How Much Slack Was There in the Chinese Economy Prior to its Economic Reform of 1978?

by

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Abstract: The existence of economic slack or inefficiency is a common phenomenon of economies that operate under mandatory central planning. It implies that the economy operates in the interior of its set of production possibilities and not on its frontier. It also implies that output can be increased without any increase in the inputs if the constraints which prevent the economy from operating on the frontier in the first place are removed. Thus, there is "surplus potential output". The objective of this study is to attempt to identify and estimate the surplus potential output in the Chinese economy prior to its economic reform in 1978. This will help answer the question of how much of the Chinese economic growth since 1978 can be attributed to the reduction and elimination of the pre-existing economic slack. This question is important because the increase in output due to the reduction or elimination of the economic slack can only take effect once and cannot be continuing. It will also affect the attribution of the sources of Chinese economic growth. Our investigation suggests that a reasonable estimate of the magnitude of the surplus potential output of the Chinese economy on the eve of its reform is approximately 50% of the actual realized output in 1978.

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1. Introduction

China has made tremendous progress in its economic development since it began its economic reform and opened to the World in 1978. It is currently the fastest growing economy in the World—averaging 9.7% per annum over the past 36 years (even though its rate of growth has recently slowed down to around 7%). It is, however, historically unprecedented for an economy to grow at such a high rate over such a long period of time.

What are the sources of this Chinese economic growth? They include the growth in the conventional tangible inputs, physical capital and labor; the growth in intangible inputs, such as human capital and R&D capital; technical progress, also known as the growth of total factor productivity (TFP); and technology transfer from abroad. They include the effects of the realization of economies of scale. But they should also include the reduction and elimination of the economic slack or inefficiency that existed in the Chinese economy prior to its economic reform and opening to the World in 1978.

The existence of economic slack or inefficiency is a common phenomenon of economies that operate under mandatory central planning. It implies that the economy operates in the interior of its set of production possibilities and not on its frontier. The "distance" between where an economy operates and its frontier is then the economic slack. It also implies that output can be increased without any increase in the inputs if the constraints which prevent the economy from operating on the frontier in the first place are removed. Thus, there is "surplus potential output". The objective of this study is to attempt to identify and estimate the surplus potential output in the Chinese economy prior to its economic reform in 1978 and to help answer the question: How much of the Chinese economic growth since 1978 can be attributed to the reduction and elimination of the pre-existing economic slack? This question is important because the increase in output due to the reduction or elimination of the economic slack can only take effect once and cannot be continuing. When an economy already operates on its production possibilities frontier, there is no more surplus potential output and further increases in output will have to come from the outward movement of the production possibilities frontier, which requires increases in tangible and intangible inputs or technical progress. It will also affect the attribution of the sources of Chinese economic growth.

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While many studies, including Hsueh and Liu (1980), Lin (1988, 1992), Rawski (1994, 1995) and Naughton (1995, 2007) have analyzed the effects of Chinese reforms on the Chinese economy, there has not been any quantitative estimate of the size of the pre-existing economic slack that was reduced and eliminated through the economic reform. It is, however, in general difficult, if not impossible, to identify and distinguish from aggregate time-series data of a single country or region how much of a given increase in output is due to a movement from the interior of the set of production possibilities to its frontier and how much is due to a movement of the production possibilities frontier itself. This is true regardless of whether the economy in question is a centrally planned or a market one. Yet, it is well known that for an economy operating under mandatory central planning, there is inherent economic inefficiency, and hence economic slack, even though the size of the slack is not known (see Section 3).2 Stochastic production frontier analysis has been proposed to identify and estimate the frontier of the set of production possibilities (see Aigner, Lovell and Schmidt (1977)). However, such an approach is not possible with aggregate time-series data if they are available for only a single economy. If cross-sectional or panel data are available within an economy, it may be possible to identify and estimate the frontier of the set of production possibilities under some assumptions. Yet in a centrally planned economy, even cross-sectional data are of no help as all the production units in a centrally planned economy are likely to operate in the interior of their sets of production possibilities.

But for economies transitioning from a centrally planned system to a market system, as in the case of China, there is actually an opportunity to identify the pre-existing slack, by observing the economic performance before, during and after the implementation of the market-enabling economic reform.3 Our objective here is to introduce two different simple methods to estimate the size of the surplus potential output, or its mirror image, the economic slack, in China before its economic reform in 1978. This possibility hinges on a number of observations and assumptions discussed below:

First, economic reform can remove the constraints in the economy which prevent it from operating on its production possibilities frontier in the first place. The effect of the

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[2] With aggregate time-series data of more than one economy, it is in principle possible to identify and estimate the degree of relative economic inefficiency under suitable assumptions.

[3] In the absence of a transition from a centrally planned to a market economy, it would be difficult to identify and estimate the economic slack, as the slack may persist over time. It is only when the economic slack is reduced or eliminated over time because of economic reform that it has a chance of being identified and estimated.

economic reform on the reduction and elimination of the economic slack, if any, when it is fully implemented, is for one-time only and not continuing. Moreover, the effect is not instantaneous, as it takes time for the prior constraints in the economy to be removed so that the economic slack can be reduced and eliminated and the surplus potential output realized. Thus, it is necessary to look beyond the first year(s) of the economic reform, although the effect will eventually dissipate. In this study, we make the working assumption that on average, it takes six years for the full effect of the economic reform to be realized.[4] We thus compare the economic performance of the pre-reform, reform, and post-reform periods to try to identify the effect of economic reform on the reduction or elimination of the pre-existing economic slack.

Second, it is also necessary to try to control for the effects of additional inputs, if any, during the reform period, as they would have caused the production possibilities frontier to move outward and output to be increased. Even in the absence of economic reform, the set of production possibilities would still be expanding, although the economy might continue to operate in its interior rather than on its frontier. Thus, the increase in output during the reform period cannot be entirely attributed to the economic reform itself--the effects of the "usual and customary" increases in inputs during the same period must also be taken into account and deducted first. Since data on the quantities of the additional inputs during the reform period are not readily available, we make the assumption that the effects of the increased inputs during the reform period, if any, on the growth of output can be approximated by the trend rate of growth of output in the six years before the reform period. Thus, the increase in output during the reform period is attributable to economic reform only after the subtraction of the increase in output that would have occurred if output had continued to grow at the pre-reform trend rate. While this assumption may seem arbitrary, it is actually quite realistic in the Chinese case, as throughout the reform period, say from 1979 to 1984 in the case of agricultural reform, the mandatory central plan continued to be enforced in China, so that additional supplies of inputs, beyond what was then usual and customary, were unlikely. [5] Alternatively, one can also assume that the economic

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[4] We also experimented with alternative assumptions on the duration of the economic reform period. However, our results are robust as to whether the reform period is assumed to be four, five or six years (see Appendix Table 1). They are also robust with regard to the assumed durations of the pre-reform and post-reform periods (see Appendix Table 2).

[5] Moreover, Chinese economic reform first occurred in the agricultural sector. It would be quite a few years later that the industrial sector began to supply inputs such as chemical fertilizers and insecticides to the agricultural sector.

performance in the six years after the reform period represented the expected normal condition after all the prior constraints imposed by central planning in the economy were removed. Thus, one would attribute the excess of the growth of output in the reform period over the post-reform trend rate of growth to the reduction and elimination of the pre-existing economic slack.

China is a large country, and economic reform was implemented at different paces and to different degrees in different parts of the country, so it is difficult to identify from data on the Chinese economy as a whole the effects of economic reform and hence to estimate the magnitude of the surplus potential output that might have existed. We therefore focus on Anhui Province and Shanghai Municipality to estimate the magnitude of the surplus potential output. Anhui is chosen because that was where the Chinese agricultural reform was first proposed and implemented, in late 1978. Shanghai is chosen because it was the very last Chinese provincial-level administrative unit to undergo urban non-agricultural economic reform, in early 1992. Thus it is possible to identify and estimate from the economic performance of Anhui and Shanghai the effects of the introduction and implementation of the respective agricultural and non-agricultural economic reforms on the reduction and elimination of the economic slack there, which then can be used to obtain estimates for China as a whole. This study represents a first attempt to identify and estimate the pre-existing slack in a centrally planned economy prior to its transition to a market economy.

In Section 2, we introduce the concept of a set of production possibilities for an economy and illustrate the meaning of economic slack or inefficiency, differentiating between a movement from the interior of the set of production possibilities to its frontier and an outward movement of the frontier of the set of production possibilities itself. In Section 3, we explain briefly why there is inherent economic slack or inefficiency in a centrally planned economy. In Sections 4, we give a brief chronology of the early Chinese economic reform. In Sections 5 and 6, we examine the economic records of Anhui Province and Shanghai Municipality respectively and try to identify and estimate the surplus potential outputs that might have existed at the beginning of their respective agricultural and non-agricultural economic reforms. In Section 7, we attempt to fit the data on China, Anhui and Shanghai in a simple piecewise linear econometric model of growth under reform. In Section 8, we estimate the magnitudes of the surplus potential outputs in China, Anhui and Shanghai that

might have existed prior to the economic reform using the econometrically estimated parameters in Section 7. Some brief concluding remarks are made in Section 9.

2. The Meaning of Economic Inefficiency

First, we illustrate the notion of economic efficiency as employed by economists by introducing the concept of a set of production possibilities of an economy. The set of production possibilities of an economy, for given fixed quantities of the primary inputs of the economy (for example, the quantities of tangible or physical capital, labor and land), is the set of all possible combinations of quantities of goods and services that can be produced by the economy. In Chart 1, the set of production possibilities of a two-good economy, X1 and X2, is presented. The two axes of Chart 1 measure the quantities of the two goods, X1 and X2, respectively. At time zero, the set of production possibilities of this economy is given by the area bounded by the blue curve and the two axes, which is shaded in blue--all combinations of the quantities of the two goods X1 and X2 within the blue-shaded area can be produced by the economy with its given fixed quantities of inputs. A feasible production plan is a combination of X1 and X2 that lies within the set of production possibilities, including its boundaries.

Chart 1: A Set of Production Possibilities of a Two-Good Economy and Its Expansion over Time

A Set of Production Possibilities
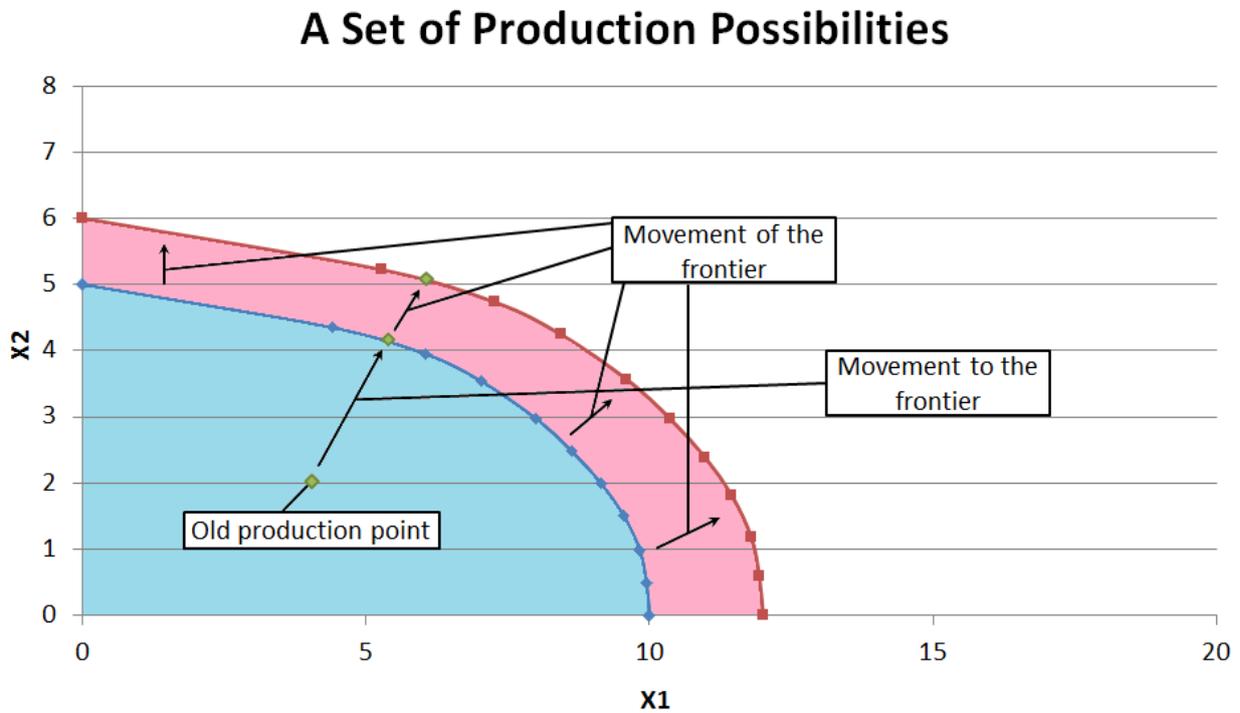
A feasible production plan is said to be efficient if any increase in the quantity of one good, say X1, must be accompanied by a decrease in the other good, X2, and vice versa. Note that on the blue curve, the upper boundary of the set of production possibilities, any increase in X1 must be accompanied by a decrease in X2, and vice versa, so that every combination of the quantities of the two goods on the blue curve is an efficient production plan. The blue curve thus represents the frontier of the set of production possibilities of the economy at time zero.

