Grain Policy: Rethinking an Old Issue for China

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1. Introduction

China has historically always been one of the most populous nations in the world. With a current population of 1.4 billion, it is the largest country. Throughout the history of mankind, a growing population has always been the sign of peace and prosperity. That has been the golden rule till the 19th century, when Thomas Malthus made the famous growth rate comparison of population and food. Since then, a large and rapidly growing population has been seen as a curse or at least as a drag as far as economic growth is concerned.

At the beginning of the 20th century, China’s population was 400 million. Despite wars (Japan, WWII, the civil wars, etc.), natural and man-made disasters (the floods, famine, the Cultural revolution, etc.), China’s population still more than tripled. This has become an extremely heavy burden on the Chinese government. Indeed, for most of its history, the People’s Republic of China was in a constant struggle to feed the mass population. The fact that they were able to, for the most part, accomplish this is a feat in itself.

This paper is an attempt to revisit the grain policy in this grand scheme of feeding the masses. It is not meant to be a detail policy paper, but a proposal aimed at provoking discussion, debate, and more in-depth research in this area. We do not claim any advancement of theory or technique, the novelty lies in applying theory originally developed for the emissions and environment literature onto grain policy, and trying to solve two other critical problems facing China at this time: deteriorating income equality and pressure of mass migration.

2. Economic Reform: Remarkable Accomplishments and Looming Problems

Since the initiation of the “Comprehensive Economic Reform” (CER) in 1978, China has accomplished far more than most former socialist country can ever dream of. These accomplishments are well documented and are mostly common knowledge nowadays.

The CER began from pragmatic necessity as China struggled through two food crises between the late 1960s and early 1970s (Hou, Mead, and Nagahashi 2005), and can be seen in the simple fact that till 1984 the CER was limited to the rural agricultural sector. Unlike perestroika, where the reform was more on political freedom and superficial economic changes, China’s reform was almost exclusively centered on the economic side. The reform was far deeper than a cosmetic makeover, it became a fundamental change in the entire economic doctrine (Fei and Hou 1994). The literature has characterized China’s reform in terms of privatization, pragmatisms, marketization, and monetarism (the re-introduction of money as “money”). Clearly, at the outset, the central leadership did not have an overall design. This is perhaps best stated by Perkins (1988) stated,

“It is unlikely that China’s leaders had worked out a blueprint ... This reform process was still
under way in 1987 and appears likely to continue for some time. Where it will all end is not known to anyone either inside or outside of China.”

True as this may be at the time when Perkins wrote his milestone paper, the development of the past decade and a half should leave no doubt in anyone's mind as to where the reform will end (Hou and Hou 2002). Indeed, as Zheng (2004) so powerfully put that it is vital we understand the stage we are in. We are no longer in the experimentation stage. The time of “crossing the river while feeling for the stone” is over. We are in the age of establishing coherent economic systems and institutions. While the measurement of the efficiency of specific experiments or reforms is still relevant and important, it is time to set our sight on broader comprehensive development strategies.

With this mind, let us paint (in the broadest of strokes) the current bottlenecks facing China. Despite the well-established accomplishments of the reform, the benefit has been very uneven. This is in total contrast to the ideology of communism and has its potential threat to the sustainability and harmony of the continued march towards a market economy. Many of these inequalities must have been expected, but were delegated to secondary consideration following Deng’s belief that it was necessary to make some people rich first.

The fact that the reform initiated in the rural agricultural sector (the household responsibility system), the standard of living of the rural farmers saw real improvement and the rural–urban earnings gap diminished in the early stages of the reform. But this pattern was reversed when the CER was extended to the urban manufacturing sector in 1984/85, and has been widening ever since (Chang and Hou 1997, Ravallion and Chen, 2004). The second stage of the reform saw the increased autonomy of the State Owned Enterprises (SOEs), this led to the layoff of old permanent “iron rice bowl” workers and the hiring of contractual workers. With the issuance of identification cards (late 1980s), the population can now, for the first time since the late 1950s, travel around the country without showing any official “permission” letter from their local authorities. And, just as importantly, with the abolishment of the grain rationing coupons in the early 1990s, new migrants now have access to food necessities (Bao, Hou, and Shi, 2005ab).

