⁴

¹³ Approximately at the same time China saw the rise of the Mohist school. This school was interested in logic and scientific questions. However, this school, together with many others, was soon suppressed by the first emperor of the Qin dynasty and was never encouraged by subsequent emperors (Cook 2003 p187).

¹⁴ The influences from outside included the Minoan civilization in Crete that was deeply influenced by Egyptian civilization, the Persian civilization in Asia Minor that inherited much from the Sumerian, Assyrian, and Babylonian civilizations among others, and the Phoenician achievements in the fields of sailing, colonizing, and spelling system, to name a few.

Not only could they provide grain to the Greeks through trade, but also various intellectual stimuli. Second, since most Greek city-states were not self-sufficient in grain, and had to export wine, olive oil, and pottery among other commodities to trade for wheat and other food,¹⁵ the Greek economy, including its farming sector, was to a significant extent connected with domestic and foreign markets instead of being locally oriented. Third, even with food imports, the city-states with their small plain could not accommodate their own population growth. Consequently, overseas commercial activities, adventures and colonization became necessities in the Ancient Greek lives (Bairoch 1988). There was a built-in incentive among Greeks to be outward-looking, to seek information, and to be curious about the outside world in order to secure foreign markets for trade and overseas territory for emigration. The Greeks had plural reference systems provided by the Minoans, Egyptians, Babylonians, Persians, Assyrians, and Phoenicians among others. Many Greek scholars traveled extensively to these civilization centers.¹⁶ Fourth, the Aegean and the Mediterranean played “a mediating and unifying role” (Bairoch 1988 p71) among surrounding civilizations, while also forming natural barriers for foreign powers. This permitted the Greeks a more independent path of evolution. Fifth, a peninsula with only one way out, very similar to an island, tends to screen out intruders, resulting in ethnic homogeneity (Cook 2003). The competing Greek city-states shared the same language, culture, and tradition.

¹⁵ According to Bairoch’s estimation, “...Greece probably had to import a quantity of grain sufficient to support some 20-40% of its urban population, if not more.” (1988 p77)

¹⁶ See, for example, what Herodotus wrote in his famous *History* about his own travel experiences in Egypt and other Middle Eastern countries.

3.3. Answer to the second Needham issue

However, these five reasons can only explain why Greeks rose from obscurity to the forefront of the world arena in a relatively short period of time. The Greek catching-up, while impressive, was by no means unique. Throughout history, numerous nations have risen from obscurity in relatively short periods of time. Those who happened to live next to inspiring civilizations could have very steep learning curves, especially when they were motivated to imitate. China itself witnessed the fast catching-up of numerous nomadic nations living along its northern border. Various nomadic tribes learned almost every technical trick from China in just several hundred years before many of them defeated China on the battlefield.

However, usually the growth in barbarians' knowledge and technology leveled off after catching up. What really made the Greek experience a miraculous exception lies first in the fact that during the classical period, the ancient Greeks leaped forward, leaving other civilizations far behind in terms of technology and scientific thinking, and second, in the fact that the Greeks succeeded in achieving this feat with a relatively small population size,¹⁷ a departure from all the other ancient civilizations. What the Greeks achieved cannot be explained by Lin's hypothesis, but can be by geographical hypothesis of this paper. The unique geography of Greece gave rise to its unique social institutions and organizations. The latter in turn gave the Greeks a big edge over all the other civilizations in acquiring unconventional sources of growth.

¹⁷According to Bairoch (1988 p76), the total population of Greece around 500 BC was about two millions. On average, a typical city-state had a small population of no more than 20, 000. Among the few that had a larger urban center, Athens had the largest population. The urbanization levels of different city-states varied in the range of 15-30%. Obvious, the total population of ancient Greece was easily dwarfed by other agrarian civilizations.

First, Athens and some other Greek city-states adopted democracy. Consequently, truths could be sought openly without the fear of political persecution by kings or priests who often viewed truths as their monopoly. Second, the Greeks benefited from the agglomeration effect that arose from its many competing urban centers. Third, the inherent urge to trade with and colonize other areas around the Mediterranean encouraged not only scholars, but the public at large to be curious about foreign markets, foreign cultures, and foreign ideas in order to get information relevant to commercial interests and colonial enterprises. Fourth, the Greeks must have benefited from gains from trade. Such gains, which did not dawn on any nation until Ricardo explained them in his theory of comparative advantage, are part of the reason why Athens and other city-states with small population and barren land could have completed so many huge public works during the short classical period (510-331 BC). Fifth, the adoption of the spelling system that the Greeks learned from the neighboring Phoenicians must have greatly eased the difficulties in reading and writing, and hence promoted education among Greeks. The human capital of an average Greek citizen must have been higher than his or her counterpart in other civilizations where hieroglyphs, pictographs, or cuneiforms were in use. In the latter case, only a very small upper class, mostly noblemen and priests, could have the leisure and resources to learn and master them. The vast majority was left illiterate and ignorant.