In contrast, all combinations of quantities of X1 and X2 in the interior of the set of production possibilities are inefficient production plans, because for them, either X1 or X2 or both can be increased without decreasing either X1 or X2. For example, consider the production plan at time zero represented as the "old production point", which lies in the interior of the set of production possibilities. As it moves towards the blue curve, every combination of X1 and X2 on the way is feasible and represents an increase in both X1 and X2. The "old production point" is therefore an inefficient production plan. The distance between it and the frontier can be considered to be a measure of the degree of economic inefficiency or slack, or alternatively, of the size of the surplus potential output, at time zero.

Over time, if the quantities of the primary inputs, tangible capital, labor and land, are increased, or if there is technical progress, so that output can be increased without increasing the inputs, the set of production possibilities will expand, as additional production plans become feasible. This is represented in Chart 1 as the outward movement of the frontier of the set of production possibilities, from the blue curve to the red curve, and the expansion of the set of production possibilities to include the area shaded in red as well.

It is important to distinguish between a movement from the interior of the set of production possibilities to its frontier and an expansion of the set of production possibilities. In the former case, no additional inputs are required. In the latter case, either additional inputs, or technical progress, which is not free of cost, are required. Moreover, a movement from the interior of the set of production possibilities to its frontier is a one-off opportunity-- once the frontier is reached, further increases in output will be dependent on the expansion of the set of production possibilities itself, which will require additional inputs, tangible or intangible. However, it is not entirely straightforward to try to distinguish between a movement from the interior of the set of production possibilities to its frontier and a movement of the frontier of the set of production possibilities itself.

In the case of the Chinese economy, prior to the economic reform which began in 1978, significant economic slack and hence surplus potential output existed because of the inherent inefficiency of a centrally planned economy. This implies that the Chinese economy operated in the interior of its set of production possibilities at the time. Under the economic reform, conditional autonomy was granted to the producers and free markets were established, removing prior constraints on their choices of actions. This would allow the economy to begin to move to the frontier of its set of production possibilities and realize its surplus potential output. We shall try to measure the magnitude of the surplus potential output in the Chinese economy prior to its economic reform of 1978 by comparing the economic performance in the periods preceding the reform, during the reform, and following the reform. We shall try to identify and estimate the increase in output that can be attributed to the reduction and elimination of the prior economic slack.

In June 2015, the proposed political reform package was voted down in the Legislative Council. Hong Kong missed a real opportunity to improve its governance and

enhance the livelihood of its people. What Hong Kong needs to do now is to try to mitigate the negative long-term economic consequences of the failure to implement the proposed economic reform and launch new initiatives that will help to ensure its long-term economic prosperity.

3. The Inherent Economic Inefficiency under Central Planning

From 1953, when China adopted its First Five-Year (1953-1957) Plan, to the end of the last Century, the Chinese economy operated under a series of mandatory five-year central plans, modeled after the former Soviet Union. However, in a centrally planned economy, there is always inherent economic inefficiency, which in turn implies the continuing existence of economic slack or surplus potential but unrealized output in the economy. This surplus potential output can in principle be realized with the introduction of economic reforms granting autonomy to the producers and providing incentives for them through the free markets, which should then lead to a one-time spurt in the growth of real GDP, possibly phased in over several years, even in the absence of increases in inputs.

Why is there inherent economic inefficiency in a centrally planned economy? A principal characteristic of a centrally planned economy is the administrative allocation of resources. What goods and services to produce? How much to produce? Where to produce them? What raw materials and parts should be used to produce them? From which enterprises should the raw materials and parts be bought? To which enterprises should the outputs be sold? All of these decisions are made by the central planners and embodied in the mandatory central plan. Enterprises do not have any autonomy in these decisions. The prices of goods and services are also completely set in the central plan and are only used for accounting purposes. They do not necessarily reflect relative scarcities in the economy and do not play any role in the equilibration of market supply and demand. For reasons to be explained below, a centrally planned economy always has slack, that is, it always operates in the interior and not on the frontier of its set of production possibilities. Thus, output can be increased by simply reducing the slack--by moving to the frontier from the interior of the set of production possibilities--in principle without having to increase any inputs. The existence of inherent inefficiency therefore also implies the existence of surplus potential output.

In order to understand why there always exists inefficiency in a centrally planned economy, we consider the following simple example drawn from agriculture. There are two farm households, headed by two farmers, A and B. Each has a hectare of land. Both cotton and rice are needed by the economy. The central planner's problem is to decide: which household should grow cotton and which household should grow rice, as well as how much of each crop to grow.

First of all, there may be a problem of insufficient or inaccurate information on the part of the central planner. The central planner may not know which one of the two plots is more suitable for growing cotton or rice. Moreover, the central planner may also not know whether Farmer A can grow cotton better than Farmer B or vice versa. If the central planner makes any mistake in the assignment of the production responsibilities, a simple rearrangement of the assignment can increase total output without having to increase any input.

Second, the central planner may fail to optimize, even if he or she has the complete information. Full optimization may not be possible, for example, across all the farmers, because of the immense complexity of the problem or because of unforeseen constraints. Failure of optimization again implies that for the economy as a whole there is room for increasing output without having to increase any input.

Third, there is also the problem of a lack of incentive on the part of the farmers to exceed the assigned production targets even if they are in principle able to do so. To the farmer, if he or she manages to produce an output that exceeds the assigned production target, not only would his or her income not increase under a mandatory central plan, so that the extra efforts would have gone un-rewarded, but also the assigned production responsibility for the following year might even be increased, now that the higher target has been shown to be feasible, making it more difficult for the framer to fulfill his or her obligation then. (This is sometimes referred to as the "ratchet" effect.) Thus, the optimal strategy for the farmers is to try to produce only the assigned target output as specified in the mandatory central plan, and not to try to exceed it, even if it is possible to do so. Once again there is surplus potential output that is not realized under central planning.

For these reasons, there is always economic slack, or surplus potential output, in a centrally planned economy. However, if there is a way to remove the constraints on and

provide the necessary incentives to the producers, then without having to increase the aggregate inputs assigned under the central plan, aggregate output can be increased. For example, the farmers can be given the autonomy to grow anything on their plots once they have fulfilled their obligations under the central plan, and to retain the resulting profits (and to bear the resulting losses), if any.

4. A Brief Chronology of Early Chinese Economic Reform

Chinese economic reform first began in 1978 in the agricultural sector. The household "contract responsibility system (家庭联产承包责任制)", also called the "household responsibility system", was introduced in the countryside of Anhui Province, at first almost spontaneously.[6] Under the "contract responsibility system," each member household of a commune and its production brigades was individually responsible for its share of the commune or brigade output delivery quotas assigned under the central plan. Subject to the fulfillment of its individual share of these quotas first, each member household was free to grow whatever it wished, on plots under its own exclusive management, sell its extra output on the free market at prices determined in the market, and enjoy whatever gains and suffer whatever losses entirely on its own. Then the commune, which would wind up with almost no real function for agricultural production under the "contract responsibility system", established township and village enterprises (T&V enterprises) to produce other goods and services, using its own surplus resources, and sell the outputs on the free market. Thus, the agricultural production assignment of the central plan to the commune continued to be enforced and fulfilled after the agricultural economic reform of 1978, at the same time that free markets were introduced on which output over and above and beyond the assigned production quota could be freely sold at market-determined prices.

It should be clear that no one would be made economically worse off by the introduction of the "contract responsibility system" in the agricultural sector. The commune and its officials would not be worse off, because they would still be able to deliver the required quota under the mandatory central plan to the government. The households would not be worse off, because they would not be required to produce any more output than before. In addition, the commune would be able to generate additional income through their T&V

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[6] The arrangement was first initiated by the 18 households in Xiaogang Village, Fengyang Xian, Anhui Province (安徽省凤阳县小岗村) in December 1978,.

enterprises and the households would also be able to do so by growing more on their plots and selling the extra output on the free markets. So no one would lose but anyone who would want to become a winner would be free to do so.

After the initial introduction of the "contract responsibility system" in Xiaogang Village, Fengyang Xian, Anhui Province, in December 1978, it soon spread to other parts of Anhui Province and to Sichuan Province as well. Ultimately it was adopted almost everywhere nationwide in the early 1980s, supplanting the role of the people's commune as an organization for production. Subsequently the "contract responsibility system" was also extended to the urban areas, covering the industrial enterprises as well, making the entire Chinese economy a "dual-track" economy, with the free markets functioning alongside the mandatory central plan. Shanghai, which had been responsible for contributing much of the revenue of the central government, was among the last provinces, autonomous regions and municipalities to have conditional autonomy granted to their enterprises and parallel free markets established, in early 1992.

5. The Estimation of the Pre-Reform Surplus Potential Outputs by the Direct Comparison Method--Anhui Province

While there must have been slack in the Chinese economy, and in its agricultural sector in particular, before the introduction of economic reform in 1978, it is not straightforward to estimate how much slack there was. We define the pre-reform surplus potential output as the additional output that would have been produced relative to the actual pre-reform output if the economy had been operating efficiently, that is, on the frontier of its set of production possibilities. We note that in principle, this is the additional output that could have been realized without additional inputs. For the present purpose, we do not consider the additional labor services performed by a grossly under-employed rural labor force as additional inputs.

However, since it takes time for the effects of economic reform to be fully realized and for the economic slack to be reduced and eliminated, we would have to take into account that even in the absence of economic reform, inputs and therefore output would have grown too. It is assumed that, on average, the time required for the full elimination of the economic slack is six years. In what follows, we use a primitive but direct method to estimate the size

of the surplus potential output--we simply compare the growth of real output during the six-year "pre-reform period" before the initiation of economic reform and for the two successive six-year periods after the initiation of economic reform (the "reform period" and "post-reform period" respectively). We assume that in the absence of economic reform, output would have grown during the "reform period" at the average rate of growth of the "pre-reform period", on the basis of the "usual and customary" growth of inputs. It is assumed that no new inputs, such as chemical fertilizers and insecticides that did not exist before the reform were introduced during the reform period. This is not an unreasonable first approximation as the agricultural sector was the very first to undergo reform and the industrial sector, still operating under mandatory central planning, was not in a position yet to provide the additional inputs such as chemical fertilizers to the agricultural sector. (In addition, Anhui was not particularly industrialized to start with.) The increase in output attributable to the elimination of the prior economic slack can therefore be estimated as the difference between the actual output realized at the end of the reform period and the hypothetical output at the end of the reform period assuming "business as usual" as in the pre-reform period. For example, if the actual realized output at the end of the reform period represents an average rate of growth of 9% per annum relative to the actual output at the end of the pre-reform period, and the average trend rate of growth for the pre-reform period is 3% per annum, then the growth of output attributable to the elimination of the economic slack is the difference between 9% and 3%, that is, 6% per annum compounded over six years, or 42 percent.