The stage was set for massive rural to urban migration. This was greatly facilitated by the third stage of the reform, the External Reform, as China made the irreversible stride towards openness. Starting in the mid/late 1980s, to attract foreign direct investment (FDI), many economic incentives were introduced. As part of the overall strategy, favorable provisions (such as special tax concessions and liberalized land leasing) were made available to many coastal cities to establish economic development areas and high technology development zones.

In an even more progressive move, the policy ideology shifted to “letting some get rich first.” In the 1990s, a policy package offered special treatment for designated area, to the furthered development of the private sectors and foreign invested enterprises (joint ventures). The most famous of the designated area are the special economic zones of Shenzhen, Xiamen, Zhuhai and Shantou. These became the gateway to the Chinese economy, and with their special provisions, succeeded in attracting large quantities of foreign direct investment. The success of these policies cumulated into the fact that China is now the second largest recipient of FDI (second to the US), and the after delivered amount reached US$45.46 billion in 1998 (Hou and Zhang, 2001ab, 2008).
These contributed to the fact that the Eastern/Coastal areas grew at a much higher rate than the rest of China, leading to a significant regional inequality (Chen and Fleisher 1996, Fleisher and Chen 1997, Gustafsson and Li 1998, Lee 2000). Combined with the relaxation of the *Hukou* system and the cancellation of the grain rationing coupons, the massive rural to urban, inland to coastal migration was inevitable (Bao, Hou, and Shi, 2005ab, Bao, Bodvarsson, Hou, and Zhao, 2008, 2009, 2010). With the reform of the SOEs, the urban inequality was already evident; the influx of rural migrants made it an even more pressing issue (Lu and Song 2004). This is compounded by two additional sets of facts. First, even based on the relatively conservative modified UN 1998 projection, China’s population is expected to surpass 1.5 billion in 2050. But it masks huge demographic changes also. For example, China currently has roughly 20.5% of the population aged 50 or above. By 2050, this number will swell to 42.5%, which creates a host of problems in itself as many of the SOEs are woefully inadequate in terms of pensions (Song and Chu 1997).

Second, China’s distribution of the population is extremely skewed from a geographic point of view (Heilig 1997). Roughly 10% of the population lives in 0.5% of China’s landmass. These most populated areas (about 47,000 squared kilometers) have a density of 2,428 people per km². Fifty percent of the population live in 8.2% of the landmass, and 90% of the population occupies 30% of the land area. Left unchecked, the current development pattern and the migration flows it has generated will most certainly further skew this distribution (Bao, Bodvarsson, Hou, and Zhao, 2008, 2009, 2010).

China’s entry into the WTO will most certainly bring about another set of shocks that will undoubtedly deepen the inequality. China will be having better access to many foreign markets, which will allow it to continue to grow, even at an accelerated pace (Lardy 2002). The other side of the coin is that domestic industries will also have to face increased competition from foreign imports. Certain sectors (agriculture, automobiles, and banking, for example) will face a difficult period as it adjusts to the new post WTO world. This may induce efficiency gains (Lardy 2002), but could also lead to massive elimination of the inefficient SOEs (Solinger 2003). The reduction of the scope of the SOEs will further the inequality in the urban areas, as the SOEs are over–represented by older and less educated workers, while the new jobs are typically looking for better educated (and younger) workers. The increased urban inequality will be in the form of cohort/age inequality, gender wage gap, and wider pay differences between groups of different education attainments.

The impact of WTO on China’s agriculture is not entirely clear. Though the changes to Chinese agriculture are likely to be dramatic, but there is also evidence that the Chinese agriculture is more resilient that many give it credit for (Huang, Rozelle, and Zhang 2000, Mead 2001). The trade dispute between China and Japan/Korea on its horticulture exports is evidence of China’s strength in this area of agriculture. And, despite an aggressive marketing campaign promoting US citrus products, California Citrus growers are facing stiff competition from cheaper domestic producers. The prospect for grain producers, however, is much bleaker.

