

# **The Future Effects of Population Growth and Resource Scarcities on China's Economic Development**

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April 2007

College of the Holy Cross  
Economics Department Honors Thesis  
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I would like to extend special thanks to my advisor, Professor Thomas Gottschang, for his insight and guidance throughout the course of this research. I extend additional thanks to Professor Miles Cahill, for his leadership in the honors program, and his continuous support throughout the writing process.

## **Abstract:**

The death of Mao Zedong in 1976 represented a turning point in Chinese history, both politically and economically. In a state of economic uncertainty, Chinese leaders looked to the future and the prospect of developing China into a recognized world power. The period from 1978 through the present is often regarded as a transitional period in Chinese history, as leaders sought to develop China into an efficient, industrial economy. This paper examines the rapid economic development of China over the last twenty-eight years and the economic repercussions of these reforms. The paper then examines the current state of China's economy and the feasibility of sustaining similar levels of growth in the future. Chinese economic advisors have stated a goal to triple the size of their economy by the year 2020. This paper employs sustainable development models and a neoclassical growth model to refine China's potential growth forecast in light of endogenous factors such as resource scarcities and population growth inherent to the Chinese economy. This paper concludes that population growth and resource scarcities will not impede China's immediate goal to triple the size of its economy by 2020, but will hinder future growth when China converges to Solow's steady state economic model.

## **I. Introduction**

Since 1978, the Chinese economy has experienced a 9.41% average annual real GDP growth rate and an 8.1% annual real growth rate in per capita terms. As of 2005 the purchasing power parity index (PPP) measure of GDP ranked China's economy as the second largest in the world (Chen 2004). The transition from central planning to a

thriving market-based system has earned China respect as a world power, evidenced by its acceptance into the World Trade Organization in 2001. However, to assess the feasibility of the Chinese economy sustaining such growth, economists have carefully analyzed this transitional period, differentiating the successful reforms from inefficient practices that still remain in the urban and agricultural sectors. Chinese economic advisors have stated a goal to triple the size of the economy by the year 2020, reaching a per capita GDP level of 3,000 U.S. Dollars (USD), by maintaining an annual real GDP growth rate of 7% (Chen 2004). This paper assesses the feasibility of sustaining such growth, in light of resource and population constraints inherent to the Chinese economy. This study finds that given China's current economic conditions, it is theoretically feasible to reach this projection by 2020; however, in the long run, China will eventually converge to a steady state economy where such growth is no longer feasible.

The paper begins with a historical overview of the formation of China's centrally planned economy and the reform period after the death of Mao Zedong. Several strengths and weaknesses of China's economy are discussed in order to highlight potentially troublesome areas in the context of future economic development. An analytical section follows which combines demographic theory with sustainable development models to forecast China's potential growth trajectory. Initially, a rough calculation is made to forecast when the Chinese economy will grow to the size of the U.S. economy, both in terms of total real GDP and per capita GDP. This provides a preliminary projection of China's convergence to a developed, steady state economy of an established world power. The model assumes constant returns to scale, subject to no growth constraints and provides a best case scenario for the Chinese. The feasibility of

this growth is then analyzed in the context of demographic theory and a sustainable development model, using available data reported by the World Bank and *The China Statistical Yearbook*, incorporating factors such as projected resource use and labor force volatility. Finally, the Solow growth model is used to address growth feasibility from a purely theoretical perspective and will speak to the question of whether or not China's current economy can sustain such high levels of annual growth in the long run (Jones 2002).

## **II. Literature Review**

### *The Communist Revolution: The Development of China's Planned Economy*

The Communist Revolution in 1949 initiated drastic social and economic reforms for the Chinese people. Mao Zedong, the first communist leader of China, initially intended to create a centrally planned economy in an attempt to expand China's industrial sector and to rid its agricultural sector of the vast income disparities that threatened relations between the landlord and peasant classes. By mimicking the Soviet model of a centrally planned economy, Mao sought to industrialize China by taking advantage of its agricultural sector. He intended to keep the prices of industrial inputs, produced in the agricultural sector, artificially low by forcing farmers to abide by state dictated prices, which were set significantly below the market value. With regard to China's economic transition, it is important to note that the rural and urban sectors are often treated separately; whereby reforms are often designated for one sector or the other. Mao began this transformation to a planned economy in the industrial sector, with the creation of State Owned Enterprises (Bramall 2000).

State Owned Enterprises (SOEs) were created to industrialize China and offer employment opportunities to the Chinese public. SOEs produced goods sold at state-dictated, as opposed to market-dictated, prices; however, they proved to be extremely inefficient for a number of reasons. Since prices did not reflect resource scarcities, inputs to production were used inefficiently. Due to a lack of incentives, or vested interest by the individual SOE managers, there was no reason to produce at the least cost level. In fact, it seemed that the purpose of the SOEs was to provide employment rather than to efficiently produce output. An abundance of surplus labor was hired for the sake of creating work, in an environment where the workers faced no repercussions for shirking on the job. Predictably, the SOEs ran into considerable financial difficulties (Bramall 2000).

In Mao's early years, agricultural concerns were given much less attention, mainly because Chinese officials intended to keep their developmental focus on the industrial sector. The initial agricultural reforms, however, did institute a new system of land distribution. By redistributing over forty four percent of the land from rich landlords to poor farmers by 1950, the common farmer was encouraged to join a cooperative system to maximize labor productivity and encourage specialization. However, in the coming years, Mao would not be satisfied with the progress of China's overall economic performance, forcing him to reconsider the original development plan (Du 1995).

In 1958, Mao announced the start of The Great Leap Forward, which constituted an effort to develop China's agricultural and industrial sectors simultaneously. In these five years, Mao sought to capitalize on China's abundance of inexpensive labor to ultimately develop China into a superpower in the global economy. The plan called for

the elimination of private plots in the agricultural sector, and the creation of Communes. Serving as massive collective enterprises, the Communes intended to increase agricultural and industrial output through specialization in labor, as opposed to the costly alternative of investment in capital. In retrospect, the Great Leap Forward crippled the Chinese economy. During these five years, China experienced devastating droughts, a national famine, and the deaths of millions of farmers (Du 1995).

After the Great Leap Forward (1958-1962), the Chinese government saw the need to redevelop its farming industry and consequently pledged full support to the agricultural sector, particularly to areas which suffered the greatest devastation. Reforms began in 1962 when the government raised state procurement prices for agricultural products. Previously, these prices rested well below equilibrium market prices, resulting in considerable financial difficulties for farmers. In the mid 1960's, government funding for agricultural investment also increased by about fifty percent to further revitalize the farming sector (Du 1995).

In the late 1960's Mao called for a "Cultural Revolution" to enlighten the Chinese people and rid them of class structure. The result of the Cultural Revolution (1966-1976) was disastrous in light of China's development, ultimately cutting aggregate production by nearly twenty percent. In a long term perspective, the Cultural Revolution denied the younger generations the opportunity to pursue a higher education, cutting down the eventual expertise of future Chinese intellectuals (Altschiller 1994).

Mao Zedong undertook an ambitious agenda of economic and social reforms, which in retrospect did not develop China's economy to its potential for various reasons. In an attempt to rapidly develop the industrial sector, Mao overlooked several economic

factors that could have magnified China's growth, had they been considered in the original development plan.

*Failures of China's Planned Economy: Abandoning Mao's Plan*

Bramall (2002) suggests that the failures of these plans resulted from the adaptation of the Soviet's centrally planned economic model. The prevailing conditions at the time in China were drastically different from those in the USSR. The USSR was able to develop a relatively efficient, industrial economy as a result of two main factors: a wealth of preexisting capital, and a relatively small population, whereas China had very little accumulated capital and a large and growing population. In fact China relied heavily on its agricultural sector to carry the burden of its economic needs.

Under Mao, China's comparative advantage in production was found in its large and ever increasing population. In a minimally industrialized economy, like China in 1949, accumulating capital proved to be extremely expensive and inefficient because it relied largely on foreign investment. Ideally, a greater emphasis initially needed to be placed on labor intensive industries to capitalize on China's surplus of inexpensive labor. From there, a gradual progression could have been made to accumulate capital slowly, as productivity increased. This would have been an effective way to create jobs, establish China as a contender in the global market, and finally lay a foundation for further expansion through the incremental addition of foreign capital. Instead, China skipped over these intermediary steps to immediately form its State Owned Enterprises (Bramall 2000).

*Public Discontent: The Transition after Mao*

The death of Mao in 1976 left the Chinese public in a state of great concern, as unemployment was alarmingly high, the standard of living for the average Chinese citizen bordered on subsistence levels, and political corruption tainted the entire political structure of the Communist Party. Under the leadership of Hua Guofeng, Chinese leaders were forced to compensate for the failures of the Cultural Revolution.

After the incarceration of the Gang of Four (1976) and the official termination of the Cultural Revolution, the Eleventh National Party Congress confirmed the appointment of Hua Guofeng (1977) as the party chairman, with Ye Jianying, Deng Xiaoping, Li Xiannian, and Wang Dongxing as vice chairmen. The Party Congress placed the blame of the Cultural Revolution on The Gang of Four and stated officially that, “The fundamental task of the party in the new historical period is to build China into a modern, powerful socialist country by the end of the twentieth century”. Within two years, Deng Xiaoping would be selected to take over as party chairman. (Library of Congress).

The years following Mao’s death consisted of a scattered effort to rejuvenate the Chinese economy. While certain party members believed in the theory of self reliance, others insisted that China participate in the global market in order to increase its efficiency and properly allocate its resources. Deng Xiaoping intended to make these goals a reality by rectifying industry, agriculture, transportation and energy, all of which suffered the drastic consequences of the Cultural Revolution. The Ten Year Plan, in 1978, called for these sectors to be nationally run and regulated. The plan called for a massive increase in foreign investment, more than doubling China’s imports from \$9.75 billion USD to \$23.1 billion USD. Imports were intended to develop the energy industry,

as petroleum production held the key to economic success, particularly in offsetting the import costs of entire factories from overseas (Bramall 2000).