Alternatively, the average annual rate of growth over the "post-reform period" can be taken as a benchmark for the post-reform "normalized" (or "steady-state") growth under the new policies after the prior economic slack has been exhausted during the reform period. Thus, it would have reflected the increases in labor and other inputs in response to the economic reform. The increase in output attributable to the elimination of the economic slack can therefore be estimated as the difference between the hypothetical output at the end of the post-reform period assuming that the average annual rate of growth is the same as that of the reform period and the actual output realized at the end of the post-reform period.

One may question why we choose six years as opposed to five or even four years as the time required for the elimination of the economic slack. Clearly, any reform will take time to diffuse from the village where it first started to the entire province and then to the entire country. There are also local administrative and political problems to overcome.

Moreover, the slack is likely to be reduced only gradually over time as both experimentation and learning are involved. After some preliminary examination of the data, in which the rates of growth of real output and other economic indicators generally experienced a significant decline between 1984 and 1985, we choose six years (1979-1984) as the period over which the pre-existing economic slack is likely to be entirely eliminated or exhausted in the province/autonomous region/municipality in question in response to the economic reform.[7]

We look at Anhui Province as well as China as a whole. The agricultural reform was first started in Anhui in December 1978, and soon spread to the rest of the province, and then to China as a whole. By the end of 1982, the "contract responsibility system" was introduced in almost all of the rural areas of China. So for agricultural reform (in Anhui), the six-year pre-reform period would be 1973-1978; the actual reform period would be 1979-84; and the normalized post-reform period would be 1985-1990.

In Chart 2, the rates of growth of grain output in Anhui Province and in China are presented for the eighteen-year period from 1973 through 1990. It is clear that for both Anhui Province and China, the rates of growth of grain output were higher during the agricultural reform period than either the pre-reform or the post-reform period. For Anhui Province, the average annual rate of growth of grain output during the pre-reform period of 1973-1978 was 1.35%, compared to 6.83% during the reform period (1979-1984), and 1.84% for the post-reform period (1985-1990). The surplus potential grain output in Anhui Province may therefore be estimated as either the difference in output resulting from the difference between the average annual rates of growth of the reform and pre-reform period, 5.48% per year, or that resulting from the difference between the average annual rates of growth of the reform and post-reform period, 4.98% per year. Over a six-year period, the cumulative surplus potential output may be estimated to be between 33.9% and 37.7% for Anhui Province.[8] For China as a whole, the average annual rate of growth of grain output during the pre-reform period was 4.03%, compared to 4.95% during the reform period, and 1.53% for the post-reform period. The surplus potential output in China may therefore be estimated as either the difference in output resulting from the difference between the average annual rates of growth of the reform and pre-reform period, 0.92% per year, or between the reform and post-reform period, 3.42% per year. Over a six-year period, the cumulative surplus potential

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[7] The results of our econometric analysis in Section 7 are also quite robust with regard to whether the reform period is assumed to be four, five or six years (see Appendix Table 1).
[8] The six-year cumulative effect is estimated with annual compounding. The same is true of all other estimates of cumulative effects in this paper.

output may be estimated to be between 5.68% and 22.35% for China as a whole. However, this would be an under-estimate of the size of the pre-existing potential surplus grain output for China as a whole as the agricultural reform was introduced in some of the Chinese provinces only in 1982.

Chart 2: The Rate of Growth of Grain Output, China and the Province of Anhui, 1973-1990
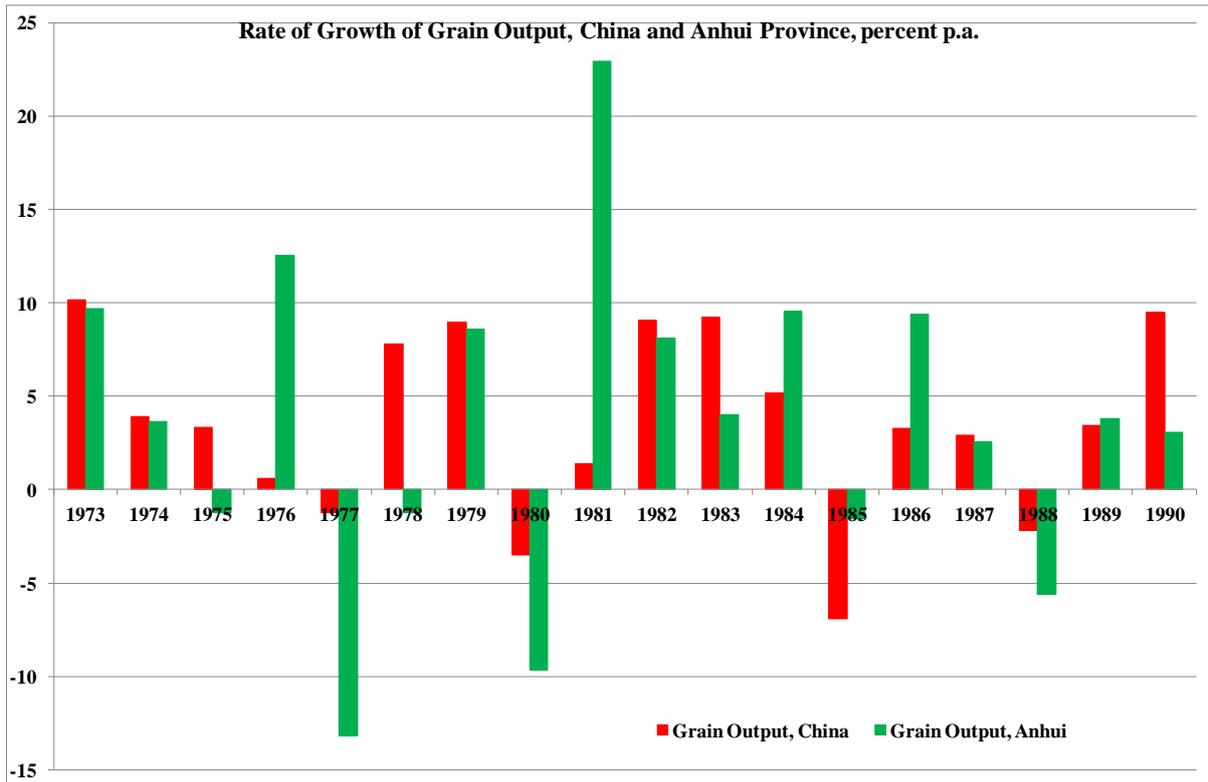
However, the agricultural sector cannot be represented by grain output alone. We next examine the data on the rates of growth of the gross value of agricultural production, adjusted for inflation, for both Anhui Province and China. These rates of growth are presented in Chart 3. It is also clear that for both Anhui and China, the rates of growth were similarly higher during the reform period than either the pre-reform or the post-reform period. For Anhui Province, the average annual real rate of growth of the gross value of agricultural production during the pre-reform period was -0.02%, compared to 8.55% during the reform period and 3.23% for the post-reform period. Thus, the size of the surplus potential agricultural output in Anhui may be estimated at between 5.32% and 8.57% per year, or somewhere between 36.47% and 65.10% cumulatively over six years. For China as a whole, the average annual real rate of growth of the gross value of agricultural production during the

pre-reform period was 2.63%, compared to 7.76% during the reform period and 4.52% for the post-reform period. Thus, the size of the surplus potential agricultural output for China may be estimated at between 3.24% and 5.13% per year, or somewhere between 21.06% and 34.96% cumulatively over six years. For similar reasons as in the case of grain output, we believe the estimated surplus potential agricultural output for Anhui is much more reliable than that for China as a whole.

Chart 3: The Real Rate of Growth of the Gross Value of Agricultural Production, China and the Province of Anhui, percent p. a., 1973-1990

Third, we examine the data on the rates of growth of the real value-added of the agricultural sector for both Anhui Province and China. These rates of growth are presented in Chart 4. It is also clear that for both Anhui and China, the rates of growth were higher during the reform period than either the pre-reform or the post-reform period. For Anhui, the average annual rate of growth of the real value-added in agriculture during the pre-reform period was 0.16%, compared to 8.03% during the reform period and 2.84% for the post-reform period. Thus, the surplus potential output in Anhui may be estimated at between 5.19% and 7.87% per year, or somewhere between 36.46% and 57.52% cumulatively over six years. For China as a whole, the average annual rate of growth of the real value-added in agriculture during the pre-reform period was 2.46%, compared to 7.28% during the reform period and 3.77% for the post-reform period. Thus, the surplus potential output may be estimated at between 3.51% and 4.82% per year, or somewhere between 23.02% and 32.63% cumulatively over six years. We should note, however, that during the post-reform period, additional inputs for agriculture such as chemical fertilizers began to be more generally available, contributing to the continued increase in agricultural output. Thus, the surplus potential output is probably more accurately reflected by the actual additional output produced in the reform period over what would have been produced if there were no economic reform and by the data on Anhui rather than China as a whole.

Chart 4: Rate of Growth of Real Value-Added in the Agricultural Sector, China and the Province of Anhui, percent p.a.
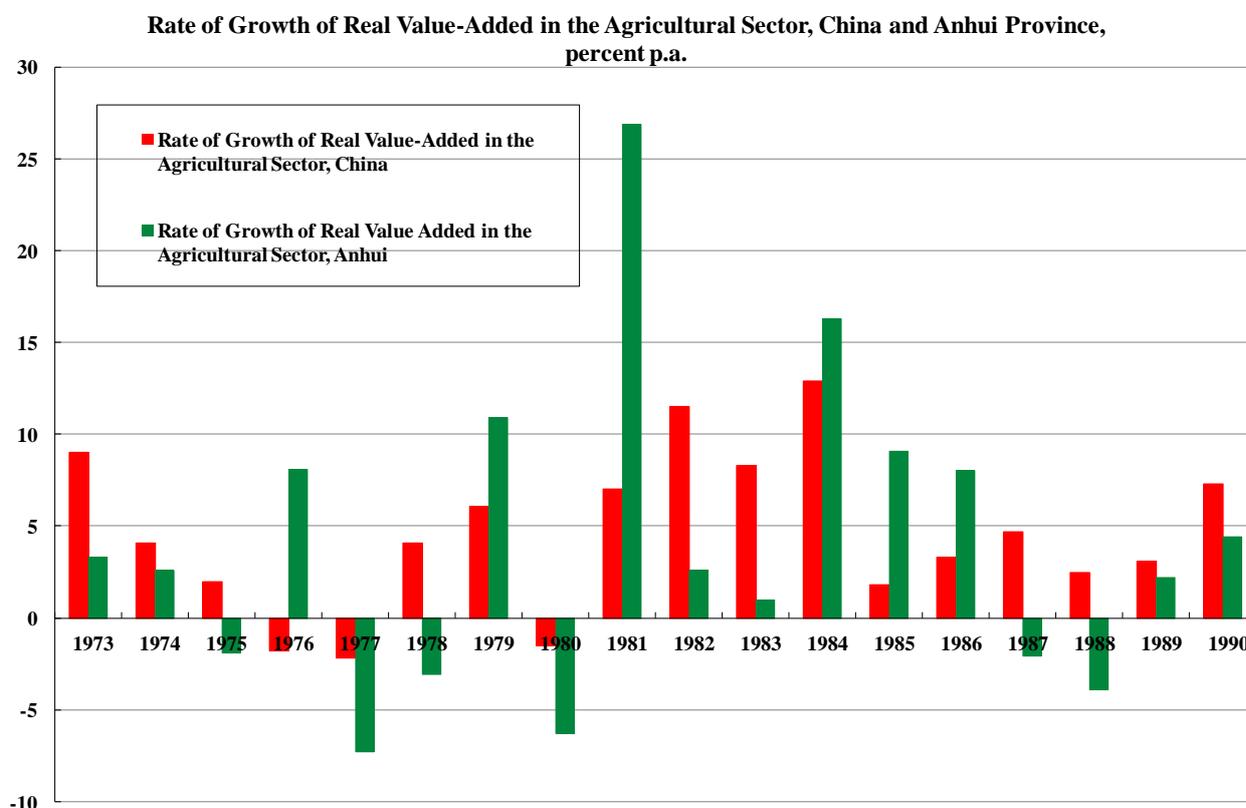
Rate of Growth of Real Value-Added in the Agricultural Sector, China and Anhui Province, percent p.a.