Many farmers have complained that it was not profitable to stay in the grain producing business as it was much more lucrative to produce fruit, for example. This has raised concerns of national security, as China still (like many countries) view a stable domestic supply of grain as vital part of the national security plan. China has assured of this security by designating “the best productivity” land as *basic cultivated land*. The basic cultivated land is not supposed to be
transferred for uses other than grain planting without special approval from the Ministry of Land and Resources.

Though China remains a net exporter of grain, its import is becoming noticeable and mostly in the higher end in terms of quality. This has led to bizarre situations, such as spring of 2004, where large amounts of wheat were imported while a tremendous supply of spring wheat (which is deemed as lower quality wheat) sat idle in reserves. To increase the quality of China’s grain, and to solve for many of the other deficiencies in the rural agricultural sector, China needs to rethink how to build the infrastructure of the rural economy (Hou and Hou 2005). This paper, however, deals with an issue that is narrower and perhaps more hypothetical and theoretical.

With this said, it is worth emphasizing that when we presented an earlier draft, a prominent U.S. scholar disagreed and stated that free trade is optimal and if China is short of grain they should simply import from the world market. We reminded the audience that free trade is optimal under a small economy assumption, and we challenged everyone present to claim that China was a small economy!! If the small economy assumption does not hold, students in International Economics should know immediately that free trade is not necessarily optimal.

It should be further noted that though the world production of grain is certainly substantial, but with the exception of a few nations, most of the grain production are highly focused on domestic consumption. Thus, the size of the world market is a relatively small portion of total grain production. This is a sharp contrast with oil, where a much larger proportion of crude oil is traded in the world market. Yet, the dramatic rise (and occasional retreat) in the price of oil is something that dominates the news everyday. Though the cause of this rise in crude oil price is many, China’s shift from an oil exporter to a net importer in the last decade is undeniably a contributing factor.

The lesson we must learn from this is that if China ever need to import grain at a significant level, the rise in the world price of grain will be much more dramatic and at an accelerated pace that makes the increase in oil price look moderate in comparison. Opponents will state that the turnaround of grain production is less than a year, so any fluctuation will be temporary. Though not without merit, we do not entirely agree. Much like in regression analysis, the obsession is whether the coefficient is statistically significant, but even insignificant, if the magnitude of the effect is large enough, the effect still cannot be totally ignored. In addition, we are not as confident as our opponents in the market being able to readjust in an annual fashion.

Take the global food crisis of 2007 for example, the agriculture price index surged a record 61%. The reasons are complex (Hou 2008), the strong demand in Asia (including China), bad crops in Argentina and Australia, combined with loss of acreage to corn (resulting from the push for bio-fuel, ethanol) are among the more important ones. In the first quarter of 2008, the run continued, pushing wheat prices up to US$10.36/bushel, which is three times the level 12 months ago! The U.S. Department of Agriculture estimates that wheat stocks have reached their lowest level in 60 years. There is already tremendous concern that Africa will starve, as the price is rising beyond what they can afford. Can you imagine if there was a sudden unforeseen market failure (if the Chinese grain production is left completely to the free market) in China, and needed to import 5% of the grain China needs?
3. The Governor’s Grain Bag Responsibility System

As we mentioned earlier, China’s reform began exclusively in the rural agricultural area, and did not spread to the urban/industrial sectors till 1985. There was a considerable narrowing of the rural–urban income gap in the early years of the reform as the household responsibility system and the two-tier pricing system (guaranteed government procurement and the free market tract) improved the standard of living of the rural farmers, while leaving the urban dwellers unaffected or even be welfare-improving (Hou, 2004).