Unfortunately, the Ten Year Plan was riddled with faulty assumptions, flawed logic and unrealistic expectations. Contrary to the beliefs of Chinese leaders, China was not rich in oil, crippling the backbone of their development plan. In fact, initial estimates overestimated China's petroleum reserves by over one hundred percent. The failure to more accurately predict petroleum output forced Chinese leaders to reevaluate the Ten Year Plan. Without the revenue that was expected to come from oil exports, the government could not financially support the various projects it originally endorsed, particularly the construction of new factories. Having realized that a specific, chronological development plan was not realistic for the Chinese economy, leaders adapted a more flexible approach, an approach that would change as time went on. Upon the abandonment of Ten Year Plan, in 1978, China entered what is now known as the Reform Period (Reynolds and Kim 1988).

#### *The Reform Period (1978-Present): Agricultural Reform*

During the reform period, the Chinese intended to build on the previous successes of agricultural reform with a gradual restructuring of the entire agricultural sector. Chinese planners instituted three main steps that helped convert China from the failures of the commune system, to the preliminary forms of household farming and open markets. Initially, plans called for a drastic restructuring of the pricing system, specifically with regards to state procurements. These prices were readjusted to more accurately reflect resource scarcities. Secondly, more households were given the option to exercise greater autonomy with regards to production management decisions, through

a household quota system. Rather than commune directors prescribing set crop allocations, households finally had the flexibility to adapt production decisions to fit changing weather and growing patterns. Finally, the most monumental step pertained to the legalization and expansion of free markets, providing further incentives for farmers to produce above state dictated household quotas, and to sell surplus crops at premium, open market prices. By 1987, free markets in China represented almost twenty percent of domestic agricultural sales (Du 1995).

Several of China's agricultural objectives had been realized by the late 1980's, including transferring production decisions to the household, increasing labor productivity and transferring surplus agricultural labor to non-agricultural industries. However, even today, amidst the success of the agricultural reform period, there still exist several hindrances within the agricultural economy curtailing potential future expansion. Economists argue that procurement prices still do not entirely reflect open market prices, government investment in agricultural technology could still be much higher, and input distribution mechanisms are still relatively inefficient.

As Feng Qihua noted in *China Daily* (2002), China's entry into the World Trade Organization in 2001 could spell disaster for China's agricultural sector. With the enactment of the household contract system, farmers tend to think and produce on a smaller scale. However, to compete in the global market, and keep prices competitive, Chinese farmers will have to look to cooperative production efforts, to encourage specialization and produce with economies of scale. A Chinese farmer contracts on average one quarter of a hectare of land, in comparison to American farmers who each have, on average, more than 73 hectares of land. Clearly, China's competition can

produce at much lower costs, which could force China to reevaluate its land distribution system in the very near future (Feng 2002).

*The Reform Period (1978-Present): Industry*

State enterprise reform consisted of two main phases. Mimicking the successful reforms in the agricultural sector, leaders initially carried out a gradual restructuring of incentives for enterprise managers and an enhanced role of the market in determining prices. From 1979-1980, enterprise managers were given increased authority over the allocation of resources and the delegation of profits. For the first time, profits could be rolled over into additional capital investments, or divided among employees in the form of bonuses. By the early to mid 1980's, the preliminary stages of privatization began to take shape as the contract system was enacted, allowing surplus production to be sold in an open market environment. Managers were allowed to retain profits on surplus production, providing incentives to produce at the least cost level.

In 1993, China experienced the preliminary forms of diversified enterprise ownership, which created the market competition that state ownership lacked. Finally, in 1997, smaller SOEs began to privatize, as many larger SOEs converted to limited liability or publicly traded companies, with shareholders actually owning the company. It is important to note, however, that China has no intention of privatizing all of its industrial firms, as SOEs still constitute a major portion of industrial production (Bramall 2000).

Much like the criticism of China's current agricultural inadequacies, its industrial sector continues to be the subject of similar criticism. Lixin Colin Xu (2005), an economist for the World Bank, did extensive research on China's industrial labor redundancy, defined by workers with a marginal product of zero. In order to empirically

estimate the extent to which labor redundancy persists, Xu (2005) derived a production function encompassing total factor productivity, the common rate of productivity growth, the number of employees in a given province, total capital stock, and a conditional variable to represent any random shock to productivity that could not be explained by the previous variables. After running a variety of regressions, Xu (2005) determined that if all redundant labor across provinces were to be released the average unemployment rate could reach a level as high as 25%.

Taking this work one step further, Xu (2005) derived representative functions for the supply and demand of labor within the Chinese economy. Xu then regressed the supply and demand functions against several endogenous and exogenous variables, arriving at a few conclusions: a one standard deviation increase in schooling decreased unemployment by 19%; a one standard deviation decrease in labor redundancy would increase unemployment by 9%; changes in economic growth, trade, or foreign direct investment (labor demand factors) had no effect on unemployment figures; and finally a one standard deviation increase in the private sector raised unemployment by nearly 20%. These statistics allude to a major problem facing Chinese industrial employment, in that the causes of unemployment have very little to do with the market demand for labor due to growth, trade, and foreign direct investment, rather they are directly correlated to the inefficiencies of SOEs. Although China has made great strides in its industrial development, Xu (2005) alludes to potential problems within the industrial sector that may impede future growth, such as the labor surplus and the inefficiency of SOE workers. Despite China's unprecedented industrial progress, it currently remains the focus of several socioeconomic concerns.

### *Economic Consequences of Industrial Reform*

The privatization of the urban sector of China's economy brought forth several economic and socioeconomic consequences. Aimin Chen's (2004) socioeconomic analysis of the reform period offers valuable insight into the problems associated with the transitioning economy. However, the economic analysis fails to differentiate between short and long term consequences on issues like unemployment. Profit-driven entrepreneurs will not employ surplus labor when additional workers offer low marginal productivity. However, on the aggregate level, unemployment is not necessarily a negative consequence; it can actually mobilize resources in a positive manner. By terminating those who are not capable of carrying out their duties in a specific industry, it allows workers to pursue lines of work where they will be more productive. Furthermore, by releasing surplus labor, production costs inevitably decrease, leading to a lower consumer price in China's emerging open markets. Therefore, it can be argued that the privatization trend greatly benefited the consumer and contributed to the increased social welfare of China (Yabuki and Harner 1999).

Chen (2004) argues, however, that the negative socioeconomic repercussions outweighed the economic progress of China during this period. Firstly, due to accountability standards that workers are now being held to, the intensity of the workload for the urban worker has increased dramatically. Since many workers are no longer employed by the state, the marginal productivity of each laborer is being closely monitored, to ensure that each worker's contributions to the firm outweigh the cost of their wage. Therefore, the accountability standards that were implicitly established with privatization drastically changed the nature of work, as employees are being forced to

compete with other workers for jobs, knowing that a sub par performance could leave them unemployed. Clearly the privatization trend has greatly increased the efficiency of Chinese industry; however, the privatization trend has drastically altered the nature of work in China, as well as the annual levels of unemployment, problems which will certainly factor into future economic development (Chen 2004).

#### *China's Current Economic Status*

As noted earlier, reform programs have developed China's current economy into the second largest in the world, using the purchasing power parity measure of GDP. Per capita annual consumption has increased from 437 Yuan in 1985 to 3611 Yuan in 2005. The level of savings has seen an equally dramatic increase from 153 Yuan per capita in 1985 to 5780 Yuan per capita in 2005 (World Bank 2005). Although this increase in savings can be attributed directly to a loss of job security, it is also due to a greater return from saved funds, an increase in disposable income as more Chinese are now claiming wages above the subsistence level, and a greater accessibility to developing financial markets. China has experienced an increase over the last twenty eight years in areas such as life expectancy, literacy rate, and enrollment figures for school aged children (Chen 2004). Finally, China's economic development has allowed it to become a major factor in the global economy, exporting almost 600 billion USD in 2004, with a trade surplus of 31.95 billion USD (World Bank 2005).

It is clear that China made remarkable strides in both economic and socioeconomic growth over the course of this transitional period. However, there remains much work to be done to modernize the Chinese economy and allow for future growth (Chen 2004). Having taken a deeper look at China's transitional period, many

economists have been intrigued and stumped by the question of whether or not China can sustain such growth patterns. This will be the focus of the analytical section of this paper.

### **III. Forecasting Economic Growth: Analytical Framework**

#### *Preliminary Estimates*

The analytical section of this paper begins with a comparison between China and the United States, in order to compare the development path of China to the development path of an established economy. This will highlight China's past economic growth, and draw attention to the obstacles it will likely encounter in future years. First, a calculation of potential real GDP growth will indicate when the aggregate size of the Chinese economy may resemble the overall size of the U.S. economy. This measure will then be used to calculate the year when per capita GDP in China could equate to that of the United States. This calculation assumes a 7% annual real GDP growth rate for China, as anticipated by Chinese economic advisors and a projected average real GDP growth rate (2.94%) for the United States, provided by the World Bank. The calculations begin with each country's GDP in 2005, and uses projected real growth rates, not PPP figures. These growth rates will be assumed to be the future growth rates in China and the United States, subject to no diminishing marginal returns or growth constraints. This calculation will provide an estimated growth trajectory for China in relation to a developed economy under steady state conditions. It will later provide a valuable comparison measure to a more accurately estimated long run, steady state model, which will illustrate the magnitude of potential future growth constraints. A basic Neoclassical model will

highlight the potential short run effects that population growth and resource scarcities could have on China's growth trajectory, helping to identify a potential time frame as to when China could converge to a steady state and begin to experience diminishing marginal returns, ultimately hindering overall economic growth.

The convergence of China's and the U.S.' aggregate growth trajectory can be derived from equation (1). The Chinese projected growth rate,  $\alpha$ , is set to 7%, as identified by Chinese leaders.  $Y_{China}$  represents the size of China's current economy, roughly 1.9 trillion USD. The U.S. projected growth rate,  $\beta$ , is set to 2.94%, which represents a projected real GDP growth rate.  $Y_{USA}$  represents the current size of U.S. GDP, roughly 11.7 trillion USD.

$$Y_{China} (1 + \alpha)^x = Y_{USA} (1 + \beta)^x \quad (1)$$

$$x = 47 \text{ years}$$

As calculation (1) indicates, the U.S. and Chinese aggregate economies will converge in roughly forty seven years, at a dollar amount of approximately 46 trillion USD if they maintain their expected growth rates. This takes into account no considerations of population growth or resource availability. Graphically, it is clear that China's unusually high exponential growth factor, 7%, has its greatest effect starting in the late 2020's.