In 1978, the distribution of Chinese GDP by sector originating was primary (agriculture), 27.90%, secondary (manufacturing, mining and construction), 47.56%, and tertiary (services), 24.54%. If we multiply the estimated Anhui potential surplus output of 57.52% in the primary sector, estimated above, to the share of the primary sector in GDP, we obtain 16.05%, which, on the assumption that similar slacks existed in the primary sectors of all Chinese provinces, regions and municipalities, can be used as an estimate of the pre-existing potential surplus output in terms of GDP in the primary sector of China.

Fourth, we examine the data on real disposable income per capita in the rural areas for both Anhui Province and China. The data, which are only available for the years after 1978, are presented in Chart 5. Chart 5 shows that the rate of growth of rural real disposable income per capita was the highest for both Anhui and China during the reform period. The average annual rate of growth during the reform period was 19.07% for Anhui and 16.46% for China, compared to average annual rates of and 8.91% and 3.75% respectively in the post-reform period. The implied surplus potential output was 78.69% for Anhui and 105.00% for China. However, the increase in rural real disposable income per capita did not come

solely from agriculture; it also came from the secondary sector, through the Township and Village enterprises and through the homeward remittances of migrant laborers, and through the service sector.

Chart 5: Rate of Growth of Real Disposable Income per Capita in Rural Areas, China and the Province of Anhui, percent p. a.
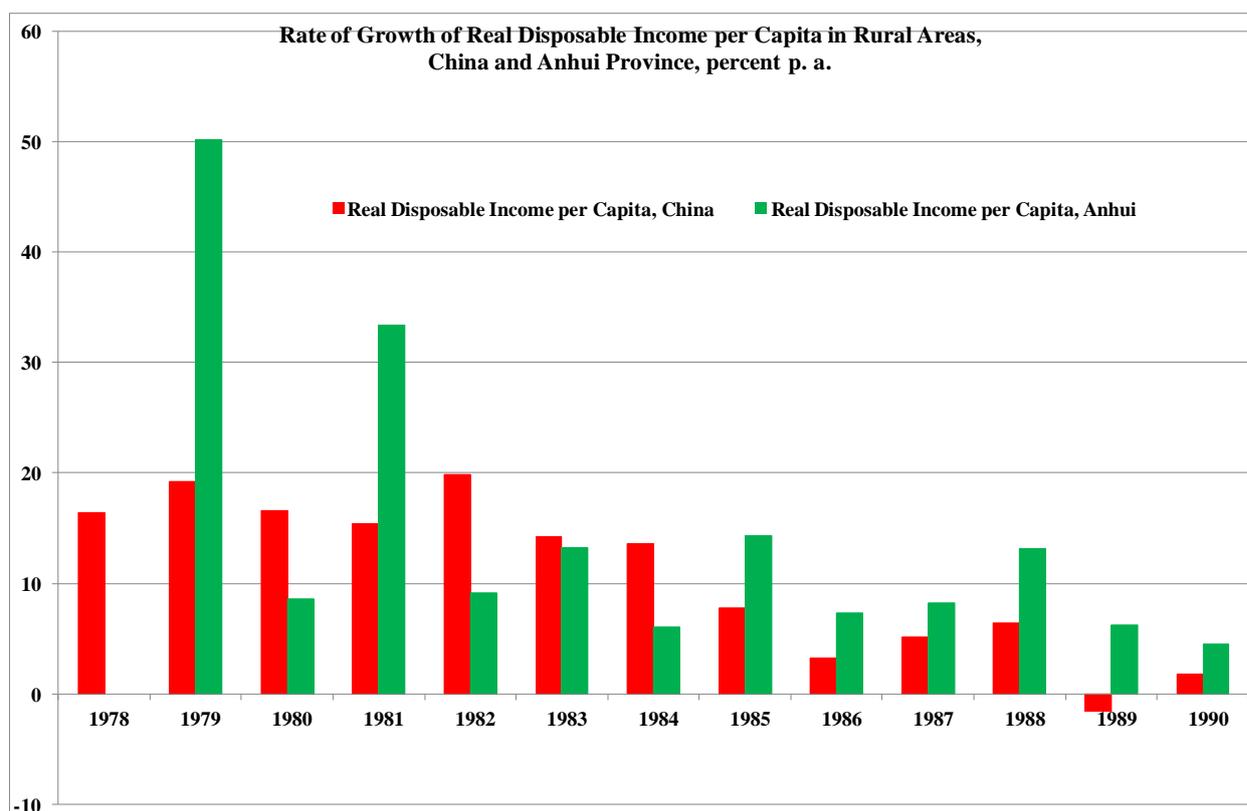
Finally, we examine the data on the rate of growth of real GDP for both Anhui Province and China. The data are presented in Chart 6. For Anhui, the rate of growth of real GDP increased from 2.58% in the pre-reform period to 11.24% in the reform period, an increase of 8.66%, or 64.65% cumulatively over a six-year period. In the post-reform period, the real GDP of Anhui grew at 7.38%. However, we believe the increase in real GDP during the post-reform period should be attributed to the economic reform measures implemented in the urban areas subsequent to the agricultural reform and not to the agricultural reform per se. For China as a whole, the rate of growth of real GDP increased from 5.97% in the pre-reform period to 9.22% in the reform period, an increase of 3.25%, or 21.14% over a six-year period. It then fell back to 8.85% in the post-reform period. However, we believe the increase in real GDP during the post-reform period should be attributed to the non-agricultural reform

measures implemented in the urban areas subsequent to the agricultural reform and not to the agricultural reform per se.

Chart 6: The Rate of Growth of Real GDP of China and the Province of Anhui, percent p. a.

The Rate of Growth of Real GDP, China and Anhui Province, percent p.a.

■ Rate of Growth of Real GDP, China

■ Rate of Growth of Real GDP, Anhui
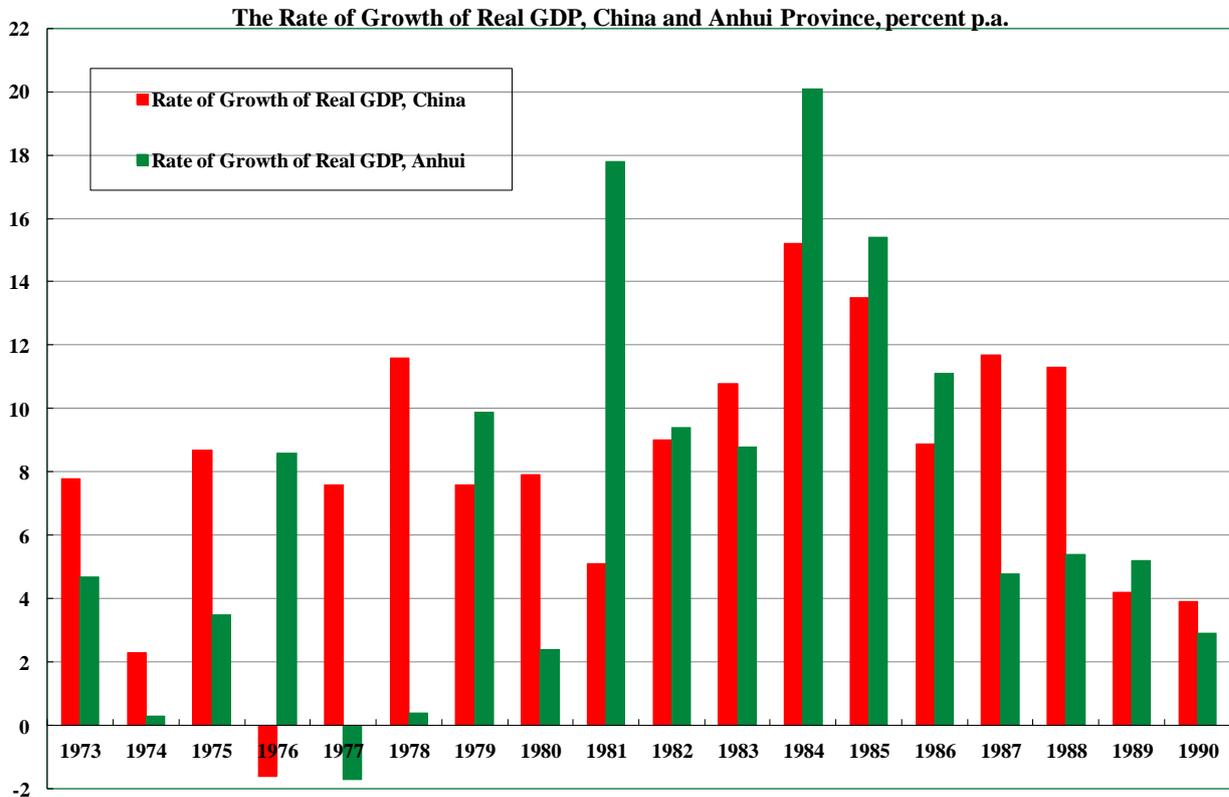
It is clear from the data presented above that the economic reform implemented in late 1978 did have a highly significant one-time effect on the economic performance of both Anhui Province and China. This one-time effect can be attributed to the reduction and/or elimination of the economic slack that had existed prior to the economic reform. We summarize our estimates of the surplus potential output in Table 1 below.

Table 1: A Summary of Estimated Pre-Reform Surplus Potential Outputsin China and the Province of Anhui, percent

Summary of Estimated Surplus Potential Outputs (percent)						
	Anhui			China		
	Relative to Pre-Reform	Relative to Post-Reform	Average	Relative to Pre-Reform	Relative to Post-Reform	Average
Real GDP	64.65%	25.53%	45.09%	21.14%	2.23%	11.68%
Grain Output	37.70%	33.90%	35.80%	5.68%	22.35%	14.02%
Real Gross Value of Agricultural Production	65.10%	36.47%	50.79%	34.96%	21.06%	28.01%
Real Value-Added of Agricultural Sector	57.52%	35.46%	46.49%	32.63%	23.02%	27.82%
Real Income per Capita of Rural Population		78.69%	78.69%		105.00%	105.00%
Average	56.24%	42.01%	49.13%	23.60%	34.73%	29.17%

As we can see from Table 1, relative to the pre-reform period, the estimated surplus potential output for Anhui ranges between 37% and 65%. Relative to the post-reform period, the estimated potential surplus output for Anhui ranges between 25% and 36%. We believe that the difference in economic performance between the pre-reform and the reform periods is probably more representative of the effect of economic reform alone, and that the difference in economic performance between the reform and the post-reform periods only provides a lower bound for the effect of economic reform since more inputs from the industrial sector would have become available in the post-reform period. For China as a whole, relative to the pre-reform period, the estimated surplus potential output ranges between 5% and 34%. However, the effect on the Chinese economy as a whole during the 1979-1984 period is probably a significant under-estimate of the pre-existing surplus potential output as the agricultural reform had not been uniformly implemented in all of China until the end of 1982.

Taking all of these considerations into account, we believe that an estimate of the existence of a pre-reform potential surplus output in the agricultural sector on the order of 50% for Anhui, and by extension for the agricultural sector of the Chinese economy as a whole, is not unreasonable.