<table>
<thead>
<tr>
<th>Year</th>
<th>Output of Grain(^a)</th>
<th>Per Capita Output(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>30477.0</td>
<td>318.74</td>
</tr>
<tr>
<td>1980</td>
<td>32056.0</td>
<td>326.69</td>
</tr>
<tr>
<td>1985</td>
<td>37911.0</td>
<td>360.70</td>
</tr>
<tr>
<td>1987</td>
<td>40298.0</td>
<td>371.74</td>
</tr>
<tr>
<td>1988</td>
<td>39408.0</td>
<td>357.72</td>
</tr>
<tr>
<td>1989</td>
<td>40755.0</td>
<td>364.32</td>
</tr>
<tr>
<td>1990</td>
<td>44624.0</td>
<td>371.74</td>
</tr>
<tr>
<td>1991</td>
<td>43529.0</td>
<td>378.26</td>
</tr>
<tr>
<td>1992</td>
<td>44265.8</td>
<td>379.97</td>
</tr>
<tr>
<td>1993</td>
<td>45648.8</td>
<td>387.37</td>
</tr>
<tr>
<td>1994</td>
<td>44510.1</td>
<td>373.46</td>
</tr>
<tr>
<td>1995</td>
<td>46661.8</td>
<td>387.28</td>
</tr>
<tr>
<td>1996</td>
<td>50453.5</td>
<td>414.39</td>
</tr>
<tr>
<td>1997</td>
<td>49417.1</td>
<td>401.71</td>
</tr>
<tr>
<td>1998</td>
<td>51229.5</td>
<td>410.46</td>
</tr>
</tbody>
</table>

\(^a\) Measured in 10,000 tons.
\(^b\) Measured in kilos.

This can also be seen in the table above. The per capita output of grain steadily increased from 1978 till 1987. This was followed by two years where the grain production showed a slowdown. This was part of the cause of the inflation that led to the student demonstration in Tiananmen. There was a “reset” of the economy after Tiananmen, and this is seen in the sharp increase in grain production. However, between 1992 and 1994, China had two bad harvests (the per capita grain output dropped from 387.37 in 1993 to 373.46 in 1994) and was forced to import 5% of their wheat consumption.\(^8\) This led to a 20% surge in the world wheat price. Compared to food prices of 2007/8, it is tame by comparison, but at that time caught world-wide attention demanding the Chinese government take action.

That year, the Chinese government issued a proclamation targeting a 95% self-reliant rate on the three-grains (rice, wheat, and corn). And in 1995, the provincial “Governor’s Grain Bag Responsibility System” was introduced (which was not lifted until 2004). Under this system, the provincial governors are responsible for balancing the demand and supply of grain within their jurisdiction so as to maintain the stability of the grain price. As a complementary action, the central government boosted procurement prices (above the world price), discouraged cotton and oil seed production in favor of grain by offering farmers incentives. This concern on grain production and emphasis on agriculture can be seen clearly in the ninth Five Year Plan (1996–
2001) whereas Agriculture was front and center in the Plan. The success of these efforts can be seen in the impressive grain production in 1996 to 1998.

Though this responsibility system was generally a success in boosting grain production and stabilizing regional grain prices, the result varied significantly across provinces. For example, to increase supply in a rich province with high population density (and hence grain demand) such as Jiang Su, the grain farmers were heavily subsidized. Yet, in poorer provinces where grain production was in surplus (such as An Hui), grain farmers were taxed to reduce supply so as to balance demand and supply.

What was original designed to increase the level of regional self-sufficiency in grain consumption had led to a net welfare loss. In addition to the counter-productive subsidy of farmers in rich provinces and taxation of grain producers in poor regions, the Governor’s Grain Bag Responsibility System has led to allocation of land use in contradiction to their comparative advantage. As the years went by, these all started to take its toll. The grain production was only 457.17 billion tons in 2002 (more than 10% below that of the 1998 level), and decreased another 5.8% in 2003. Finally, the government ended the Governor’s Grain Bag Responsibility System, and began a series of liberalization reforms in the grain market. These included the reform of the State trading companies, and the establishment of central and local grain risk funds. Many of these were done parallel with the Governor’s Grain Bag Responsibility System.