The convergence of China's and the U.S.' per capita growth trajectory can be derived from equation (2). The Chinese projected growth rate,  $\vartheta$ , is set to 7.3%, as identified by Chinese leaders.  $Y_{China}$  represents the size of China's current per capita production, roughly 1,709 USD. The U.S. projected growth rate,  $\pi$ , is set to 3.3%,

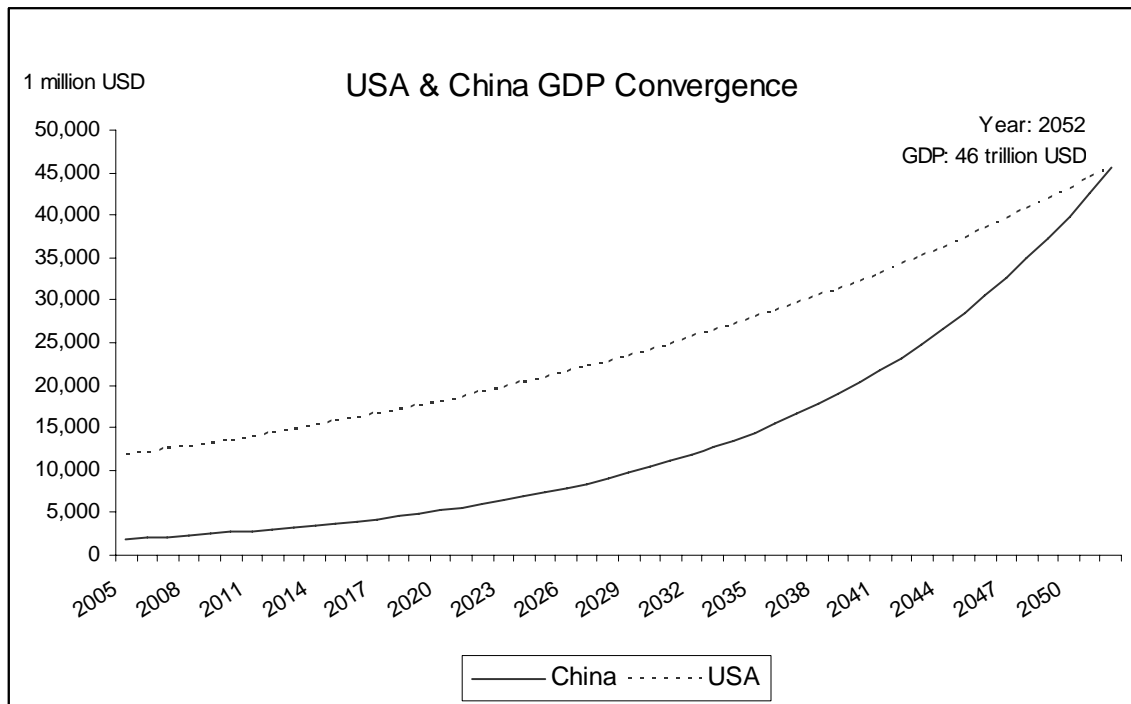
which equals a five year running average of per capita GDP growth.  $Y_{USA}$  represents the current size of U.S. per capita GDP, roughly 42,000 USD.

$$y_{China}(1 + \rho)^x = y_{USA}(1 + \pi)^x \tag{2}$$

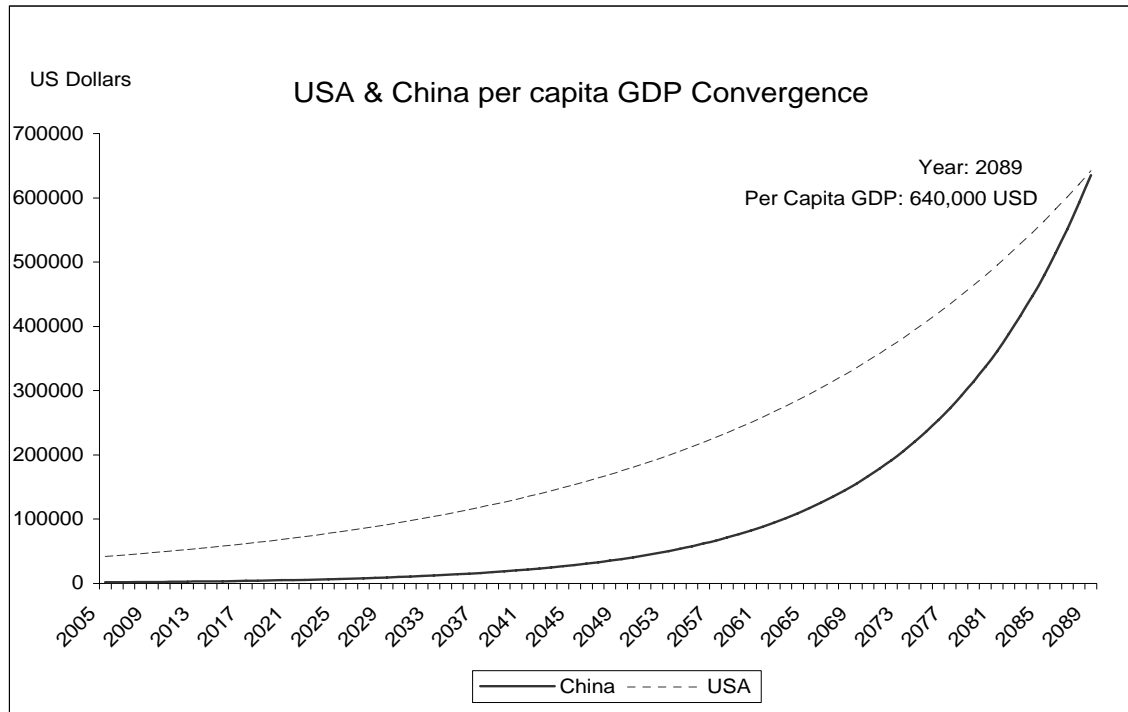
$$x = 84 \text{ years}$$

As illustrated by calculation (2), China’s per capita GDP will converge to a similar level to that of the U.S. in roughly eighty four years, at a monetary value of approximately 640,000 USD if expected growth rates continue. This model assumes a constant growth rate for both countries and holds no considerations for any future growth constraints. Although these calculations hold several unrealistic assumptions, it highlights the best case scenario for China’s economic development path. The remainder of this paper will attempt to examine the magnitude of future growth restraints, and their potential effects on this particular development trajectory.

**Figure 1: USA and China GDP Convergence**



**Figure 2: USA and China per capita GDP Convergence**



#### **IV. Determinants of Economic Growth**

##### *Composition of GDP: Growth Theory*

The previous projections put in perspective the current size of China's economy. This comparison to the United States is solely intended to illustrate the growth trajectory the Chinese hope to attain. However, the above calculations assume economic conditions will continue to be as they are today. In reality, however, population growth and resource scarcities could have an effect on China's economic development. This section takes an analytical look at the potential effects that these factors could have on China's economic progression. Using two sustainable development models, evidence is taken from past empirical work that examines the effects of population and resource constraints separately. China's current situation will

then be analyzed in the context of a comprehensive neoclassical growth model which highlights the combined effects of China's future growth restraints.

### *Population Projections*

The population projection estimates used here are based on current trends and historical progressions of similar countries. There exist a variety of methods commonly accepted by demographers to project a country's population growth. On the most basic level, demographers account for three major components of population growth and aggregate their effects on a country's total population. The average fertility rate, the average mortality rate and the net migration rate (migration less emigration) are the critical components in determining the future growth of a country's population. When breaking down the three components individually, demographers hold certain assumptions (Lutz 1996).

The mortality rate of a developing country, like China, is typically higher than that of a developed country. However, when China eventually develops medical services like those countries in the developed world, it can be inferred that the long run mortality rate is actually a constant across countries. This figure translates into more of a scientific assumption than a country specific statistic. Furthermore, demographers assume free access between countries, implying that the number of immigrants entering a given country is equal to the number of emigrants leaving a country. Therefore, the immigration rate is assumed to be zero across countries. This leaves the fertility rate as the critical component for demographers to determine the future population of a country (Lutz 1996).

In order for a population to grow, the fertility to mortality ratio must be greater than one, implying that there are more births than deaths in a given year. The fertility rate is defined as the average number of childbirths for a woman in an average lifetime. Since United Nations demographers assume the mortality rate to be constant, any growth or reduction in the fertility rate solely accounts for the population growth of a country. Demographers typically identify several potential scenarios- identifying a low future fertility rate, a constant future fertility rate, and a high future fertility rate- to examine the impact of the various levels. The high and low estimates represent the cutoff of a ninety percent confidence interval, implying that five percent of projected population totals fall above the upper bound or below the lower bound of the population projections (Lutz 1996).

Throughout the course of its development, China has endured great volatility in its population statistics. The failures of the Great Leap Forward tainted not only the political structure of the Communist Party, but also diminished China's population growth. Specifically, as a result of the devastating droughts, the mortality rate rose and the fertility rate dropped. In the late 1950's the fertility rate hovered around three births per family as opposed to a fertility rate of nearly seven just five years before. The fertility rate rebounded in the mid to late 1960's, only to drop considerably in the 1970's (6.0 to 2.4 births per family). Demographers agree that this sharp drop was caused by the implementation of a forceful family-planning system. In 1979, China adopted a one child law, barring any woman from having more than one child in her lifetime. This measure was very successful in the urban sector, cutting the fertility rate to below two. The initiative was more loosely enforced in the rural areas simply because it was much more

difficult to enforce and families on the farm needed additional children for labor purposes. Throughout the 1980s, the fertility rate remained around 2.4 and then took another plummet below 2.0 in the early 1990s when enforcement of the one child law was handed over to local authorities and was enforced much more strictly (Bramall 2000).

The future of China's population is largely contingent on the future fertility rate, which will be heavily influenced by the level of enforcement of the one child law. A high population trajectory can be obtained by assuming a very lax enforcement of the policy, where a conservative estimate assumes strict enforcement of the policy in both the rural and urban areas. Demographers from the United Nations calculate on a ninety percent confidence interval, that over the course of the next century, the fertility rate will rest somewhere between 1.5 and 2.7 births per woman. The following figures illustrate long run projections of the Chinese population, using high, low and constant future fertility rates (UN 2005). The Chinese will likely face a fertility rate resting somewhere between the central and high estimate, based on the recent flexibility with the one child law in the rural sector, implying future population growth, but at a diminishing rate.