In summary, when the writing system and knowledge were not monopolized by a small upper class, when political institutions were based on democracy, when urban centers attract people of all walks to meet, to deal, to debate, and to participate in public policy decisions, when an economy was market driven and trade oriented, and when competitive

trade and commercial activities demanded fact-based information and accurate accounting, then errors, mistakes, misinformation, superstition, blind obedience, and unchallenged and unaccountable authorities would more likely yield to fearless searches for truth, logic and fact-based reasoning. Such an environment would more likely provide fertile soil for the rise of rationality, scientific thinking, and scientific methodology.

Some of the Greek philosophers such as Aristotle, Euclid, Archimedes, and Herophilus should be referred to as scientists today, because they already knew how to use deductive techniques or fact-based experiments to test refutable proposition in their reasoning and experiments. Logic-based and facts-based critical thinking was the very basis of scientific methodology. In this sense, it is indeed true that the embryo of modern science arose first in ancient Greek philosophy (Yang 2003 p3). This new way of thinking enabled Greece to overcome its small population size to deepen and broaden their epistemic base, which in turn helped them to accelerate scientific and technological progress.

IV. The Elvin hypothesis and the technological explosion in the Song

4.1 The third Needham issue

The answer to the third Needham issue, i.e., why China became a leading nation only in the field of practical technology during the period from the second to sixteenth century AD, according to Lin (1995) lies in the size of China's population when invention was experience-based. However, Lin's hypothesis cannot explain why ancient Greece with a very small population had so many inventions and turned itself into an embryo of modern sciences (Mokyr 2002). His hypothesis also cannot explain why it was particularly in the

Song that China saw an explosion of technological innovations despite the fact the China became the most populous nation in the world since very early on (Maddison 2001).

4.2 Elvin's hypothesis, the H-O theory and the Social Changes behind the Song Miracle

In 1.2 we introduced Elvin's hypothesis, and mentioned that there are problems with his theory too. A first problem with Elvin's hypothesis is factual. He assumes that land area was constant (1973 p313). In reality, China experienced significant fluctuations in its boundaries, and consequently in the availability of arable land. Elvin also assumes that China's population was increasing linearly over time. In reality, China experienced severe losses of population at the beginning of almost every dynasty except for the Song. Combining these two facts, we can see that the man-to-land ratio, instead of rising monotonically, often improved for an extended period before worsening again.

A second problem in Elvin's hypothesis is logical. His hypothesis cannot explain why it was mainly during the Song dynasty when China's population pressure peaked as a result of fast growing population combined with losing large amount of arable land to invading nomads that China made the most profound technical advances (Fairbank and Goldman 2006).

The Song experience is a challenge to either Lin's hypothesis or to that of Elvin's. The following socio-economic changes taking place during that period represented a major breakaway from China's self-sufficient agrarian past. First, China's most important inventions indeed took place during this period (Elvin 1973; Landes 1998; Qi 1999). Second, China reached its highest urbanization level, and the functions of urban centers underwent profound changes during this period. Third, it was during Song that the Chinese government relaxed its monopoly and allowed the private sector to participate in

foreign trade by transforming the money-losing tribute system to a commercially sustainable trade system. Fourth, as a result of these social and economic changes, for the first and last time before the modern era China collected more tax and tariff revenues from commerce and trade than from its land (Fairbank and Goldman 2006). Let's examine the facts in detail and see why it is relevant to introduce the H-O theory and the Rybczynski theorem, given that both Lin and , .

4.3 The external changes in Territory and the consequent change in man-to-land ratio during the Song

Compared with the Tang (618-907 AD), China during the Song (960-1279 AD)¹⁸ lost the control of the Great Wall right at its birth. Hence, part of the North China Plain was lost to northern nomads and the rest of it was exposed to frequent harassment, plunders, and invasions. Many Chinese were forced to migrate to the South from the North to seek security. China eventually lost the whole North China Plain to the Jin in 1127 AD and retreated to the south of the Huai River.