4. New Paradigm: Provincial Grain Responsibility with Tradable Quotas

It is not our objective to summarize, characterize, or criticize the grain policy and the related reform efforts. Instead, we are proposing a new model, built on the philosophy of the old Governor’s Grain Bag Responsibility System, but with a twist. It is really an idea, a thought piece, rather than a rigorous model or policy. We do not profess to be even capable of developing a policy to implement the idea. We are simply advancing an idea that others may not have thought of, with the hope of attracting the attention of experts and scholars, whom are much more able than us, to give thought to the feasibility of the idea.

Before we proceed with our idea, let us first summarize some of the current problems facing China that are relevant to our concern. The negative by-product of the reform success is a rapidly increasing inequality. The rural/urban inequalities are well documented. This income disparity between the Central/Western regions of China and that of the East/Coastal has led to massive migration towards the latter. This not only strains the infrastructure of the major urban areas on the coastal provinces, it is also a significant drain on the Central/West as they are losing their younger generation of workers.

Grain production is on the decline, and farmers are becoming increasing discontent in being required to produce grain rather than more profitable economic crops. With the accession into the WTO, and China’s huge foreign exchange surplus, it is possible to rely much more on foreign imports. But this threatens national security, and may further undermine the economic sustainability of the Central/Western provinces. The subsidy to grain farmers is a major burden on government finances. The direct grain subsidy reached 11.6 billion yuan or $1.41 billion (from the grain risk fund). By 2008 it had reached a staggering 63.3 billion yuan or $9 billion. The effect on the government budget goes beyond this subsidy, as the agricultural tax burden is also being reduced. The cost of this tax reduction in 2004 was 7 billion yuan, and the agricultural tax was completely lifted in 2007. It should be clear to even the casual reader that
this grain subsidy simply is not fiscally sustainable, but a discontinuation will have catastrophic consequences far beyond China.

What we propose is something similar to the old Governor’s Grain Bag Responsibility System. Each governor is responsible for procuring 80% of the grain need for the provincial population, based on the previous year’s consumption and the current year’s projection. This is the “quota” they must fill. This is somewhat comparable to the old system that had led to inefficient allocation of land use (inconsistent with comparative advantage and opportunity cost) and contradictory policy of subsidizing farmers in rich provinces (such as Jiang Su) and taxing farmers in poorer areas (such as An Hui).

The twist we propose is to allow and encourage the governors who have difficulty fulfilling their quota to “hire” grain surplus provinces to help fill their quota. This is the same (though reversed) mechanism in the emissions credit trading. For those that are somewhat unfamiliar with this practice, let us outline the game. In areas such as Southern California where air quality regulation is strict, each firm is given a “quota” of the amount of emissions (pollutants) that they can release into the air. This “quota” shrinks with every passing year, as the polluting firms are required to improve technology and reduce their emissions.

Some firms can significantly reduce their emissions via technical innovations and actually have surplus quotas (called emission credits). However, not all firms can reduce their emissions in accordance to the regulations. These firms can “purchase” the right to pollute by buying emission credits from firms that have been able to reduce their emission to below the requirement. There has been a sizable literature on the welfare gains in this tradable permit market.10

The system we are proposing here is in the same spirit. Provinces that cannot fulfill their quota will have to buy grain from surplus provinces. We believe this will be welfare improving, and have set of positive externalities that will help alleviate some of the problems we highlighted at the beginning of this section. To demonstrate the efficiency gain and the welfare improvement, let us discuss in terms of two representative provinces. I will use Jiang Su as a representative of a more industrialize, richer, coastal province, and An Hui as a less industrialized, poorer, inland province.