Figure 3: Chinese Projected Fertility Rates

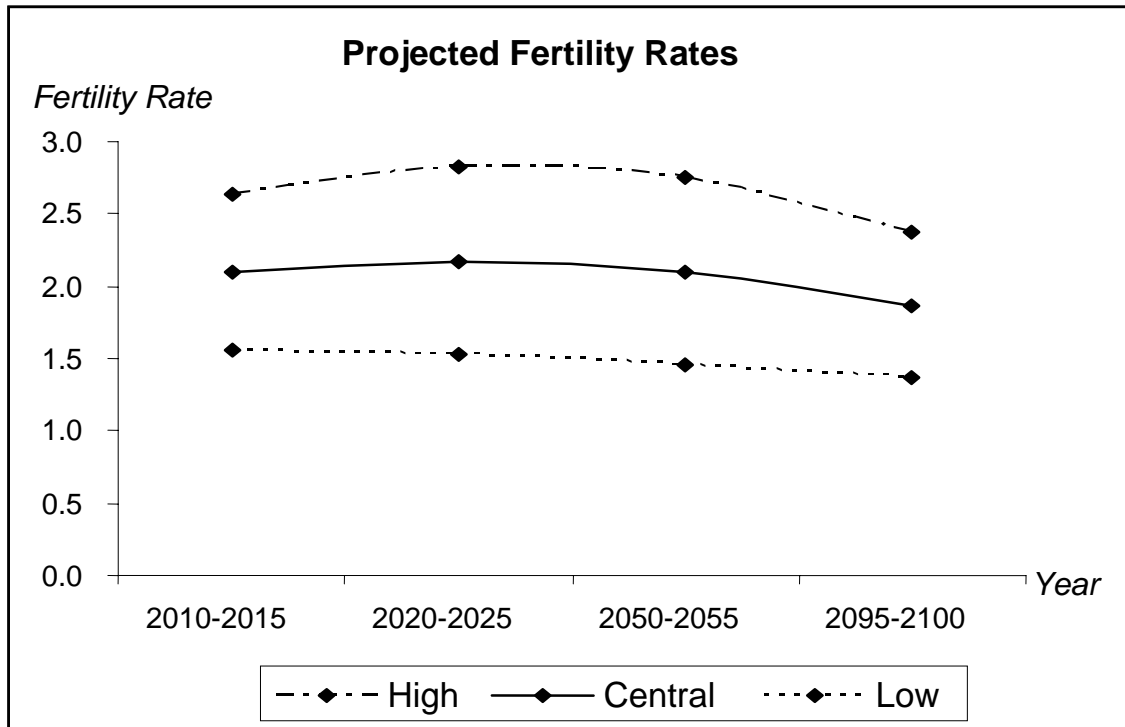
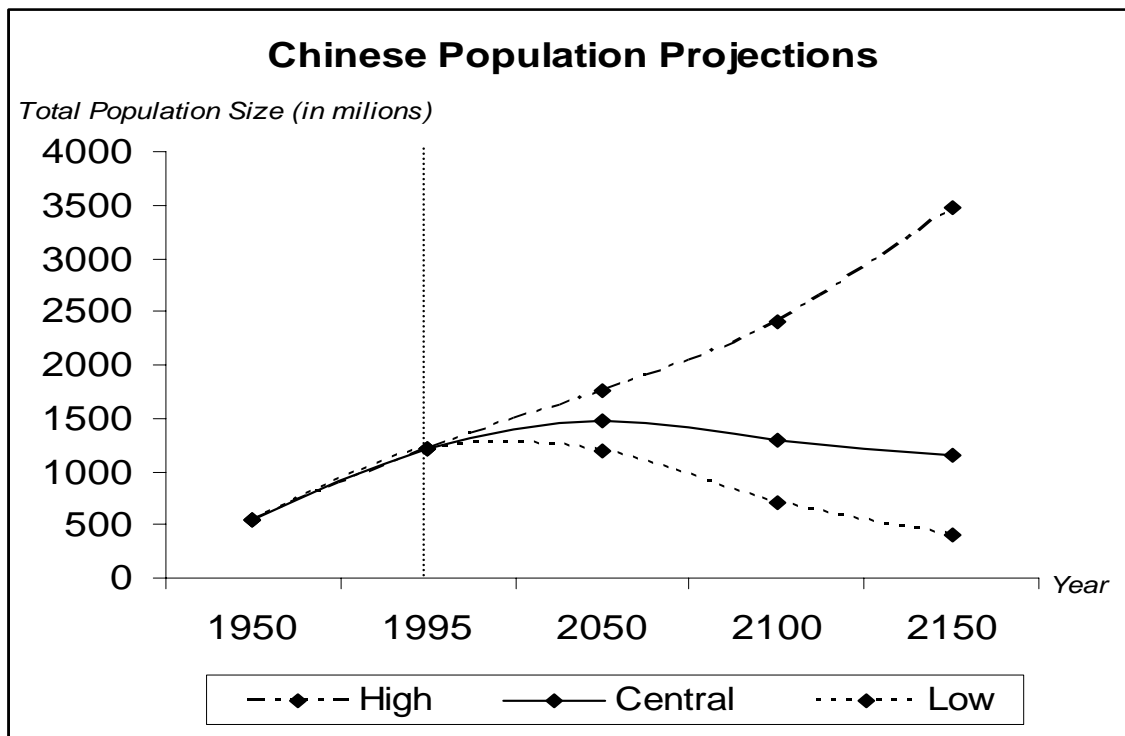


Figure 4: Chinese Population Projections



*Economic Implications of Population Growth:*

Many empirical studies highlight the relationship between demographic transitions and long run economic growth in various countries. Although few universal conclusions have been reached, there are a number of patterns associated with developing economies. Waldman (2005), a global economic consultant, compiles the results of cross-country research attempting to identify a universal relationship between demographic transitions and long run economic growth.

One particular study by Darrat and Al-Yousif (cited in Waldman, 2005), examined China prior to industrialization and reached particularly noteworthy conclusions. In a study of twenty countries, it finds that in fourteen, there exists a causal relationship that flows in a positive manner from population growth to economic growth, implying that as countries experienced population growth, the additional labor force contributed positively to economic development. However, for two countries, China and India, it finds that historically there existed a causal relationship that flowed from economic growth to population growth, in a negative manner. This indicates that as China developed economically, it experienced diminishing increases in population growth, a relationship quite different from other countries around the world. Waldman (2005) explains this unusual relationship by illustrating a four step process that developing economies undergo. The implications of determining where China currently falls within this process could provide preliminary forecasts as to the feasibility of China sustaining its 7% growth trajectory based on its population constraints.

According to Waldman's theory, countries initially experience rapid population growth as a result of poor economic conditions. Typically, population growth

accompanies poverty, or a lack of employment opportunities. Prior to the industrialization of China, its economy depended primarily on its agricultural sector. The inherent nature of farming calls for a large and active labor force. Children were regarded as additional laborers; hence, it was not uncommon for women in the rural sector of the economy to deliver more children than their urban counterparts. Additionally, due to the lack of health care and medical facilities in rural areas, the mortality rate of children under five years old was noticeably high. Therefore, women had additional children to ensure that the family would have a sufficient amount of workers to maintain the farm. Finally, as a result of farmers being self-employed, there was great concern surrounding the welfare of the elders in the community. Children were regarded as the support network for their parents and grandparents, to take care of them when they reached an age that precluded them from working on the farm. It is reasonable to conclude that China lingered in this first development stage prior to its industrialization (Waldman 2005).

Even today, despite China's remarkable strides in economic development, it is interesting to compare China's demographic composition between regions. Ranked among the poorest of regions in China, Tibet and Qinghai continue to have the highest birth rates. Furthermore, two of China's wealthiest regions, Beijing and Shanghai, rank the lowest in terms of annual birth rates. It is evident that Tibet and Qinghai contribute to population growth considerably, whereas Beijing and Shanghai hardly contribute to population growth at all. Therefore, even in China's developed economy today, current census statistics (China Statistical Yearbook) corroborate Waldman's (2005) theory that

poverty stricken areas typically experience a higher population growth rate than their counterpart regions.

The second stage of economic development occurs when a country simultaneously experiences a decline in population growth and an increase in economic growth, resulting from policy reform, resource reallocation or capital investment. When an economy begins to experience sustained growth, particularly in its industrial sector, there emerges a greater availability of both employment and educational opportunities. As industry expands, jobs are created and the options for women are greatly improved. As opposed to the rural sector, the opportunity cost of a woman having a child in the industrial sector is the forgone wage of working in an industrial setting. Furthermore, the development of industry helped facilitate the development of the services industry, particularly medical services. With more advanced medical procedures, and a considerably lower infant mortality rate, women become more confident about the survival of their children (Waldman 2005).

Indeed, with the beginning of the reform period in 1978, China experienced vast economic and social reforms, initiating a sustained period of economic growth. Since the beginnings of the reform period, the birth rate has been cut nearly in half, a clear result of the enforcement of the one child law in 1979. Per Waldman's (2005) theory, the net effect of this change has been a drastic decrease in the population growth since 1978.

Waldman's (2005) third stage of a demographic transition coincides with the development of open markets and the preliminary forms of capitalism. At this stage, the flow of causality begins to shift, very slowly. In an efficient economy, there exists a unidirectional, causal relationship between population growth and economic growth,

much like Waldman's (2005) original fourteen countries. Ideally, in an economy that efficiently allocates resources, maintains its optimal investment equilibrium, and properly maintains an efficient labor market, the addition of labor will contribute to an increase in overall production.

However, several obstacles can impede this process, many of which the Chinese are currently facing. For instance, with China's transition to privately owned and jointly owned companies, structural layoffs have been unavoidable. As surplus labor is being released from the publicly owned sector, it is taking time for displaced workers to find jobs. In the midst of this economic transition, a sizeable portion of the labor force is looking for work and not contributing to the output of the economy. Conditions such as this will preclude population growth from enhancing economic growth until the entire labor force is being utilized efficiently (Waldman 2005).

The fourth step in Waldman's progression is entirely theoretical, as very few economies around the world meet the qualifications to be considered in this category. This stage separates countries which have an abundance of natural resources. In countries with an abundance of resources, economic growth can *only* be facilitated by population growth (Waldman 2005).