Unfortunately, the plains in the South were much smaller than the North China Plain, and mainly located along the middle and lower Yangtze and its tributaries, separated by hills and mountains. The combined effects of the influx of migrants from the North and the lack of ready-for-use arable land in the South resulted in rising population pressure throughout the Song.

¹⁸ From 907 – 960 AD, the so-called Five Dynasties period, was one of the many times when China split into many small states. But this was the only period when its population was growing continuously. During other periods when China dissolved into many small states, or when an old dynasty's was replaced by a new one, population as a rule plunged significantly.

4.4 Urban expansion and functional transformation

In response to the worsening man-to-land ratio during the Song, as the H-O theory and Rybczynski Theorem predict, China's labor-intensive sector expanded, resulting in the growth of urban population and the rise of service sector. The Song witnessed the highest urbanization level throughout the whole history of China until 1980s (Chao 1995). Kaifeng (Bianjing) and Hangzhou (Lin'an), as the capitals of the Northern and Southern Song respectively, were the largest cities in the contemporary world, boasting more than one million people each. In addition, there were many other large cities, according to Gernet (1962) and Shiba (1975), such as Suzhou, Nanjing, Ningbo, and Quanzhou. They were all internationally renowned manufacturing centers or trade ports with large populations. According to C. Huang (2003), new cities specializing in ceramic production were also emerging along the Fujian and Zhejiang coastal areas during the Song in response to the growing demand for porcelain from overseas, although they were deserted later during the Ming and Qing.

China also saw profound transformation of functions played by urban centers during the Song. In the Tang dynasty and earlier, cities mainly played a political role as national or provincial centers, or as military strongholds. Commercial activities in cities were subject to political or military restrictions. According to Yang (2003, pp 237-238), city authorities before the Song imposed very restrictive rules on business activities. For example, each city designated only a few walled marketplaces for commercial use. Government guards patrolled these places regularly and locked up the gates after the officially designated business hours. There was little life in cities after dark. All the city gates were closed. One needed special permits to move around or to pass through

any of the city gates. Those who walked around without permits were subject to penalty or arrest. Beside the officially designated marketplaces, no other places within a city could be used for commercial activities. Houses could only have windows and doors facing back alleys or small lanes. Along the thoroughfares the city authorities did not allow windows or doors to be installed so no one could have a peep at the movement of officials or garrisons. Even all the lanes and alleys had their own gates, and were locked up after dark. The curfews imposed on cities and the regulations governing the marketplaces, while maximizing the security of cities as political centers or military strongholds, prevented economic and commercial activities from thriving.

During the Song, curfews and regulations of this type were lifted. Commercial activities were allowed in most parts of a city at any time. Residents were allowed to open front doors and windows into main streets and thoroughfares, or convert their houses into shops and stores. The government encouraged the formation of various guilds (Chen and Qiao 1998) because they helped facilitate the collection of commercial taxes. They also played a more positive role in protecting free competition among member firms.

4.5 From money-losing tribute system to mutually beneficial trade system

As Fairbank and Goldman (2006) point out, during the Han and Tang dynasties, China replaced its trade system with the tribute system.¹⁹ However, this tribute system underwent profound changes during the Song. Defeated and humiliated frequently by Liao, Jin, and later by the Mongolians, the Chinese emperors during the Song had few illusions that they were superior to their neighbors, a belief that the Chinese officials and people typically had before and after the Song. Landes (2006) has emphasized this belief

¹⁹ The tribute system actually aimed at political loyalty and the respect China sought from its neighbors. In return, China showered them lavish gifts such as silk, porcelain, and other highly regarded handicrafts. These exchanges often became heavy financial burdens for China.

as one possible explanation of China's failure to learn from foreigners. During the Song period, the fact that China had to pay heavy tributes to northern powers to buy short-lived peace made the Song emperors more pragmatic in their attitudes toward trade and foreign merchants (C. Huang 2003). According to him, China abolished many of the practices typically observed under the tribute system. For example, in order to reduce financial losses, The Song government discouraged its neighboring nations from sending their envoys to China, but encouraged foreign merchants to come in order to raise more tariff revenues.