6. The Estimation of the Pre-Reform Surplus Potential Outputs by the Direct Comparison Method--Shanghai Municipality

We next examine the economic record of Shanghai. Economic reform came very late to Shanghai. Shanghai had the responsibility of providing much of the revenue of the Chinese central government and was not allowed to undertake new investment projects until early 1992, after the famous "Southern Inspection Tour" of Mr. DENG Xiaoping. It is precisely because Shanghai was not allowed to fully develop its economy until 1992 that it

provides an opportunity for us to estimate the pre-reform economic slack in the secondary and tertiary sectors in China, using Shanghai as a typical case. Thus, for Shanghai, instead of focusing on the period immediately after the beginning of economic reform in 1978, we look at the six-year period from 1992 to 1997, and compare the economic performance to those during the preceding seven-year pre-reform period of 1985-1991, and the following six-year post-reform period of 1998-2003. We choose 1985-1991 to be the pre-reform period rather than 1986-1991 because the latter half of 1989 and 1990-1991 were abnormally slow-growth years for China because of the June 4 incident in 1989. In addition, since agriculture is not important in Shanghai, we shall restrict our attention to the growth of its real GDP and the real value-added of its secondary and tertiary sectors.

In Chart 7, the rates of growth of real GDP of Shanghai Municipality and China as a whole are presented for the nineteen-year period from 1985 through 2003. It is clear that for both Shanghai and China, the rates of growth were higher during the Shanghai reform period of 1992-1997 than either the pre-reform or the post-reform period. For Shanghai, the average annual rate of growth of real GDP more than doubled from the pre-reform period of 6.9% to 14.1% during the reform period, dropping back to 11.0% in the post-reform period. The fact that the rate of growth in Shanghai in the post-reform period fell significantly from 14.1% to 11.0% supports the interpretation that the growth spurt during the reform period was due to the one-off effect of the elimination of the pre-existing economic slack and the realization of the surplus potential output. Cumulatively, the growth spurt during the reform period accounted for an additional 51.4% increase in the real GDP of Shanghai over the pre-reform period. For China as a whole, the average annual rate of growth of real GDP during the pre-Shanghai reform period was 8.9%, compared to 11.9% during the reform period, and 8.5% for the post-reform period. Cumulatively, the surplus potential output for China may be estimated to be between 19.2% and 21.9% over the six-year Shanghai reform period (bear in mind that economic reform had been on-going for the rest of the country for more than ten years by 1992).

Chart 7: The Rate of Growth of Real GDP, China and Shanghai Municipality, percent p.a.

The Rate of Growth of Real GDP, China and Shanghai Municipality, percent p.a.
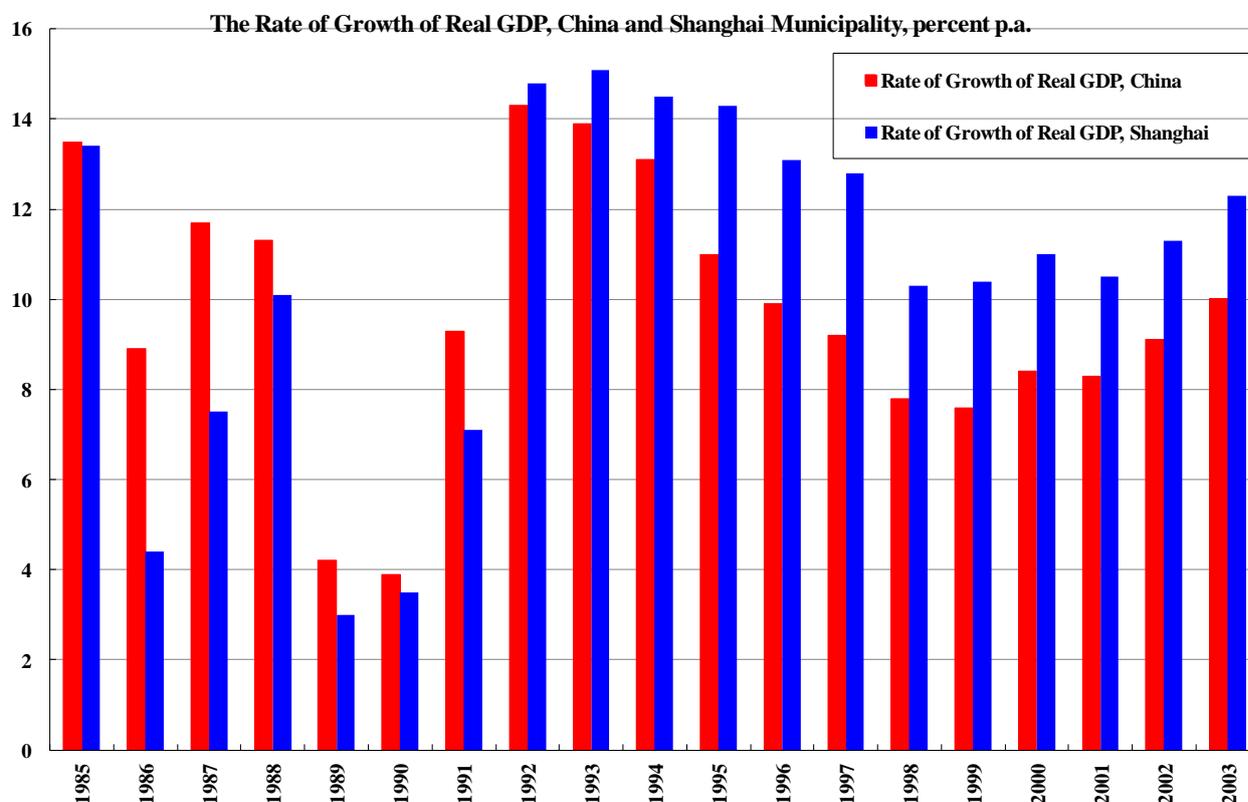
In Chart 8, the rates of growth of real value-add in the secondary sector (which includes manufacturing, mining and construction) in Shanghai and China are presented for the nineteen-year period from 1985 through 2003. It is also clear that for both Shanghai and China, the rates of growth were similarly higher during the reform period than either the pre-reform or the post-reform period. For Shanghai, the average annual rate of growth also more than doubled from 6.6% in its pre-reform period to 14.1% in its reform period, and then dropped back to 11.2% in its post-reform period. The growth spurt in Shanghai during its reform period accounted for an additional cumulative increase in its real value-added in the secondary sector of 53.8%, which may also be attributed to the elimination of the pre-existing economic slack in the secondary sector in Shanghai. Again, the significant decline in the rate of growth in the post-reform period supports the interpretation that the growth during the Shanghai reform period was due to the one-off elimination of the pre-existing economic slack. For China as a whole, the average annual rate of growth of real value-added in the secondary

sector during the pre-reform period was 11.01%, compared to 15.9% during the reform period, and 9.6% for the post-reform period.[9] The growth spurt in China as a whole during its reform period accounted for an additional cumulative increase in its real value-added in the secondary sector of 33.5%, which may also be attributed to the elimination of the pre-existing economic slack in the secondary sector.

Chart 8: The Rate of Growth of Real Value-Added in the Secondary Sector, China and Shanghai Municipality, percent p.a.

The Rate of Growth of Real Value-Added in the Secondary Sector, China and Shanghai Municipality, percent p.a.
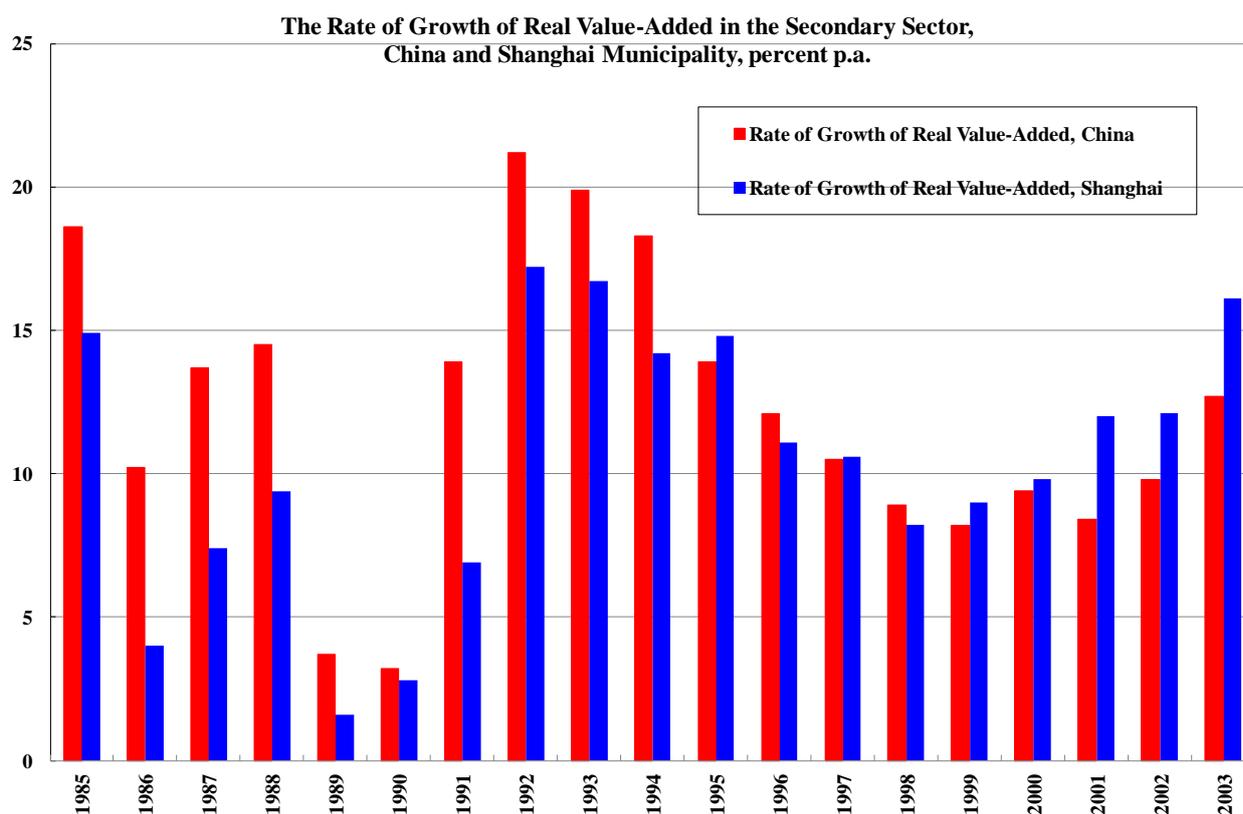
In Chart 9, the rates of growth of real value-add in the tertiary (service) sector in Shanghai and China are presented for the nineteen-year period from 1985 through 2003. The pattern for Shanghai is similar to those in the cases of real GDP and real value-added in the secondary sector: the rates of growth were also higher during its reform period than either the pre-reform or the post-reform period. The average annual rate of growth increased from 9.0% in its pre-reform period to 15.2% in its reform period, and then dropped back to 11.8% in its post-reform period. The growth spurt in value-added in the tertiary sector in Shanghai during

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[9] However, the rate of growth during the post-reform period might have been affected negatively by the East Asian Currency Crisis of 1997-1998 and positively affected by the Chinese accession to the World Trade Organisation (WTO).

its reform period, which accounted for an additional cumulative increase in the real value-added in its tertiary sector of 44.0% may also be similarly attributed to the reduction/elimination of the pre-existing economic slack in Shanghai.

Chart 9: The Rate of Growth of Real Value-Added in the Tertiary Sector, China and Shanghai Municipality, percent p.a.