It is very difficult to gauge exactly what effect China's population will have on economic growth; however, it is possible to draw theoretical conclusions from Waldman (2005). Currently, China's aggregate economy can be placed in Waldman's third development phase. Given its position on the development path, the effects of population growth will be determined by China's market efficiency. Since China currently relies on a transitioning economy, several structural imbalances need to be

corrected and the job market must open itself up to labor mobility. If China can improve its levels of labor discrimination and labor redundancy, theoretically, one could say that future population growth will contribute positively to economic growth. Therefore, the effect of future population growth depends on the efficiency of Chinese markets in years to come, and the jobs that need to be created to employ the future working generations. Based on the shifting composition of GDP, it is encouraging for the Chinese to see an increasing urban population producing a greater percentage of China's growing GDP. This implies a positive, unidirectional relationship between population and economic growth in its industrial sector (Waldman 2005).

#### *Composition of the Chinese Economy*

The composition of China's GDP theoretically points to Waldman's unidirectional shift in population and economic growth. According to leading demographers, the industrial population has experienced a sharp increase post 1989. Prior to 1989, as the industrial sector accounted for 26.2% of total population growth, while it now counts for 39.1%. This transition reflects an overall shift in the composition of China's GDP, as the industrial sector now constitutes a larger proportion of the Chinese economy. Although growth in industrial output resulted partly from technological progress, it also reflects the ability of China's industrial sector to concurrently sustain population and economic growth. Tables 1 and 2 provide ten year averages of proportions of GDP and total output by sector. Immediately following are Figures 5 and 6, which are time series graphs illustrating the change in GDP composition, and total output from 1978-2004 (World Bank 2005).

**Table 1: Composition of the Chinese Economy**

Sector	1984	1994	2004
<b>Agriculture</b>	32.0	20.2	15.2
<b>Industry</b>	43.3	47.8	52.9
<b>Services</b>	24.7	31.9	31.9

*\*%GDP*

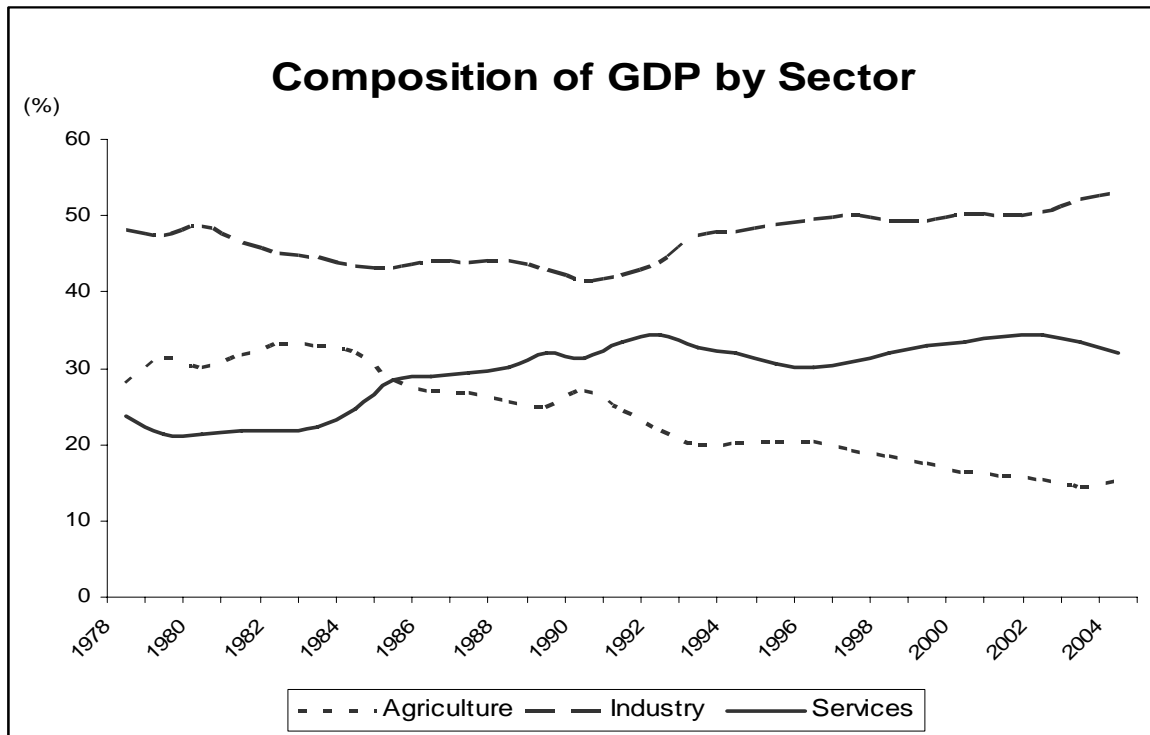
**Table 2: GDP Output by Sector**

Sector	1984	1994	2004
<b>Agricultural</b>	664.04	887.68	2036.18
<b>Industry</b>	898.21	2100.49	7086.37
<b>Services</b>	512.41	1401.79	4271.21

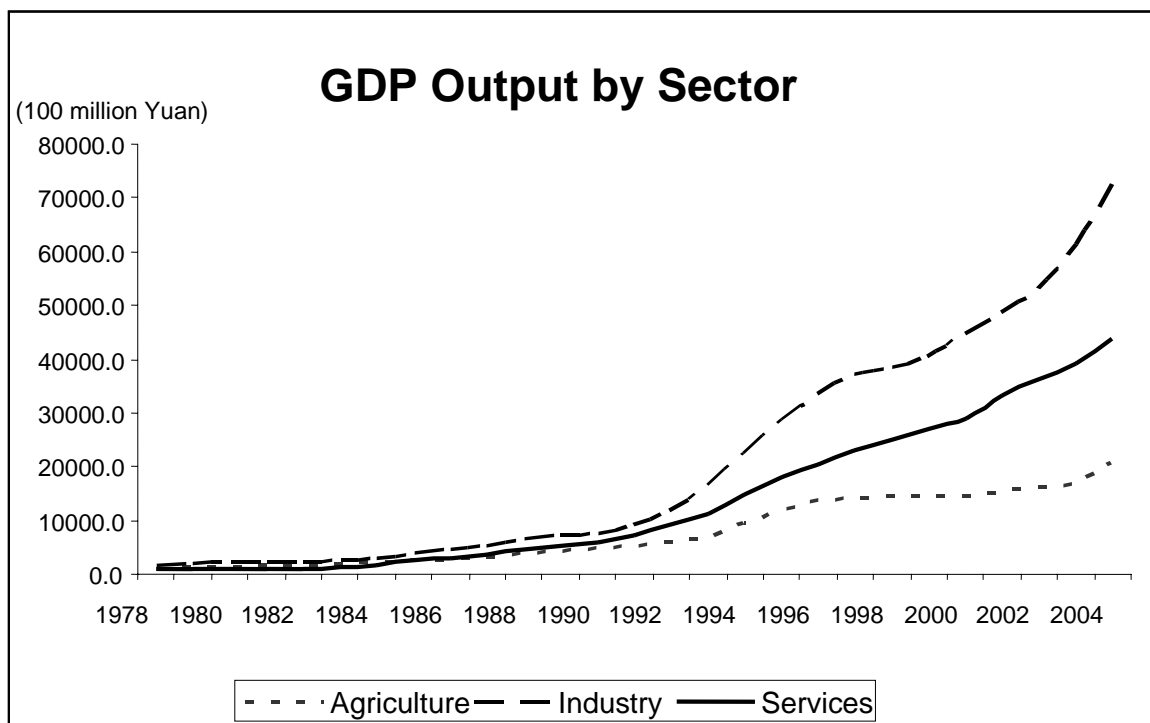
*\*100 million Yuan*

As illustrated by Figures 5 and 6, the percentage of total output coming from the agricultural sector has decreased over time; however, the dollar value of output has actually increased. According to economic growth theory, these statistics reflect a sector bound by fixed resources, arable land. The overall graph insinuates a positive growth indication because this shows that farmers can now produce more efficiently with the fixed resources afforded to them (Jones 2002). In light of China's ultimate goal, industrialization, the 688% increase (110.89 billion USD to 874.86 billion USD) in industrial output, from years 1984-2004, indicates that China is growing in the manner that Chinese leaders intended during the reform period. Additionally, it is encouraging for the Chinese to see that the increase in industrial population, along with technological advancements, is driving an increase in industrial output, as described by Waldman's third phase of development (Lutz 1996).

**Figure 5: Compositions of Chinese GDP by Sector**



**Figure 6: GDP Output by Sector**



### *Growth Constraints: Resource Scarcities*

Determining the future effects of resource scarcities on a country's economy can be quite difficult for a number of reasons. Although certain key resources are technically considered nonrenewable, it is very difficult to determine when human consumption will completely deplete these resources as more resources are constantly being discovered and alternative fuels are constantly being developed. For example, the world's demand for oil continues to grow on an annual basis; however, so do global oil reserves. This does not mean that oil is being created from nothing; it means that new oil sources are constantly being found and new technologies allow oil companies to drill in places previously unavailable. Therefore, instead of trying to determine when China will run out of a given resource, it is more pertinent to study historical trends of economies and societies as they adapt to the changing demand for resources in order to project potential future scenarios.

The obvious implication of resource scarcities is that population growth will make it more difficult to afford countries the resources they need to effectively manage their economies. Although many resources cannot be replenished and cannot be manufactured, the sustainability of the world resource market may in fact not have anything to do with population growth, but rather with technological innovation.

According to Lambert (1996), the future of the resource market may not be as bleak as many economists claim. Lambert (1996) writes that resources in the global market are in fact becoming less scarce as time progresses. Lambert (1996) looks at the supply and demand for resources in a competing global open market model. In such a model, it is not significant which countries are rich in oil and clean water, it is of more significance

that the resource market follows the principles of supply and demand and promotes trade and specialization between countries.

If resources continue to become more scarce, the prices of natural resources should reflect this scarcity. In reality, however, resource prices have decreased considerably over the last century. In 1950, global resource prices were one half relative wage prices. In 1990 resource prices were one fifth the cost of relative wage prices. Therefore, it is clear that resource prices have decreased over time. According to competitive supply and demand principles, this can be the result of either of two scenarios: a decrease in demand or an increase in supply. According to resource consumption statistics, the shift in prices clearly could not be the result of a decrease in demand, as annual consumption of oil and other nonrenewable resources has increased dramatically in the last fifty years, implying that that resource levels have actually increased over time (Lambert 1996). According to economist William Baumol (1996),

Measured in terms of their prospective contribution to human welfare, the available quantity of our exhaustible and irreproducible natural resource may be able to rise unceasingly, year after year. Rather than approaching exhaustion with continued use, their effective inventories may actually be growing and may never come anywhere near disappearance (cited in Lambert 1996).