The government also relaxed its monopoly on international trade, viewing tariff revenues as an important source of income. It allowed the private sector to trade directly with foreign merchants in China or abroad, a policy that China abandoned in the Ming and Qing. In order to share the possible risks inherent to overseas trade, people tried new commercial and financial practices (C. Huang 2003). The lucrative nature of foreign trade attracted people of all walks, from merchants to ordinary people, from officials to generals, even nuns and monks. China had never seen its trade ties so extended as during the Song. Foreign merchants from Korea, Japan, Southeast Asia, India, Arabia, and East Africa came to China via maritime routes. Copper coins, silk, tea, porcelain, and many other labor-intensive manufactured products, and knowledge-intensive products such as books and paintings were among the most sought-after Chinese exports. In return, China imported grain, cattle, timber, minerals, spices and other land-intensive products.

Chinese ships, known for their size and weight, and guided for the first time in the world history by magnetic compasses, regularly visited ports in Southeast Asian and the Indian Ocean (C. Huang 2003). It was also during the Song that China became the first nation

in the world to adopt paper money and put it into wide circulation, a breakthrough in monetization and commercialization. This invention reflected both the growing demand for money, and willingness to base business on trust and credit.

4.6 The Song was searching for a different path from its past

The combined effect of the rising urbanization level, the changing orientation in urban functions, the wider division of labor, prosperous commerce and international trade, the wider use of money including paper money, and the highly visible participation of the private sector in foreign trade, provided a more favorable environment for new inventions during the Song. An increasingly open economy enabled China to start to organize its production in a manner responsive to the changes in its own factor endowment by exploring possible divisions of labor and specialization beyond its borders (but still within the world known to China). Not accidentally, Fairbank and Goldman (2006) point out that China collected for the first time and last time in its long history until the modern era more tax and tariff revenues from commerce and trade than from its land during the Song.

The extensive trade relations with foreign nations also suggest that there could be relatively free exchanges of ideas and information between China and its trading partners. According to C. Huang (2003) many Arab merchants actually chose to live in China's big cities such as Quanzhou. Given the fact that during this period Arabs were keepers of the ancient Greek legacy and were leading the world in many fields (Huff 1993), these exchanges with Arabs and other nations must have provided a favorable and stimulating environment in China for new inventions and innovations, and more importantly, for their rapid applications, a rare phenomenon in China after the Song. As Landes (2006) points

out, most of time in China “the history of advances, ..., is one of points of light, separated in space and time, unlinked by replication and testing, obfuscated by metaphor and pseudo-profundity, limited in diffusion... in effect, a succession of ephemera.”

The Song dynasty was an obvious exception. Of course,

V. Territory expansion and technological stagnation

5.1 The fourth Needham issue

Now let’s look at the possible answer to the fourth Needham issue as to why China lost its technological lead and then, after the 16th century, became a relatively backward nation even in practical techniques. While Western Europe resumed the path once taken by the ancient Greeks characterized by urbanization, democracy, commerce and trade, and overseas colonization, China was induced to retreat back to its agrarian past from the track sought after during the Song. This divergence not only explains why Europe advanced so fast, but also explains why China degenerated into a backward nation so dramatically.

Let’s take a look at the man-to-land ratio after the Song. The subsequent dynasties after the Song (960-1279) are the Yuan (1271-1368), Ming (1368-1644), and Qing (1644-1911). Each of the three dynasties experienced, at least at their early periods, population declines relative to their territory. These trends were the opposite of the Song’s experience.²⁰ China’s man-to-land ratio actually improved throughout the whole Yuan period, most of the Ming period, and from the early to middle Qing for the following reasons.

²⁰ Population in the middle Ming experienced further growth after recovering to the peak of the Song. The Qing repeated the same pattern, although it grew to a much larger population in the 18th century. However, throughout the Yuan, the population never reversed its declining trend.

First, in Table 1 and Figure 1 we can see that throughout the whole Yuan, population continued to decline while China's territory became much larger than that of the Song (Tan 1982, Vol. 7). Second, during the early Ming, China saw a declining population until 1400. Its total population did not surpass the peak of the Song until around 1500 (Figure 1). It is true that the Ming's total territory was smaller than that of the Yuan, but much greater than that of the Song. What the Ming lost were Mongolia and Xinjiang (Tan 1982, Vol. 7), which were never China's main agrarian areas. Compared with the Song, the Ming's territory was much greater, as the country regained the whole North China Plain, part of Manchuria and the whole Southwest. All these regions had favorable climates for agriculture. By pushing the northern border back to the Great Wall and beyond, the Ming secured the North China Plain, the most important agrarian area in China since ancient times. Third, and most importantly, after the middle Ming, land-saving and water-saving crops such as peanuts, potatoes, sweet potatoes, corn, and cotton, were introduced into China and expanded rapidly. This significantly enhanced the carrying capacity of the hilly South and mountainous Southwest, making them the new destinations for large-scale migration. Because of the relatively short growing period, these crops were also suitable for the fertile but cold Manchuria plain.