The Rate of Growth of Real Value-Added in the Tertiary Sector, China and Shanghai Municipality, percent p.a.
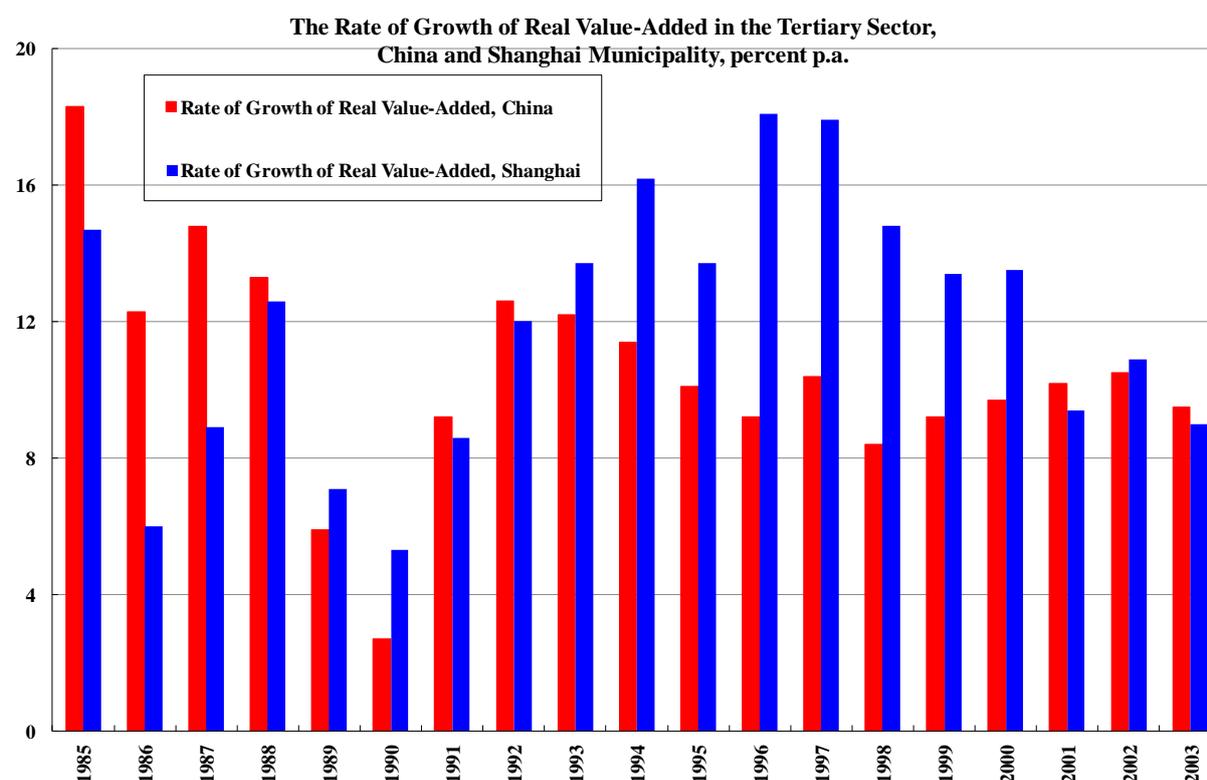
It is clear from the data presented above that the urban non-agricultural economic reform implemented in Shanghai beginning in early 1992 did have a highly significant positive impact on the economic performance of Shanghai Municipality, especially when compared with the its pre-reform period. We summarize our estimates of the surplus potential outputs in Table 2 below.

Table 2: A Summary of the Estimated Pre-1992 Surplus Potential Outputs in China and Shanghai Municipality, percent

Summary of Estimated Surplus Potential Outputs (percent)					
	Shanghai			China	
	Relative to Pre-Reform	Relative to Post-Reform	Average	Relative to Pre-Reform	Relative to Post-Reform	Average
Real GDP	51.37%	20.33%	35.85%	19.16%	21.85%	20.51%
Real Value-Added, Secondary Sector	53.81%	18.73%	36.27%	33.47%	44.74%	39.11%
Real Value-Added, Tertiary Sector	43.97%	22.44%	33.21%	0.97%	8.67%	4.82%
Average	49.71%	20.50%	35.11%	17.87%	25.09%	21.48%

As we can see from Table 2, the estimated surplus potential outputs for Shanghai Municipality were between 43% and 53% when compared with the pre-reform period. Taking into account the fact that the difference in economic performance between the pre-1992 and the 1992-1997 periods is probably more representative of the effect of the economic reform in the non-agricultural sectors (with the post-1997 period negatively affected by the East Asian currency crisis and positively affected by the accession of China to the World Trade Organisation (WTO)), we believe that an estimate of the existence of a pre-reform non-agricultural economic slack on the order of approximately 50% in Shanghai and by extension in China is not an unreasonable one.

In 1978, the distribution of Chinese GDP by sector originating was primary (agriculture), 27.90%, secondary (manufacturing, mining and construction), 47.56%, and tertiary (services), 24.54%. If we multiply the estimated Shanghai surplus potential outputs of 53.81% in the secondary sector and 43.97% in the tertiary sector to their respective shares in GDP and add them together, we obtain 36.38%, which can be used as an estimate of the pre-reform surplus potential outputs in terms of GDP in the secondary and tertiary sectors of China as a whole.

The average estimated surplus potential outputs for the Chinese economy as a whole in Table 2 are also on the order of 20%. However, we believe that this is not a reliable estimate of the pre-existing surplus potential output for the Chinese economy as a whole because by 1992 the rest of China had already undergone significant agricultural and non-agricultural economic reforms.

7. The Econometric Estimation of a Piece-Wise Linear Model of Economic Growth--Anhui Province and Shanghai Municipality

An alternative and more systematic method for estimating the size of the surplus potential output (or its mirror image, the pre-existing economic slack) is to assume that the natural logarithm of real output grows in accordance with a piecewise linear functional form with respect to time.[10] Prior to the reform, the natural logarithm of the real output is assumed to take the form:

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[10] Still another alternative is to estimate a production function, relating the real output to the primary inputs of tangible capital and labor as well as technical progress econometrically. The estimated production function then allows us to test whether the economic performance during the reform period is different from those during both

$$\ln Y_t = \alpha_0 + \gamma_0 t, \ 0 \le t < t_0,$$

where t is a time trend variable taking the value 0 at the beginning of the pre-reform period, say 1973 in the case of Anhui (or 1985 in the case of Shanghai) and t_0 is the first year of the reform period, say, 1979 for the agricultural sector in Anhui (or 1992 for the secondary and tertiary sectors in Shanghai). For $t_1 > t \ge t_0$,

$$\ln Y_t = \alpha_0 + \alpha_1 + \gamma_0 t + \gamma_1 (t - t_0),$$

where t_1 is the first year after the end of the reform period, say 1985 (or 1998), α_1 represents a possible jump and γ_1 represents a possible increase in the trend rate of growth at the beginning of the reform period. The above equation simplifies into:

$$\ln Y_t = (\alpha_0 + \alpha_1 - \gamma_1 t_0) + (\gamma_0 + \gamma_1) t.$$

For $t \ge t_1$,

$$\ln Y_t = (\alpha_0 + \alpha_1 + \alpha_2 + \gamma_1 (t_1 - t_0) - \gamma_2 t_1) + (\gamma_0 + \gamma_2) t,$$

where α_2 represents a possible jump (up or down) and γ_2 represents a possible change in the trend rate of growth at the beginning of the post-reform period. Taken together, we have:

(1) $\ln Y_t = \alpha_0 + \gamma_0 t + \alpha_1 D1 + (\alpha_1 + \gamma_1 (t_1 - t_0) + \alpha_2) D2 + \gamma_1 D1.(t - t_0) + \gamma_2 D2.(t - t_1),$

where D1 = 1, during the reform period, $t_1 > t \ge t_0$, and 0 otherwise;

D2 = 1, during the post-reform period, $t \ge t_1$, and 0 otherwise.

In Chart 10 we present a chart of such a typical piecewise linear function representing the growth path of the natural logarithm of real output during the pre-reform, reform and post-reform periods.

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the pre-reform and post-reform periods, and if so, to provide an estimate of the magnitude of the difference, which can the be attributed to the pre-existing slack before the reform. However, the necessary data are not readily available to carry out this exercise.

Chart 10: The Hypothetical Path of Growth of the Natural Logarithm of Real Output Pre-, During and Post-Reform
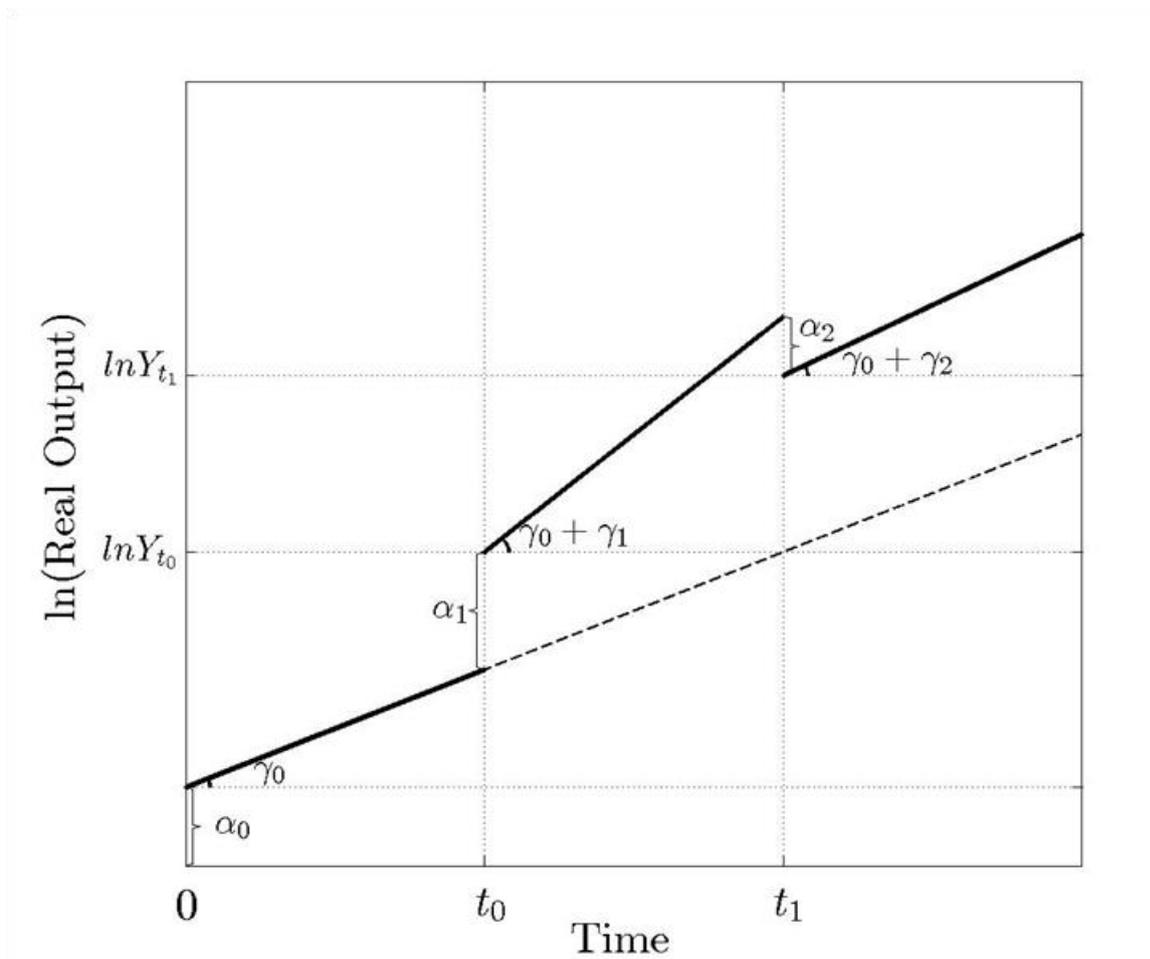
If we now take first differences of Equation (1) above, we obtain:

For $t < t_0$, $\ln Y_t - \ln Y_{t-1} = \gamma_0$;

for $t = t_0$, $\ln Y_t - \ln Y_{t-1} = \alpha_1 + \gamma_0$;

for $t_1 > t > t_0$, $\ln Y_t - \ln Y_{t-1} = \gamma_0 + \gamma_1$;

for $t = t_1$, $\ln Y_t - \ln Y_{t-1} = \alpha_2 + (\gamma_0 + \gamma_1)$; and

for $t > t_1$, $\ln Y_t - \ln Y_{t-1} = \gamma_0 + \gamma_2$.