To us, the choice was natural. Shanghai borders on Jiang Su (much like Washington, D.C. borders with Virginia), so does the Pu Dong SEZ (Special Economic Zone). Jiang Su has one of the largest concentration of FDIs, plus the most successful system of private enterprises, joint ventures, and reformed State-owned enterprises. Given the industrial investment and the high value-added manufacturing goods, agricultural production is simply too expensive in terms of what Jiang Su has to give up. That was part of the problem of the old Governor’s Grain Bag Responsibility System. In contrast, An Hui has historical always been an agricultural province. The lack of funds (as the local savings have been attracted to Jiang Su), continued outward migration, and other factors, An Hui continues to be one of the poorer provinces.

I will term Jiang Su as the MIP (More Industrialized Province), and An Hui as the LIP (Less Industrialized Province). I assume that the marginal cost (in terms of opportunity forgone) is higher for the MIP and lower for the LIP, as shown in the graph below. For simplicity, let us assume that the quota is the same for both provinces, and is set at A. If the more industrialized
province (MIP) purchases crops from less industrialized province (LIP) by the amount that equals the distance AB, then the total cost of crop production would fall by the area ABDF for the MIP. To make up this quota shortfall, the MIP purchase from the LIP. Thus, the LIP will production in LIP would increase by the area ACEG. Since ACEG is smaller than ABDF, from the central planner's view, the total social cost would be reduced. In other word, the overall social welfare will increase.

![Diagram](file://path/to/diagram.png)

To present this in a more formal sense requires setting up a mathematical model. Though we have derived the basic results, but this paper is geared as a “thought” piece, we will dispense with the math model in favor of a more intuitive discussion.

4.1 The Cost Effectiveness Rule

The objective of the central government is to minimize the total costs of producing a targeted amount of grain. The first order condition will lead to the optimal cost effectiveness rule: *cost-effective is achieved if and only if the marginal cost of production is equalized for each province.*

In lieu of a former proof, we present the following logical argument.

Whenever the marginal cost in one province is greater than that in another, overall costs can be reduced without changing the production level by decreasing production in the high-cost province and increasing it in the low-cost province.

4.2 The Price of the Tradable Quota

If each province produces all the grain to fill their quota, the MIP will have a higher MC (AF in the graph) than that of the LIP (which will only be AG). For the first unit of the traded quota, MIP will be willing to pay *up to* AF, while the LIP will demand *no less* than AG. Thus we can easily conclude that the trade price for this first unit will be between F and G. Due to increasing
marginal cost, the gap between the lower and upper bound of the trade price will diminish as the trade volume increases. It can be clearly seen in the graph, given the quota traded (AB = AC), the final price for the tradable quota will be somewhere between D and E. The actual price will depend on the bargaining power of the two sides. If there were enough traders in this quota market, the equilibrium price would be equal to the marginal cost of each province.

4.3 Everyone Gets a Larger Slice of the Enlarged Pie

Before we do full derivation, we will attempt to outline the mathematical model. Let the cost function for province $i$ be defined as

$$C_i = A_i Q_i^{\alpha_i}$$

where $C$ is the cost, $Q$ is the quantity of grain production, and $A$ is a coefficient which takes into account all other factors. The equilibrium price of the tradable quota is equal to $MC$, or

$$P = MC_i = \alpha_i A_i Q_i^{\alpha_i - 1}$$

From which we can solve for $Q_i$ in terms of $P$.

$$Q_i = A_i^{1-\alpha_i} A_i^{1-\alpha_i} P^{1-\alpha_i}$$

This will give us $n$ equations, where $n$ is the number of provinces. But, we have $n+1$ variables ($n Q_i$ plus the price). However, we have an adding up constraint, i.e. the total grain production must meet the quota requirement set by the central government:

$$\sum Q_i = \bar{Q}.$$  \hspace{1cm} (3)

By substituting all the $Q_i$ in the set of equations in (2) into the above, we can calculate the equilibrium price of the tradable quota. When we substitute this equilibrium price into the set of equations in (2), we can obtain the optimal amount of grain production for each province.