Combining all these factors, it is safe to say that compared with the Song, the man-to-land ratio during the first half of the Ming (1368 to 1500) was actually improved. Even after then, this ratio did not deteriorate immediately for the following reasons. First, the Ming had a much larger territory than the Song, but its population was about the same as the Song by 1500. Second, given the availability of land and water-saving crops in the

late Ming, the man-to-land ratio would not become much worse until 1600 when its population grew to be much larger than that of the Song.

The Qing had a similar pattern with regard to the changes in its man-to-land ratio. In Table 1, we can see that the population declined at the beginning of the Qing, and it did not recover to the Ming's peak of 160 million until after 1700. Meanwhile, during the Qing dynasty, China's territory was further expanded from what it had been under the Ming's reign. It gained the whole of Mongolia, secured control over Xinjiang, Tibet and its adjacent areas, acquired Taiwan, and expanded and secured its control over the whole of Manchuria. Except for Manchuria, some parts of Xinjiang, and Taiwan, it is true that the other newly acquired or secured territories were not good for China's traditional staple crops of rice and wheat. But when potatoes, sweet potatoes, peanuts, corn, and cotton became part of farmers' choices, these newly acquired or secured territories actually accommodated much of the population who migrated in large-scale from eastern and central China.

This is exactly what the H-O model and the Rybczynski theorem predict. According to them, the acquisition of new territory will lead to the expansion of the land-intensive sector at the expense of the labor-intensive sector. In light of these theories, we should expect to see the spread of population from the center to more peripheral areas in pursuit of arable land. Urbanization levels would decline as a result of the contraction of the labor-intensive sector. During the Ming and Qing, as large amounts of population moved to the vast and newly secured inland and deep mountains at a time when transportation and communication infrastructures were backward, the economy became more inward looking and self-sufficient. The importance of domestic commerce and foreign trade

declined. All these socio-economic changes led to a decline in the nationwide divisions of labor, reduced specialization, reduced levels of urbanization, reduced agglomeration effects, and stagnant technology. Let's look at the empirical data in detail.

5.2 Large-scale migration to the new frontier

From the Yuan on, China saw its population increasingly dispersed, usually from the center to the Southwest, Northwest and Northeast. The linguistic evidence supports this statement. For example, China's Southwest covers a huge geographical area known for high mountains and deep valleys. As the severe differentiation of dialects in China's hilly Southeast²¹ shows, language in the mountainous terrain of China's Southwest should have also highly differentiated. Surprisingly, the dialects prevailing in this area today are very close to Mandarin and can be understood by Mandarin-speakers. Since Mandarin as an accent was formed during the Yuan, and has become the prevailing accent in the North China Plain since then, one can infer that the majority of the local people in the Southwest must be the descendents of those who came from China's Mandarin-speaking areas during or after the short-lived Yuan period.

Beside the difficulties in transportation and communication caused by high mountains and deep valleys, long distance usually also plays a significant role in differentiating dialects from their mother tongue and from each other. However, the accents of the dialects in Northwest and Northeast are very similar to that of Mandarin despite the

²¹ In sharp contrast to China's Southwest, in China's Southeast there are many highly differentiated dialects. The local dialects in Jiangxi, Zhejiang, Fujian, Guangdong, Jiangsu, and Hunan are very hard, if not completely impossible, to understand for Mandarin-speakers today. Although the accent of the local dialects was close to that of China's central area as late as during the Tang, the mountains, valleys, long distances, and long intervals of separation from their mother tongue made these dialects very different from each other, let alone Mandarin, in their accents.

remote distance. This fact suggests that the local population in China's Northwest and Northeast were descendents of more recent migrants from Mandarin-speaking areas. Historical documents show that during the Yuan, Ming, and Qing, there was large-scale migration. First, in response to the depletion of the population in the North China Plain by wars and nomadic invasions, the early Ming emperors forced the populations of some big cities in the lower Yangtze (the most developed area in contemporary China) to move to the North (Chen and Qiao 1998 pp24-25). As population pressure built up in China's central area, more people were driven into more hilly or mountainous areas in Southern Anhui, Western Hunan, Guizhou, Guangxi, Yuannan, and Sichuan during the Ming. During the Qing, as the population pressure built up again in central China, many moved to the Northwest (the Central Asian part of China) and the Northeast (Manchuria).