Despite Lambert's argument that basic economic principles dispel any notion that global resource reserves will hinder economic growth in the near future, it is still useful to analyze a few specific resources in order to anticipate long run problems, particularly land. Arable land holds the key to food production and the sustainability of civilization, both in China and abroad. With an increase in population, future generations will need land on which to live, and land on which to grow crops. A key component to sustainable

development rests in the hands of farmers, and their ability to keep food production growth on pace with population growth. Agricultural production can also be analyzed in Lambert's global market theory. For countries like China, it is not important that they produce enough food to feed the entire country; rather, it is important that China capitalizes on its most efficient industries. The access to free global markets and open trade will encourage division of labor, specialization, and optimal economic efficiency around the world (1996).

It is not clear that arable land is close to being exhausted. In the 1990s, after the most recent census of natural resource depletion, it was estimated that 24% of land in the world is arable and suitable for farming but, only 8-10% of suitable land was cultivated. Despite the fact that so much suitable land lay dormant, food growth continued to outpace population growth by over 1%, a trend that has endured for the last century. Additionally, labor hours per year in the agricultural sector continue to decrease for a given crop yield, and a given allotment of land, implying that technology and productivity have carried the burden of land resource scarcities for quite some time.

An alternative approach to analyzing resource constraints is not to view resources as actual products, but rather view them in terms of the services that they provide for the consumer. Oil for instance, has no value to a consumer until it is used for a specific purpose. In this sense, the key to future resource scarcities is not focusing on the level of future reserves, but rather adapting technologies to more efficiently carry out the services that resources provide. In this sense, the actual amount of remaining resources is not as important as the manner in which they are used. This offers valuable insight into the future availability of water, land and oil. Short run scarcities of these resources will

necessitate technological growth in order for productivity to increase to a level that will counteract an increased resource demand. To cite a pertinent example, the production of one acre of arable land is tripled by irrigation alone (Lambert 1996). Adapting new technologies is just as valuable, if not more valuable, than discovering more resources. On a more aggregate level, the Earth has seen nearly a six fold increase in population since 1800, and has simultaneously endured an eight fold increase in productivity. Therefore, based on historical trends and basic economic principles, it is reasonable to conjecture that global resource scarcities are actually short run issues that force technological and productivity growth, which corroborates Lambert's (1996) theory that resource constraints may actually promote economic efficiency, rather than hinder future economic growth.

A more formal method of analyzing efficiency is to employ a resource intensity function. A resource intensity function calculates a ratio that shows how many units of resources are needed to produce a given unit of output. It calculates the amount of a specific resource being used, per dollar of GDP. Thus, lower resource intensity is a consequence of higher efficiency. As illustrated by equation (3), resource intensity,  $I$ , equals resource use,  $R$ , divided by per capita GDP,  $y$ , times population,  $L$ .

$$I = \frac{R}{yL} \quad (3)$$

Alternatively, the equation can be analyzed using each variables' respective growth rate. As equation (4) indicates, the growth rate of resource use is equal to the sum of the growth rate of resource intensity, the growth rate of per capita GDP and the growth rate of the population.

$$\dot{R} = \dot{I} + \dot{y} + \dot{L} \quad (4)$$

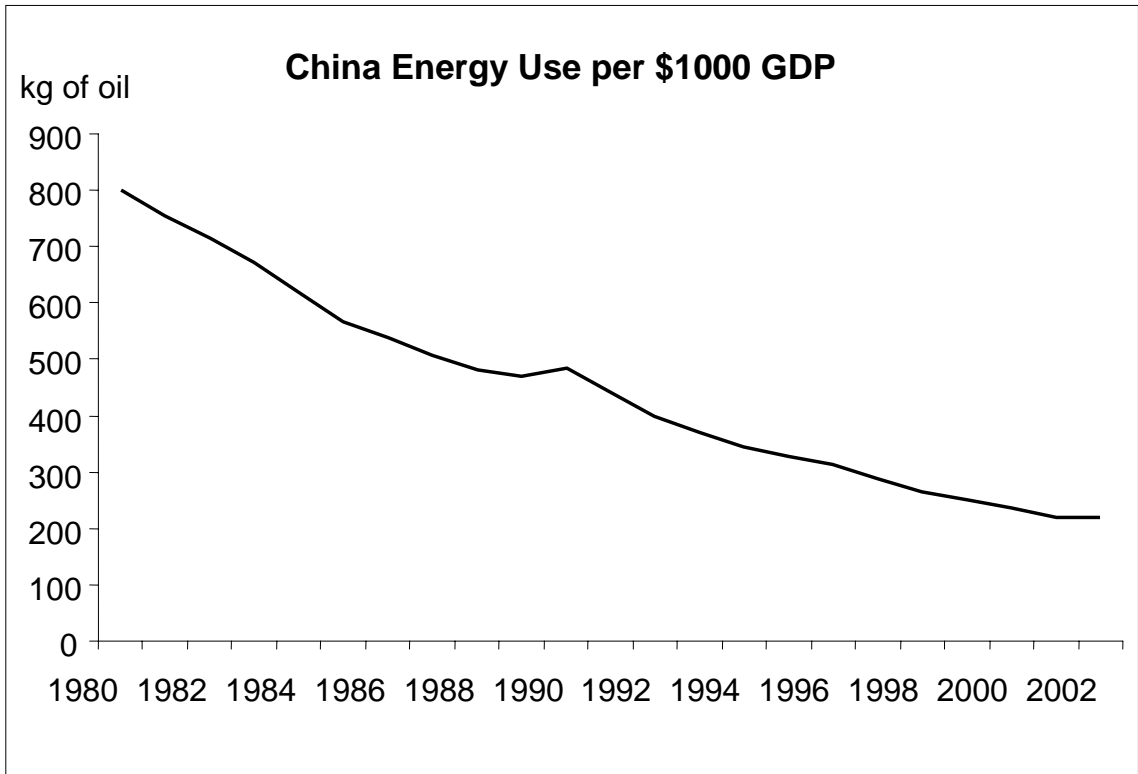
Assuming that the growth rate of resource use is equal to zero, the equation says that for per capita output to have a positive growth rate, resource intensity must be falling faster than the population of a country is growing, assuming constant returns to scale (equation 5).

$$\begin{aligned}\dot{R} &= 0 \\ \dot{y} &= -\dot{I} - \dot{L}\end{aligned}\tag{5}$$

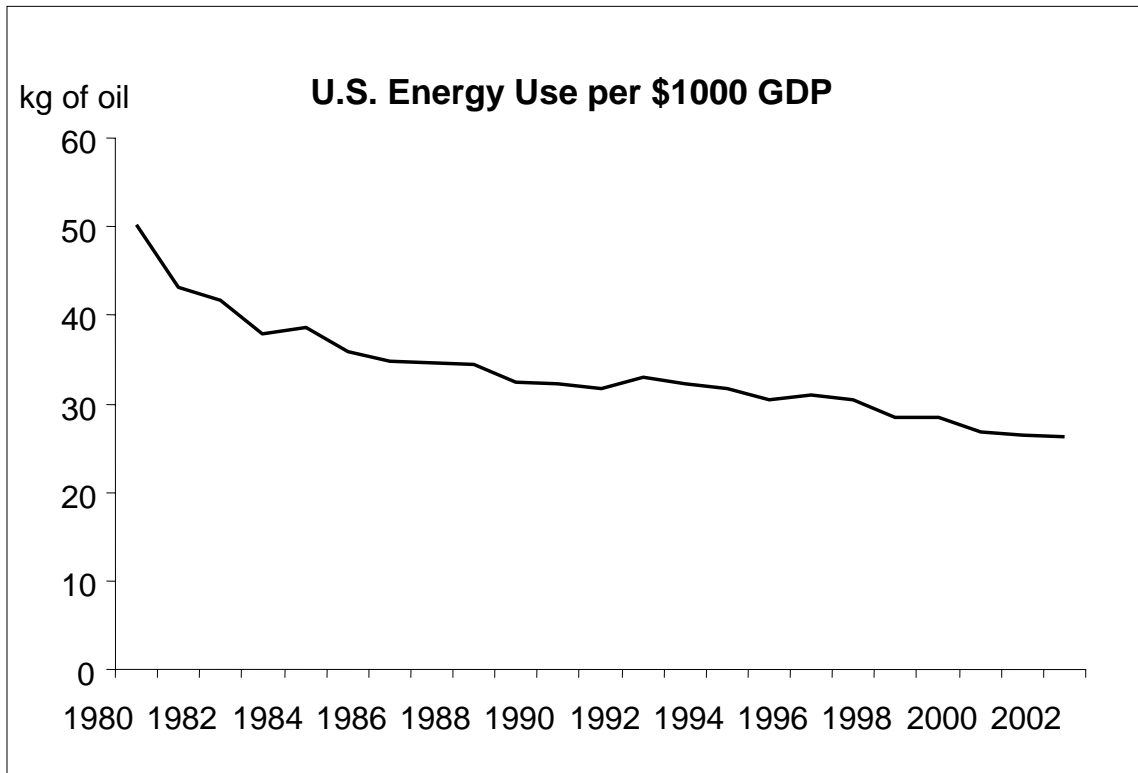
This identity encompasses several economic factors, such as the population growth projections, resource availability, and the development of not only capital, but technologically advanced capital (Jones 2002).

The following graphs illustrate China's resource intensity function, and how it has progressed since the beginning of the reform period. In order to accommodate such large numbers, a time series analysis was performed to calculate how many kilograms of oil the Chinese economy requires to produce \$1,000 USD worth of goods and services. A clear decline in resource intensity has been the result of increased productivity and efficiency, as well as a continuous expansion in the services industry. Although China has made remarkable strides in optimizing its resource use, a comparison to the U.S. resource intensity shows it is still far from potential efficiency levels. Because China has a declining resource intensity and potential for dramatically lower levels in the future, it is reasonable to conclude that China will continue to experience positive per capita production growth in the future with its current resource levels (Jones 2002).