Taken together, we have:

$$\ln Y_t - \ln Y_{t-1} = \gamma_0 + \alpha_1 d_1 + \alpha_2 d_2 + \gamma_1(D1 - d_1 + d_2) + \gamma_2(D2 - d_2),$$

where $d_1 = 1, t = t_0$, 0 otherwise; and

$d_2 = 1, t = t_1$, 0 otherwise.

This is then our basic estimating equation after appending a stochastic disturbance term with the usual assumed properties:

(2) $\ln Y_t - \ln Y_{t-1} = \gamma_0 + \alpha_1 d_1 + \alpha_2 d_2 + \gamma_1 (D1 - d_1 + d_2) + \gamma_2 (D2 - d_2) + \varepsilon_t.$

The econometric model is applied to the real value-added in the primary (agricultural) sector and the real GDP of Anhui Province and China, with the reform period set to 1979-1984, and to the real value-addeds in the secondary and tertiary sectors and the real GDP of China and Shanghai Municipality, with the reform period set to 1992-1997.

We note that α_1 and α_2 are possible jumps (up or down) in the constant term. It is reasonable to expect a positive jump at the beginning of the reform period. A jump (up or down) at the end of the reform period is also possible. The expectation is that a negative jump is likely at the end of the reform period as the pre-existing economic slack is exhausted. We first test the hypothesis that $\boldsymbol{\alpha_2 = 0}$, that is, there is no jump, up or down, at the beginning of the post-reform period. We next test the hypothesis of no reform effect, that is, there is no jump at the beginning of the reform period, and no change in the slope of the growth path during the reform period. This amounts to the joint hypothesis that $\boldsymbol{\alpha_1 = \gamma_1 = 0}$. The p-values of the tests of these two hypotheses are presented in Table 3. The hypothesis that there is no jump between the reform and post-reform periods can be rejected for China and for Shanghai (for real GDP and real value-added of the secondary sector), but cannot be rejected for Anhui and for the tertiary sector of Shanghai). The hypotheses of no reform effect are decisively rejected for both Anhui and Shanghai. However, these hypotheses cannot be rejected for China during the 1979-1984 period. We believe this is due to the relatively slow diffusion of the reform effects across the entire Chinese economy, especially at the beginning of the economic reform. For the period 1992-1997, the hypotheses of no reform effect are rejected for China at 1% significance level.

Table 3: p-Values of the Tests of Hypotheses

	China		Anhui		Shanghai	
	$\alpha_2 = 0$	$\alpha_1 = \gamma_1 = 0$	$\alpha_2 = 0$	$\alpha_1 = \gamma_1 = 0$	$\alpha_2 = 0$	$\alpha_1 = \gamma_1 = 0$
Real GDP (1973-1990)	0.005	0.426	0.281	0.003	N.A	N.A
Real GDP (1985-2003)	0.002	0.002	N.A	N.A	0.000	0.000
Real Value-Added, Primary Sector (1973-1990)	0.049	0.170	0.795	0.003	N.A	N.A
Real Value-Added, Secondary Sector (1985-2003)	0.005	0.000	N.A	N.A	0.001	0.002
Real Value-Added, Tertiary Sector (1985-2003)	0.001	0.009	N.A	N.A	0.289	0.000

The estimated parameters of the piecewise linear functions are presented in Table 4. First of all, we note that the estimates of the α_1's, the jumps at the beginning of the reform period, are consistently positive and are statistically significant except for the real GDP of China in 1979 and the tertiary sector of China in 1992. The real GDPs of both Anhui and Shanghai jumped 7% at the beginning of their respective reform periods. Second, the estimates of the α_1's are all greater than the corresponding estimates of the α_2's, the jumps at the end of the reform period, except for the real GDP of China in 1985. In particular, the estimates of the α_2's for the post-reform period of 1998-2003 are all negative and statistically significant (except for the tertiary sector of Shanghai), lending support to the interpretation that the high rates of growth during the reform period were one-off in nature, reflecting the elimination of the pre-existing economic slacks. Third, the estimates of the γ_1's, the increases in the rates of growth during the reform periods, are all positive, except for the tertiary sector of China, and moreover, they are all greater than the estimates of the γ_2's, the increases in the rates of growth during the post-reform periods. These results are actually quite robust with extending the pre-reform period back to 1952 and the post-reform period forward to 2014, the results of which are reported in the Appendix Table 2.

Table 4: Estimated Parameters

	China		Anhui		China			Shanghai		
	Sample Period: 1973-1990				Sample Period: 1985-2003					
	Real GDP	VA Primary	Real GDP	VA Primary	Real GDP	VA Secondary	VA Tertiary	Real GDP	VA Secondary	VA Tertiary
α_1	0.015	0.035*	0.069***	0.102***	0.048***	0.088***	0.016	0.071***	0.094***	0.027*
	(0.020)	(0.018)	(0.016)	(0.024)	(0.014)	(0.021)	(0.020)	(0.014)	(0.017)	(0.013)
α_2	0.035**	-0.055**	0.034	0.015	-0.033***	-0.053***	-0.021***	-0.033***	-0.047***	-0.010
	(0.016)	(0.025)	(0.030)	(0.057)	(0.008)	(0.016)	(0.005)	(0.004)	(0.011)	(0.009)
γ_1	0.033	0.048	0.084**	0.070	0.023	0.035	-0.001	0.064***	0.062***	0.062***
	(0.026)	(0.031)	(0.034)	(0.062)	(0.016)	(0.027)	(0.020)	(0.015)	(0.020)	(0.015)
γ_2	0.018	0.016	0.031	0.015	-0.002	-0.012	-0.009	0.038**	0.047**	0.020
	(0.026)	(0.020)	(0.021)	(0.033)	(0.014)	(0.023)	(0.020)	(0.015)	(0.021)	(0.016)
γ_0	0.058**	0.024	0.025	0.002	0.085***	0.104***	0.103***	0.067***	0.064***	0.086***
	(0.020)	(0.018)	(0.016)	(0.024)	(0.014)	(0.021)	(0.020)	(0.014)	(0.017)	(0.013)
Observations	18	18	18	18	19	19	19	19	19	19
R-squared	0.219	0.258	0.497	0.216	0.316	0.366	0.062	0.638	0.529	0.574

Notes: The dependent variables are the first differences of the the natural logarithms of real GDP, real value-added in the primary sector (VA Primary), the secondary sector (VA Secondary), and the tertiary sector (VA Tertiary). The real outputs are measured in 2014 Yuan. Numbers in parentheses are estimated standard errors calculated using the Huber/White (1980)/sandwich estimator. The symbols ***, **, * denote significance at the 1%, 5% and 10% respectively.

8. The Estimation of the Pre-Reform Surplus Potential Outputs by the Econometric Method--Anhui Province and Shanghai Municipality

Using the estimated parameters in Table 4 above, we proceed to estimate the surplus potential outputs that might have existed at the beginning of the reform periods. At the very end of the pre-reform period, the natural logarithm of real output (Y_{t0-}) is given by:

$$(3) \quad \ln Y_{t0-} = \alpha_0 + \gamma_0 t_0.$$

If there were no prior economic slack, then the change in natural logarithm of real output at the end of the reform period (Y_{t1-}) compared to the end of the pre-reform period would be given by:

$$(4) \quad \ln Y_{t1-} - \ln Y_{t0-} = \gamma_0(t_1 - t_0).$$

If there were slack, then the change in natural logarithm of real output would be given by:

$$(5) \quad \ln Y_{t1-} - \ln Y_{t0-} = \alpha_1 + (\gamma_0 + \gamma_1)(t_1 - t_0).$$

The natural logarithm of the surplus potential output may therefore be estimated as the difference between Equation (5) and Equation (4):

$$(6) \quad \alpha_1 + \gamma_1(t_1 - t_0) = \alpha_1 + 6\gamma_1;$$

and the surplus potential output is given by:

$$(7) \quad \text{Exp}(\alpha_1 + 6\gamma_1).$$

Equation (7) is the formula used to estimate the pre-reform surplus potential output. The results are presented in Table 5 below. The estimated surplus potential outputs, whether derived by the direct comparison method or the econometric method, are broadly similar. Based on the experiences of Anhui and Shanghai, an estimate of a pre-reform surplus potential output of approximately 50% for the Chinese economy may be supported.

Table 5: Estimated Surplus Potential Outputs Compared to the Pre-Reform Period (percent)

Table 5: Estimated Surplus Potential Outputs Compared to the Pre-Reform Period (percent)						
	China		Anhui		Shanghai	
	Direct Method	Econometric Method	Direct Method	Econometric Method	Direct Method	Econometric Method
Real GDP (1973-1990)	21.14%	23.74%	64.65%	77.36%	N.A	N.A
Real GDP (1985-2003)	19.16%	20.44%	N.A	N.A	51.37%	57.62%
Real Value-Added, Primary Sector (1973-1990)	32.63%	38.13%	57.52%	68.54%	N.A	N.A
Real Value-Added, Secondary Sector (1985-2003)	33.47%	34.72%	N.A	N.A	53.81%	59.36%
Real Value-Added, Tertiary Sector (1985-2003)	0.97%	1.01%	N.A	N.A	43.97%	49.03%

An alternative approach would be to extrapolate the growth path of real output during the reform period for a further six years beyond the end of the reform period, which would be given by:

$$(8) \quad \ln Y_{t1+6} - \ln Y_{t1-} = 6(\gamma_0 + \gamma_1);$$

and compare it with the estimated growth path during the post-reform period based on actual data, which would be given by:

$$(9) \quad \ln Y_{t1+6} - \ln Y_{t1-} = \alpha_2 + 6(\gamma_0 + \gamma_2).$$

The estimate of the difference in real output, or the (foregone) surplus potential output, is given by:

$$(10) \quad \text{Exp}\,(-\alpha_2 + 6(\gamma_1 - \gamma_2)).$$

The results are presented in Table 5A, which shows somewhat smaller estimates of the pre-reform surplus potential outputs, on the order of approximately 20% for both Anhui and Shanghai.   However, we believe the estimates in Table 5 to be more reliable and representative as the economic performance of the post-reform periods are influenced by many other factors and in particular by the growth in inputs.

Table 5A: Estimated Surplus Potential Outputs Compared to the Post-Reform Period (percent)

Table 5A: Estimated Surplus Potential Outputs Compared to the Post-Reform Period (percent)						
	China		Anhui		Shanghai	
	Direct Method	Econometric Method	Direct Method	Econometric Method	Direct Method	Econometric Method
Real GDP (1973-1990)	2.23%	5.65%	25.53%	32.84%	N.A	N.A
Real GDP (1985-2003)	21.85%	20.08%	N.A	N.A	20.33%	20.80%
Real Value-Added, Primary Sector (1973-1990)	23.02%	28.02%	35.46%	37.03%	N.A	N.A
Real Value-Added, Secondary Sector (1985-2003	44.74%	39.79%	N.A	N.A	18.73%	14.68%
Real Value-Added, Tertiary Sector (1985-2003)	8.67%	7.14%	N.A	N.A	22.44%	29.95%

9. Concluding Remarks

One of our estimates of the magnitude of the surplus potential output of China on the eve of its economic reform in 1978 is 52.43% of Chinese GDP (16.05% from the primary sector (see Section 5) and 36.38% from the secondary and tertiary sectors combined (see Section 6)). A similar conclusion of a surplus potential output of approximately 50% may also be reached on the basis of the results for Anhui and Shanghai in Table 5. This may seem like a large number, but it really is not.

On the assumption that the Chinese real GDP in 1978 was 50% higher than it actually was, the implied average annual rate of growth between 1978 and 2014 would have been 8.49% instead of 9.72%. Thus, the reduction of the economic slack existed before 1978 accounts for approximately 1.23 percentage points of the economic growth over the past 36 years, or approximately 12.5 percent of the post-1978 economic growth. The remaining economic growth of 8.49% per annum can be attributed to the growth of tangible capital and labor, technical progress or growth of total factor productivity, and economies of scale. Of course, most of the reduction and elimination of the economic slack would have occurred during the first decade after the initiation of economic reform (with the exception of Shanghai). But an average annual rate of growth of 8.49% over 36 years is still a most impressive economic achievement.