5.3 Declined urbanization level

China's urbanization level, from the peak of 22% during the Song fell to as low as 9% in the late Qing (Chao 1995).²² China also saw the relative stagnation of its large urban centers compared with Europe. For example, although China was known as the home of some of the largest cities in the world during the Song, such as Kaifeng, Hangzhou (Lin'an), and Quanzhou,²³ and despite the fact that China was the most populous nation in the world, between the period 1500-1900, not even one of the ten largest cities in the world was located in China.

²² Elvin (1973), Skinner (1977), and Bairoch (1988) also notice the reverse in China's urbanization level since the Song.

²³ Bairoch quotes a great Arab traveler and writer as saying that Quanzhou during the 13th century to 14th century with a population of 500,000 was the largest port in the world. However, according to Bairoch, its population shrank gradually to an extent that it was "practically vanishing by the mid-nineteenth century." (1988 p354)

No wonder that Fairbank and Goldman (2006, p.172) feel “strange that after the Song cities of Kaifeng and Hangzhou were established, no great cities of over a million emerge in China until the nineteenth century.” If big cities symbolize a higher level of division of labor and specialization, the stagnation in the growth of big cities certainly indicates stagnation in the deepening of division of labor and specialization of the Chinese society. As population dispersed to the vast inland, as predicted by the H-O theory, the household industries also spread from coastal areas to the vast, formerly underdeveloped inland to overcome the increasing transportation and communication costs.

In response to the inward movement of population, and the “ruralization” (Chao 1995) or “familization” (Phillp Huang 1991) of handicraft industries, China saw the emergence of numerous small towns in its vast inland to cater to the needs of the localized marketing, production and regional interactions (Skinner 1977).

5.4 Zheng He’s voyages and the closed-door policy

It is well established that throughout most periods of the Ming and Qing, China followed a closed-door policy (Fairbank and Goldman 2006) with two exceptions. The first was during the period 1405-1433 when Zheng He, with support from Emperor Yongle, mounted seven naval expeditions to Southeast Asia, South Asia, the Middle East, and East Africa. The second exception was during the late Qing when China was forced to open five seaports to foreign trade in 1842 after the first Opium War. In between these two historical events, China only opened its doors briefly several times throughout most of this long period. Foreign merchants were only allowed to visit Guangzhou as a special favor. They were not permitted to live in Guangzhou permanently, let alone travel around or reside outside Guangzhou. By confining foreign merchants to the small quarters of

Guangzhou, the vast majority of Chinese were never exposed to new ideas or new products from the West except for a few things such as the drug opium.

Zheng's grandiose voyages themselves have very limited impact on China's economy, ideology, and institutions. Zheng's adventures were remembered mostly for the large number of and the huge size of his boats, the massive size of his entourage, the lavish way in which he showered gifts on various local authorities that he met during his voyages, the maritime distance that his fleet covered, and the historical fact that China reached East Africa ahead of Europe. While it is truly a remarkable achievement by China to have launched these voyages, they left almost no imprint on China's economic development, financial and trade institutions, geographical or anthropological discoveries, or philosophical outlook. Not motivated by commercial incentives or scientific curiosity, Zheng, in sharp contrast to the Song's merchants and the later European adventurers, did not find any worthwhile trade opportunities in this vast area except for some exotic birds and animals. Politically, Zheng accomplished a lot in restoring the reputation of the Celestial Empire which had been stained by the "barbarian Mongolians" during the Yuan, and in reviving the tribute system. Geographically and economically, Zheng accomplished little, not even finding any land or a maritime route unknown to the Arabs or Indians. Ranking officials at the imperial court sharply criticized his voyages as a waste of the nation's treasury. Mainly for this reason, China not only stopped sending any more fleets abroad after Emperor Yongle passed away, but also burned all the blueprints of the ships and the maritime maps used by Zheng. China also prohibited non-official trade with foreign nations, and put foreign trade once again under the yoke of the tribute system as in the Han and Tang, an unfortunate setback from

the path that the Song's China was taking. The question is, how could China do so without triggering shortages of food or even causing famine? The answer lies in the fact that, different from the Song's China, China in the Ming and Qing had greatly expanded land territory.