**Figure 7: Chinese Resource Intensity**



**Figure 8: U.S. Resource Intensity**



## IV. Implications

### *The Neoclassical Growth Model: Background*

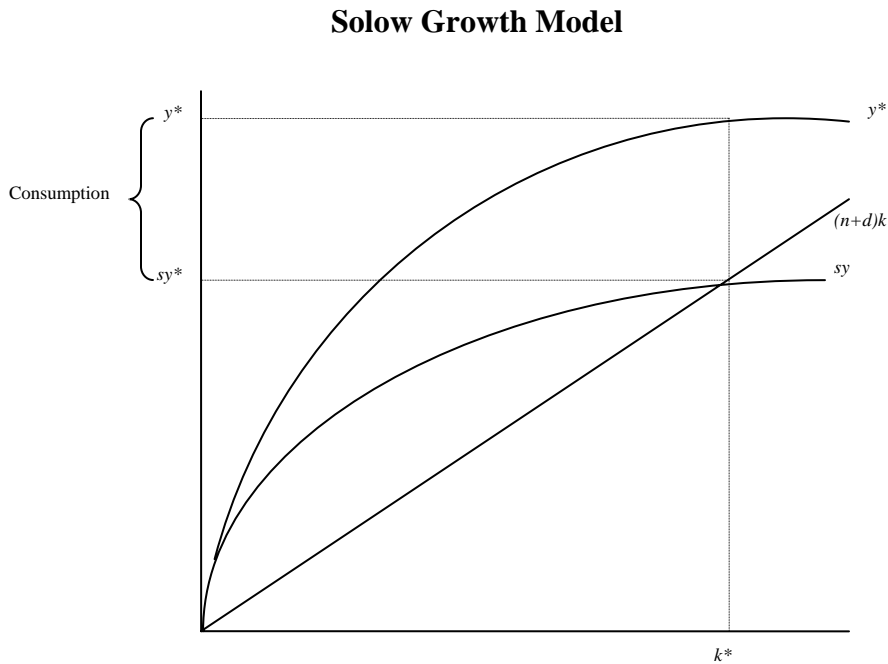
The neoclassical growth model explains economic growth using several variables, highlighting the importance of capital accumulation and technological progress as essential factors to sustained economic growth. Solow provided a theoretical foundation to forecast a country's potential growth trajectory, encompassing factors such as capital accumulation, population growth (specifically labor force participation), the rate of technological advancement, and the capital depreciation rate, see Jones (2002) for a review.

The neoclassical growth model concludes that potential GDP growth is the consequence of a stable, steady state capital-to-output ratio, which Solow showed is the savings rate over the sum of the labor force growth rate, productivity growth rate and the capital depreciation rate. The implications of this model are enormous. The growth rate of potential GDP for real economies is equal to the sum of the growth rate of the labor force plus labor productivity, thus per capita GDP grows at the growth rate of labor productivity (Jones 2002). However, the level of GDP at a particular point in time is sensitive to the saving rate as well as the growth rate of labor and productivity.

Graphically, a country's growth path can be seen by plotting capital on the horizontal axis and national income on the vertical axis. The curve labeled  $sy$  represents per capita savings and hence investment in capital, as in Figure 9, given a standard production function. Assuming that  $g=0$ ,  $(n+d)k$  represents the level of investment required in order to keep capital per worker constant over time, a scenario that Solow refers to as the steady state. The intersection of these two functions is the equilibrium

level of per capita investment and hence GDP. Assuming that all income is used for investment or consumption expenditures, the distance between per capita income and per capita investment equals the level of per capita consumption (Jones 2002).

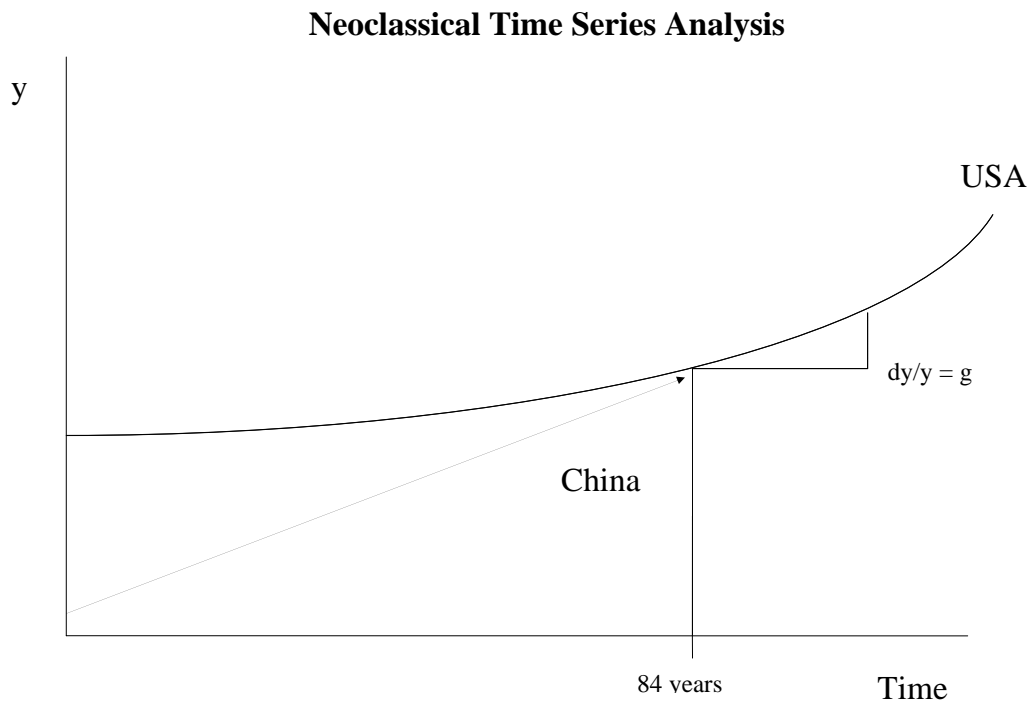
**Figure 9: The Solow Growth Model**



The Solow Model provides a snapshot of an economy at its steady state capital-to-output ratio, where a sustained GDP growth rate is maintained by means of efficient markets, a constant productivity growth rate and an optimal allocation of resources. It seems likely that the Chinese economy is currently converging to this steady state equilibrium, by means of productivity growth. Developing economies traditionally experience abnormally high growth rates until they reach this steady state, sustained growth path. A time series illustration of per capita GDP growth illustrates China's current position with respect to a steady state growth trajectory.

China's surplus of unemployed and redundant labor currently set its economy below this steady state equilibrium path because labor resources are not being fully employed and natural resources are not being used efficiently. Assuming that the U.S. growth trajectory in Figure 2 represents an economy in Solow's steady state equilibrium, it is reasonable to conjecture that China will reach this steady state per capita equilibrium in eighty four years, if its current growth continues, as seen in calculation (2).

**Figure 10: Neoclassical Projection**



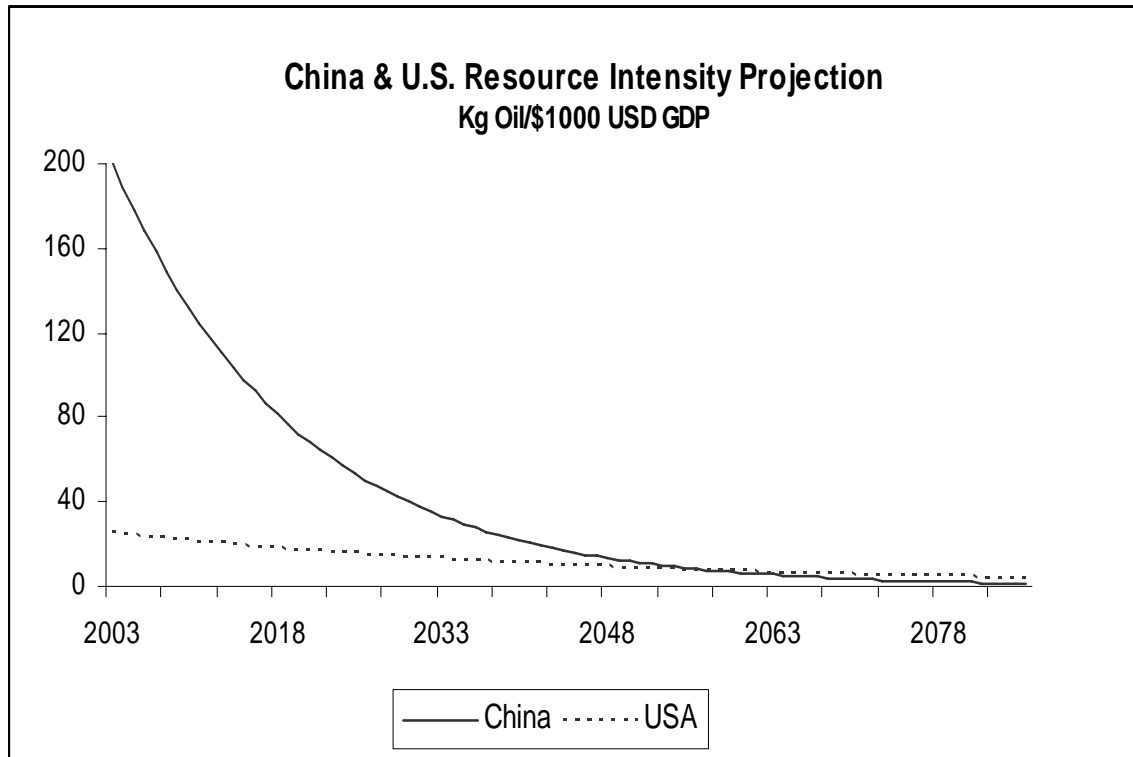
There are multiple factors to consider while examining population growth in the context of a short run neoclassical model and the long run Solow model. In the short run, as Waldman (2005) conjectures, population growth will be beneficial to China's economy, as it will help build up its labor force. Although China's anticipated diminishing population growth rate does not satisfy the conditions of Waldman's third

developmental stage, China's labor force could experience growth from other sources. The redundant labor in China's industrial economy is currently contributing nothing to its overall GDP, hence a marginal product of zero. By terminating and re-employing redundant labor in industries where workers can maintain a marginal product above zero, it is as if the labor force grows, similar to the effect that population growth would have on the labor force. Therefore, despite projections of diminishing growth to China's overall population, the privatization trend will partially counteract this projection if surplus laborers can be relocated to more efficient roles. This in turn will promote economic growth during China's convergence to its steady state growth level. This is illustrated in Figure 10 by China's relatively steep growth trajectory. If current trends continue, in roughly eighty four years, this trajectory will converge to a steady state per capita model where population growth may begin to hinder future economic growth, by lowering the steady state capital-to-output ratio.