Another way of looking at the importance of this pre-existing economic slack is to imagine an economy growing at a rate under its potential by 1.23% per annum, then over 36 years, the cumulative surplus potential output amounts to 56%. In other words, Chinese real GDP would have been less than half of what it is if there had been no economic slack in the economic prior to 1978. The existence of a surplus potential output of 50% implies a prior economic slack of one-third or 33.3 percent.

Since most of the economic slack would have been reduced/eliminated at a relatively early stage of the economic reform, it is likely that approximately two percentage points of Chinese economic growth per annum during the first two decades of Chinese economic reform can be attributed to the reduction in the economic slack alone.

However, it is also important to note that the movement from the interior of the set of production possibilities to its frontier is a one-off phenomenon and cannot be replicated. It is therefore almost certain that by the late 1990s, the initial economic slack resulting from the inherent inefficiency of a centrally planned economy would have been exhausted.

The same methodology used here may be applicable to the identification and estimation of the pre-reform potential surplus outputs of other reformed or reforming previously centrally-planned economies. It can also be extended to the estimation of the potential surplus output of every individual Chinese province, autonomous region and municipality before their respective reforms. We would need to identify the precise beginnings of the agricultural and non-agricultural reforms in each province, region and municipality. But if we can obtain estimates of the surplus potential output of each province, region and municipality in China, we shall be able to derive an even more reliable estimate of the size of the surplus potential output in 1978 for the Chinese economy as a whole.

Finally, an intriguing question has to do with the economies of the former Soviet Union and the formerly socialist countries of Eastern Europe. Clearly, there must have been significant slacks in these economies prior to the break-up of the Soviet Union in 1991. However, these slacks did not seem to have enabled any growth spurt in these economies during their transition from centrally planned to market economies. The pre-existing surplus potential outputs did not seem to have been ever realized. Why? This is a question worthy of additional research.

References

Aigner, Dennis J., C. A. Knox Lovell and Peter Schmidt (1977), "Formulation and Estimation of Stochastic Frontier Production Function Models," Journal of Econometrics, Vol. 6, pp. 21-37.

Hsueh, Tien-Tung, and Pak-Wai Liu (1980), "Collectivization of Chinese Agricultural Production, 1952-1957: A Land-Saving Organizational Change," Journal of Comparative Economics, Vol. 4 , pp. 378-398.

Lin, Justin Y. (1988), "The Household Responsibility System in China's Agricultural Reform: A Theoretical and Empirical Study," Economic Development and Cultural Change, Vol. 36, No. 3, Supplement: Why Does Overcrowded, Resource-Poor East Asia Succeed: Lessons for the LDCs? (Apr.), pp. S199-S224

Lin, Justin Y. (1992), "Rural Reforms and Agricultural Growth in China," The American Economic Review, Vol. 82, pp.34-51.

Naughton, Barry (1995), Growing Out of The Plan: Chinese Economic Reform, 1978-1993, Cambridge: Cambridge University Press.

Naughton, Barry (2007), The Chinese Economy: Transitions and Growth, Cambridge, MA: The MIT Press.

Rawski, Thomas G. (1994), "Chinese Industrial Reform: Accomplishments, Prospects, and Implications," The American Economic Review, Vol. 84, pp. 271-275.

Rawski, Thomas G. (1995), "Implications of China's Reform Experience," The China Quarterly, Vol. 144, pp. 1150-1173.

White, H. L., Jr. (1980), "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," Econometrica, Vol. 48, pp. 817–838.

Appendix

Appendix Table 1: Estimation Results Using Different Reform Periods

	China		Anhui		China			Shanghai		
	Real GDP	VA Primary	Real GDP	VA Primary	Real GDP	VA Secondary	VA Tertiary	Real GDP	VA Secondary	VA Tertiary
	Panel A: Sample period: 1974-1988 (Five-year Reform Period)				Panel A: Sample period: 1987-2001 (Fiver-Year Reform Period)					
α_1	0.047**	0.019	0.108***	0.073***	0.100***	0.032	0.056***	0.104***	0.032**	0.078***
	(0.015)	(0.025)	(0.029)	(0.019)	(0.026)	(0.023)	(0.017)	(0.015)	(0.012)	(0.014)
α_2	0.061*	0.063***	0.099	0.093**	-0.049**	-0.003	-0.025**	-0.032**	0.021*	-0.013***
	(0.028)	(0.012)	(0.069)	(0.030)	(0.017)	(0.006)	(0.009)	(0.011)	(0.010)	(0.004)
γ_1	0.048	0.024	0.057	0.069*	0.056	0.015	0.036*	0.078***	0.062***	0.073***
	(0.032)	(0.027)	(0.075)	(0.036)	(0.031)	(0.024)	(0.019)	(0.019)	(0.016)	(0.014)
γ_2	0.018	0.053*	0.030	0.066*	-0.009	0.003	-0.000	0.039**	0.039**	0.040**
	(0.016)	(0.026)	(0.045)	(0.031)	(0.026)	(0.023)	(0.017)	(0.017)	(0.016)	(0.014)
γ_0	0.012	0.055*	-0.005	0.021	0.092***	0.087***	0.077***	0.054***	0.081***	0.060***
	(0.015)	(0.025)	(0.029)	(0.019)	(0.026)	(0.023)	(0.017)	(0.015)	(0.012)	(0.014)
Observations	15	15	15	15	15	15	15	15	15	15
R-squared	0.506	0.443	0.262	0.557	0.541	0.116	0.485	0.756	0.705	0.811
Hypothesis Test: $\alpha_1=\gamma_1=0$										
F statistics	4.988	0.388	7.363	7.384	10.713	4.446	8.134	26.205	8.165	16.937
p value	0.031	0.688	0.011	0.011	0.003	0.042	0.008	0.000	0.008	0.001
	Panel B: Sample period: 1975-1986 (Four-year Reform Period)				Panel B: Sample period: 1988-1999 (Four-year Reform Period)					
α_1	0.054**	0.011	0.116**	0.068**	0.109**	0.044	0.065**	0.109***	0.033*	0.081***
	(0.017)	(0.031)	(0.037)	(0.025)	(0.032)	(0.024)	(0.020)	(0.019)	(0.016)	(0.018)
α_2	0.026	0.032**	-0.056	-0.008	-0.046**	-0.018**	-0.025**	-0.036***	0.031***	-0.013***
	(0.039)	(0.012)	(0.096)	(0.043)	(0.016)	(0.006)	(0.008)	(0.007)	(0.008)	(0.002)
γ_1	0.049	0.008	0.078	0.067	0.077*	0.032	0.050**	0.092***	0.055**	0.079***
	(0.043)	(0.033)	(0.103)	(0.050)	(0.036)	(0.025)	(0.021)	(0.021)	(0.018)	(0.018)
γ_2	0.052	0.055	0.117**	0.118**	0.005	0.015	0.010	0.039	0.062**	0.049**
	(0.039)	(0.036)	(0.044)	(0.034)	(0.033)	(0.025)	(0.020)	(0.021)	(0.020)	(0.019)
γ_0	0.005	0.063*	-0.012	0.026	0.083**	0.074**	0.069***	0.050**	0.080***	0.057**
	(0.017)	(0.031)	(0.037)	(0.025)	(0.032)	(0.024)	(0.020)	(0.019)	(0.016)	(0.018)
Observations	12	12	12	12	12	12	12	12	12	12
R-squared	0.329	0.354	0.316	0.571	0.614	0.317	0.621	0.824	0.753	0.803
Hypothesis Test: $\alpha_1=\gamma_1=0$										
F statistics	5.043	0.084	5.032	3.901	7.591	3.901	7.039	18.568	6.228	10.596
p value	0.044	0.920	0.044	0.073	0.018	0.073	0.021	0.002	0.028	0.008

Appendix Table 2: Estimation Results Using Different Pre-Reform and Post Reform Periods

	China		Anhui		China			Shanghai		
	Real GDP	VA Primary	Real GDP	VA Primary	Real GDP	VA Secondary	VA Tertiary	Real GDP	VA Secondary	VA Tertiary
	Panel A: Sample period: 1962-2000				Panel A: Sample period: 1962-2008					
α_1	0.006	0.020*	0.039**	0.052**	0.058***	0.095***	0.043***	0.069***	0.087***	0.047***
	(0.019)	(0.011)	(0.016)	(0.021)	(0.012)	(0.020)	(0.012)	(0.017)	(0.020)	(0.014)
α_2	0.035**	-0.055**	0.034	0.015	-0.033***	-0.053***	-0.021***	-0.033***	-0.047***	-0.010
	(0.015)	(0.023)	(0.028)	(0.052)	(0.008)	(0.015)	(0.004)	(0.004)	(0.010)	(0.008)
γ_1	0.023	0.033	0.053	0.020	0.032**	0.042*	0.026**	0.061***	0.054**	0.081***
	(0.024)	(0.026)	(0.032)	(0.056)	(0.014)	(0.025)	(0.013)	(0.017)	(0.022)	(0.016)
γ_2	0.024	-0.002	0.034	-0.015	0.020	0.007	0.031**	0.042**	0.037*	0.053***
	(0.021)	(0.012)	(0.021)	(0.034)	(0.013)	(0.021)	(0.013)	(0.018)	(0.022)	(0.016)
γ_0	0.068***	0.040***	0.056***	0.052**	0.076***	0.097***	0.075***	0.070***	0.072***	0.066***
	(0.019)	(0.011)	(0.016)	(0.021)	(0.012)	(0.020)	(0.012)	(0.017)	(0.020)	(0.014)
Observations	39	39	39	39	47	47	47	47	47	47
R-squared	0.062	0.110	0.142	0.028	0.072	0.045	0.079	0.105	0.067	0.214
Hypothesis Test: $\alpha_1=\gamma_1=0$										
F statistics	0.798	1.611	2.901	3.072	17.748	17.948	14.506	10.301	14.831	15.070
p value	0.458	0.215	0.069	0.059	0.000	0.000	0.000	0.000	0.000	0.000
	Panel B: Sample period: 1952-2014				Panel B: Sample period: 1952-2014					
α_1	0.014	0.039***	0.060**	0.083***	0.065***	0.091***	0.049***	0.058**	0.067**	0.051***
	(0.021)	(0.014)	(0.023)	(0.026)	(0.015)	(0.026)	(0.014)	(0.023)	(0.030)	(0.014)
α_2	0.035**	-0.055**	0.034	0.015	-0.033***	-0.053***	-0.021***	-0.033***	-0.047***	-0.010
	(0.014)	(0.022)	(0.027)	(0.051)	(0.008)	(0.015)	(0.004)	(0.004)	(0.009)	(0.008)
γ_1	0.032	0.052*	0.075**	0.052	0.039**	0.037	0.031**	0.051**	0.035	0.085***
	(0.025)	(0.026)	(0.036)	(0.057)	(0.016)	(0.030)	(0.015)	(0.023)	(0.031)	(0.016)
γ_2	0.033	0.019	0.066***	0.015	0.023	-0.003	0.028*	0.019	0.000	0.046***
	(0.022)	(0.014)	(0.024)	(0.029)	(0.015)	(0.027)	(0.015)	(0.024)	(0.032)	(0.016)
γ_0	0.059***	0.020	0.034	0.020	0.069***	0.102***	0.070***	0.080***	0.092***	0.062***
	(0.021)	(0.014)	(0.023)	(0.026)	(0.015)	(0.026)	(0.014)	(0.023)	(0.030)	(0.014)
Observations	62	62	62	62	62	62	62	62	62	62
R-squared	0.058	0.093	0.154	0.031	0.044	0.015	0.041	0.021	0.008	0.149
Hypothesis Test: $\alpha_1=\gamma_1=0$										
F statistics	1.014	4.057	3.474	5.379	15.816	12.830	13.496	5.357	8.382	16.188
p value	0.369	0.023	0.038	0.007	0.000	0.000	0.000	0.007	0.001	0.000