By the late Qing population pressure was rising again and there is evidence that China was looking for a way out of the agrarian trap. But it was already too late. In the period after the 16th century, Western Europe resumed the path of overseas trade and commerce that the ancient Greeks once explored but stopped. During this period in China, however, after having greatly expanded its continental territory and improved its man-to-land ratio for extended intervals, the nation seemed to be trapped in agrarian society.

Interestingly, the timing of territory expansion seems very important for a nation to accelerating or delaying transition to a modern society. For instance, Portugal and Spain greatly expanded their overseas territory in America since the 16th century without first having their home political and economic institutions fundamentally changed. Therefore, they basically duplicated from their home the hierarchical social structures in the colonies, resulting in the consolidation of the privileges enjoyed by elites at home and overseas, and a much slower transition to become modern and developed societies both in Portugal and Spain, and in many Latin American nations compared with Canada and the US. The latter two were once colonies acquired by the Great Britain at a time when it already had profound social and economic changes that eventually led to Industrial Revolution, accelerated urbanization, and the gradual expansion of voting rights among its citizens. According to Sokoloff and Engerman (2000), these two nations represent a sharp contrast with many of the Latin American nations, the relative equity in human capital through

public schooling, political rights, and more equal land distribution among citizens greatly facilitated faster economic growth, social equity, and more successful social transition in the US and Canada. Russia represents another interesting case. It acquired a large amount of continental territory under the Tsars since 16th century in Eastern Europe, Central Asia, and Siberia. According to Domar (1989)

VI. Concluding Remarks

As China is poised to become the next economic superpower, interest in the Needham puzzle has been revived. China's past experience indeed looks dazzling and puzzling at the same time. Rising from obscurity to become the world leader in technology in the second century AD, it held this title for the next 14 centuries. China then slipped into the lamentable status of one of the poorest nations in the world in the following few centuries.

Scholars turn to different hypotheses to explain the causes of this slippage, such as China's conservative and introverted culture and traditional values (as reflected in Confucianism), xenophobic attitudes to non-Chinese things, repressive bureaucracy and autocracy, mind-binding civil service examinations, lack of diffusing and supporting institutions, Western imperialism, or the worsening man-to-land ratio. All of them have various degrees of explanatory power, but except for the last two, all of them are endogenous and shaped by some underlying variables. For example, Confucianism was often cited in the past as a negative factor in causing East Asia's backwardness; but now it is often cited as a positive factor in cultivating work ethics and respect for authorities that led to East Asian Miracle. Such contradiction greatly weakens the explanatory

power of culture as a convincing variable. The case of the Song dynasty shows that the Chinese were willing and able to change their values, attitude, and behavior when some fundamental variables such as the geographical factors changed.

The only two hypotheses listed above that could be viewed as exogenous or quasi-exogenous are Western imperialism and the worsening man-to-land ratio. To be fair, Western nations did not exert major impacts on China until 1842 when China was defeated and forced to open at the end of the first Opium War. By then China had long lost its technological lead, therefore, this hypothesis is irrelevant logically for our purpose. The other hypothesis, often cited as Elvin's hypothesis of high level equilibrium trap because it is based on worsening man-to-land ratio, also cannot answer the question of why it was exactly during the Song dynasty when the man-to-land ratio was sharply worsened that China achieved most impressive technological advances. Elvin's hypothesis also cannot explain why China failed to achieve major technical progress during the period from the early Ming to the middle Qing when its social surplus should rise as a result of its greatly expanded territory, the availability of land-saving and water-saving crops such as corn and potatoes from the new continent, but population was yet to explode. It seems that without having the social-economic institutions changed first, such as one sees in the Song period, or in ancient Greece, or in England since the medieval period, the increased availability of social surplus tends to be translated into population explosion everywhere, as Malthus predicted, and the Elvin hypothesis implies. Therefore, it is important for a nation to achieve faster technical progress to have institutional and social structural changes first.

Based on the implications of the H-O model, the Rybczynski theorem, and the endogenous growth, particularly the agglomeration effect, this paper uses geographical endowments and their exogenous changes through the changes in a nation's boundaries as its main explanatory variables in explaining why a nation's socio-economic will undergo changes, even unconsciously. This is because geographical endowments and their exogenous changes in a nation's boundaries can shape endogenous variables such as a nation's culture, ideologies, attitude, institutions, and technologies through a nation's budget constraint, but cannot be shaped by them in return. Through its interaction with population, and through budget constraints, geographical variables also interact with other variables in its production function or utility function by limiting their possible outcomes through what Mokyr called constrained contingency. Therefore, geographical endowments in this paper are not deterministic, but will increase or decrease the likelihood of certain direction that a nation will take in a period when globalization had not started yet and each nation was still live in relative isolation.