China's resource intensity clearly rests well below that of a steady state economy, as it currently requires nearly ten times as much oil to produce the same amount of output as the U.S. Therefore, in theory, if China's productivity increases to the level of a steady state economy, it could produce ten times as much output with the same amount of oil it is currently consuming. Given that China's resource intensity is falling at the pace that it is, it is reasonable to conclude that China's productivity will continue to increase as its resource intensity falls to a level comparable to that of the U.S. Like population growth, this increase in efficiency and productivity will continue to support Chinese economic growth in the short run neoclassical model. Given the declining resource intensity

trajectories of China and the U.S., a trending analysis shows that their resource intensities will converge around the year 2060.

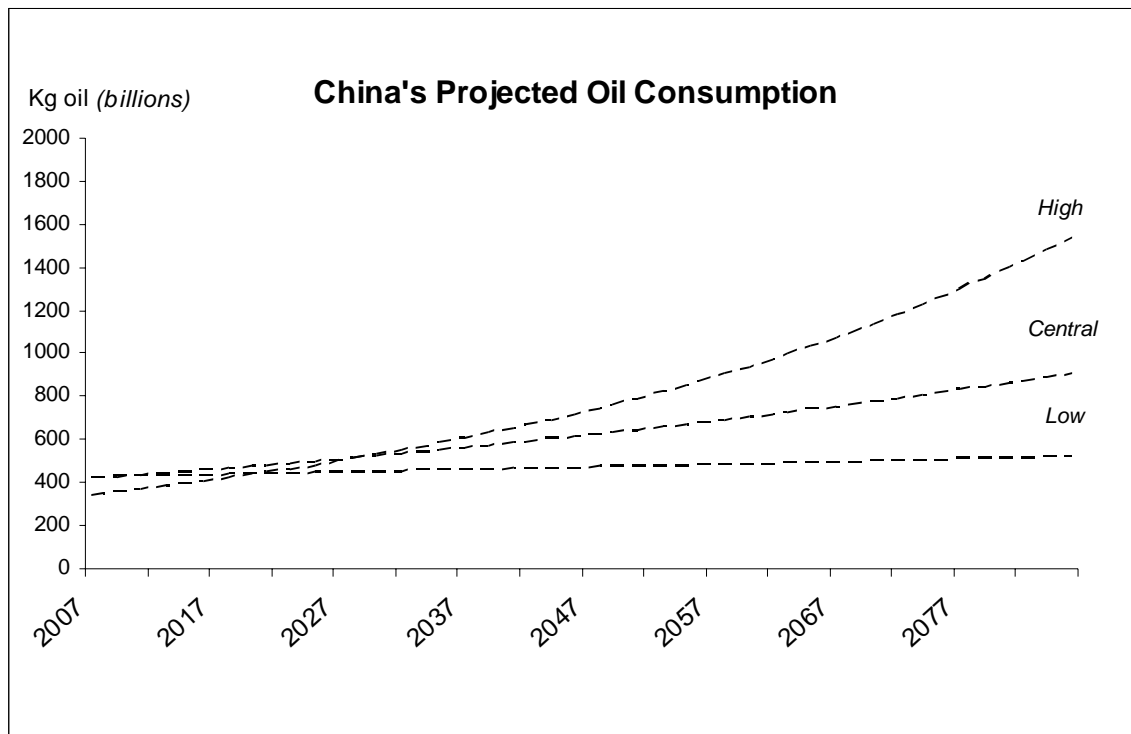
**Figure 11: U.S. and China Resource Intensity Convergence**



This paper concludes that China's declining resource intensity and effective labor force growth will fuel short run economic growth until a steady state is reached. However, this depends on China having access to enough natural resources to reach its steady state GDP levels. Figure 12 projects China's future oil consumption, by incorporating a trending analysis of projected GDP growth, its declining resource intensity, and a high, low and central projection of population growth. Although China's GDP will be increasing in the future, its resource intensity will be simultaneously decreasing. These effects are captured in Figure 12 as it shows the anticipated levels of oil consumption in the next eighty five years. In light of China's immediate goal, to

triple the size of its GDP by 2020, it appears that China will require anywhere between 440-472 billion kilograms of oil in the year 2020 compared to the 340-416 billion kilograms it is currently consuming to produce one third of the output, assuming China's resource intensity decreases at the rate that it is projected. Therefore, it appears likely that China's productivity growth will begin to bear the burden of its increased resource consumption in the coming years as economic growth and resource consumption begin to diverge. In the long run, in order for China to reach its per capita steady state capital-to-output ratio, and reach the development path of the U.S., it will require anywhere from 905 billion to 1.5 trillion kilograms of oil in the year 2087 to reach a per capita GDP of 640,000 USD, more than double the amount of oil it is currently consuming.

**Figure 12: China's Projected Oil Consumption Under Various Population Projections**



## **V. Conclusions**

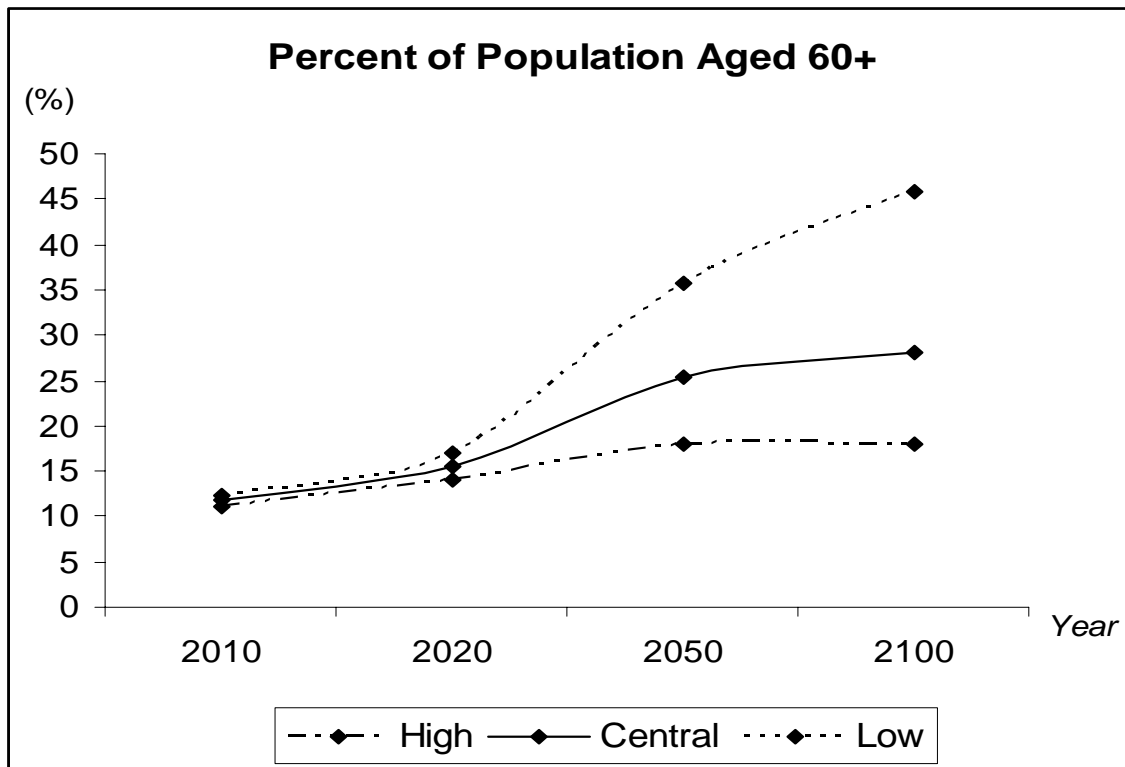
This paper examines potential scenarios for future Chinese economic growth and the possibility of the Chinese tripling the size of their economy by the year 2020, specifically with regards to the future impact of population growth and resource scarcities. This paper concludes that despite potential future growth restraints, it is an attainable goal for the Chinese to triple the size of their GDP by 2020 by maintaining a growth rate of 7% annual real GDP growth until it converges to Solow's steady state, in roughly 84 years. At this point, Chinese economic growth will be curtailed by any future population growth or resource inefficiencies because its economy would be effectively using its labor force and natural resources.

Although this paper examined the potential impacts of population growth and resource scarcities, it would be greatly improved with a greater focus on the individual components of Solow's steady state model. Since the savings rate and capital depreciation rate were not examined specifically in this model, it would be interesting to see the effects that these variables would have on future growth trajectories. Additionally, this paper would be greatly enhanced with a more in depth analysis on the development of China's services industry. The services industry will be responsible for ensuring the well being of China's retiring generation, which according the UN could see considerable growth in upcoming years.

The United Nations' population projections indicate a forthcoming shift in the composition of China's population. The enforcement of China's one child law has significantly skewed the age distribution of the Chinese population, resulting in an imbalanced demographic shift. As Figure 13 illustrates, the proportion of China's

population over the age of sixty will dramatically increase in the next fifty years. This transition could have two potential effects on China's growth trajectory (Lutz 1996). China's labor force participation rate will decrease considerably as this generation of Chinese begins to retire. Furthermore, the Chinese economy will experience a sharp decline in total savings and a sharp increase in total consumer spending, as this generation begins to spend accumulated wealth. Therefore, future development models would be greatly enhanced with an analysis of the future impact of this demographic transition.

Figure 13: Chinese Demographic Projections



The analysis of China's upcoming demographic shifts begs the question of where China's government spending will go in the future. With such a disproportionately aged population, a larger percentage of China's population will be relying on government funding for healthcare and financial support. The government will likely have to increase government spending on programs such as national healthcare to take care of this aging generation. However, with an increase in social welfare funding, the Chinese will likely face a decrease in government investment in industry.

Multiple factors can affect the growth trajectory of a developing economy, many of which have been discussed in this paper. However, given the nature of Chinese economic policy, it is reasonable to assume that China's economic goals will adjust in the future to new lines of economic reasoning brought forth by new political leaders. Therefore, this research is merely a starting point in forecasting the growth trajectory of China's economy. It is therefore a subject that must be reinvestigated as economic policy changes, and as political leadership readjusts its developmental strategies.

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