This approach sheds new light on the experiences of the Song dynasty and the subsequent dynasties. As China gradually lost the North China Plain to the invading nomads and migrants flooded to the South from the North during the Song, its population pressure rose sharply against shrinking taxable land acreage. The heavy burden to finance wars and the need to pay indemnity to invading nomads triggered profound social-economic changes. China was forced to depend less on agriculture and land taxes, and thus forced to transform its society into a more urban and commercial one. The Song not only saw a rising urbanization level, deepening divisions of labor, and extended trade ties with overseas nations, but also was experiencing the transformation of urban functions. Cities

as bureaucratic and military centers with various restrictions on commercial and civilian activities before the Song evolved into more commercially and manufacturing oriented centers that were more open and friendly to ordinary people's business and other activities. Even the tribute system, once tightly monopolized by the government before the Song, was induced by the prospect of lucrative tariff revenues to open up to allow the participation of the private sector and foreign merchants. All these changes point to the fact that China during the Song was experimenting, although unconsciously, with a new path as a response to the unfavorable changes in its geographical boundaries. In retrospect, we can see that this path was different from China's past to a significant extent, thus full of unknown risks and resistances. We will never know what would have happened had the fragile peace between the aggressive Mongolians and the commercially prosperous but militarily weak Song been somehow maintained for a protracted period. This paper is not claiming that had the Song succeeded in keeping the peace for a much longer period, since the Song had more advanced weaponry than the nomads, China would have achieved Industrial Revolution independently and much earlier than England, because many of the necessary conditions for the Industrial Revolution were still missing in that region at the time. But we can speculate that, given the continued population growth against very limited arable land available to it, the Song might seek more grain import from the neighboring countries such as Vietnam and Thailand and other Southeast Asian nations. The firms in the labor-intensive sector would further expand their production and export. In doing this, they would hire more laborers, new firms of the type would also rise and grow. These firms would also locate themselves closely to each other through try and error to benefit from the agglomeration effect. The concentration

of large number of firms, their laborers, and their family members would also give rise to a growing service sector. The same multiplying effect would take place within the service sector. Obvious, this would lead to an even higher level of urbanization. No one would know where this gradual transition from a rural society to a more urban society, triggered by the reduction in geographical boundaries, would lead to. However, as long as this transition were not stopped by exogenous forces, it would have been more likely, although not necessarily, to give rise to new technology, new financial arrangements, and new institutional innovations, just as what we see in the form of explosion of new technical and institutional inventions in the Song.

The conquest of the Song by the Mongolians made the evolution toward this direction much less likely not only because the racially highly hierarchical and abusive regime under the Mongolian rule, but also by the subsequent changes in China's geographical boundaries that actually greatly improved the man-to-land ratio for the whole Yuan, most of the Ming and from the early to middle Qing. This improved ratio induced China to return to the much safer and more familiar agrarian past. As the H-O model and the Rybczynski theorem predict, during the Ming and Qing the population became more spatially dispersed to its newly acquired territory. Meanwhile, the urbanization level fell and big urban centers shrank. China became inward looking with little interest in foreign trade and overseas exploration, as evidenced by the fact that China resumed the tribute system and closed its door to most foreign merchants during this period. Consequently, the levels of division of labor and specialization fell, and technology became stagnant at a time when Europe switched its mode of innovation from experience-based one to experiment-based one, as Lin correctly points out.

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Table 1
China's Demographical Changes from AD 1 to 1900

Year	Population (in thousands)
AD 1	59,595
960 (the first year of the North Song)	55,000
1280 (the end of the South Song)	100,000
1380 (towards the end of Yuan)	68,000
1400 (early Ming)	72,000
1480	116,000
1490	98,000
1500 (middle Ming)	103,000
1600	160,000
1640 (late Ming)	130,000
1650 (early Qing)	123,000
1700	138,000
1720 (middle Qing)	177,800
1750	260,000
1800	341,600
1850	412,000
1900 (towards the end of Qing)	400,000

Source: Based on Table D.1, Maddison, 1995.

Figure1
Changes in China's Population from AD 1 to 1900