The difference between the optimal amount ($Q_i$) and the imposed quota ($\bar{Q}_i$) determines whether this province will be a buyer or seller in the tradable quota market. By substituting $Q_i$ and $\bar{Q}_i$ into the cost function, we can compute the cost between these two options (i.e. participating in the tradable quota market or filling the quota in an autarky manner), and clearly we will have

$$C_i(Q_i) \leq C_i(\bar{Q}_i)$$

with the difference as the net welfare gain. If this sounds familiar to the comparative advantage model we teach when we demonstrate mutually beneficial trade in our Principles course, it is by no means an accident. Indeed, all the research in this area can probably be traced back to Ricardo (1963). And, a is with the basic case of comparative advantage that is taught even in
introductory principles curses, this grain policy should be mutually beneficial and efficiency enhancing.

4.4 A Summary of Potential Benefits

The objective of this paper is to propose an alternative to China’s grain policy that we believe will be practical, with minimal distortions and a potential for significant positive externalities. It is this last aspect that we wish to address here. As is common knowledge to any student of China’s ongoing reform (and outlined in this paper), the success of the CER has been, it did not come without significant costs.

The most obvious is the deteriorating income equality. Most scholars (and the general public in China mostly share the sentiment) believe that this is the most critical problem facing China, especially since equality was the staple of the Communism ideology. This inequality covers a wide spectrum of variables, among them, the geographical inequality of Coastal versus Inland provinces and the urban–rural divide. This, of course, is just scratching the surface, as the inequality issue stretches across many social (including gender, age, etc.) strata. Our focus here is on the geographical inequalities.

The root cause is, of course, the development strategy of China, where the FDI were first allowed only in selected coastal cities. Even with later relaxation of the FDI regulations, the relative attractiveness of the coastal regions remains. This, combined with the dramatic change in the farming sector, became the irresistible in attractive light that drew the surplus labor from the rural/inland areas towards burgeoning coastal cities/provinces. The draw is not just limited to workers, but also the savings and the consumption base that would have sustained rural/local commerce. The consequence of these latter aspects, which has not seemed to draw enough attention among scholars, is that they suppress the development of these rural/inland areas.

The government obviously would need to allocate more funds to subsidize the rural/inland regions, but the effectiveness would be in doubt. What is for certain is the fiscal burden on the central government. This is above and beyond the price subsidy that has become an increasing budgetary item over the years. Depending on the year, the cost of the price subsidy can be upwards of 10% of the total fiscal deficit.

The quota system we have proposed will have externalities that would spillover to these problem areas. If the grain farmers in An Hui can earn a better living, not only will this reduce the regional income inequality, it may reduce the outward migration. If the local economy were larger and more prosperous, it would stimulate commerce and even help develop light industrial bases that may have further potential in the longer run. All these would increase the tax base for the local governments, and perhaps for the central government. Furthermore, as the price of grain rises, the central government can reduce both the price subsidy and the fiscal transfer to inland provinces, which would be helpful in reducing the budget deficits that have become an increasing problem of late.
5. Full Mathematical Model

This following math derivation can be done for every province in the study.

5.1 The Setup of the Model

Land can be used for industrial production or for agricultural cultivation, or left idle. Let $i$ indicate $u$ for industrial sector, and $n$ for agricultural sector. Let $\alpha$ be the latitude location indicator measuring from the north boundary to south boundary of a province, ranging from 0 to 1. Let a continuous density function $g(\alpha)$ describe the shape of the province along the west-east dimension. Land conditions (including soil quality and weather conditions) vary across locations. Given China is in the Northern hemisphere, we assume that Land is more appropriate for agriculture as $\alpha$ increases. This assumption is arbitrary. In reality, land conditions are not strictly related to latitude. One can imagine that this assumption is the result of rearranging land according to land conditions from north to south. What we are interested in is the share of the land in a province for each sector, rather than the pattern of the allocation of land between the two sectors. Thus, whether land is concentrated or scattered for each sector would have no influence on the analysis results.

The share of the land at location $\alpha$ used for sector $i$ is denoted by $\delta_i(\alpha)$, with

$$\delta_i(\alpha) \geq 0 \text{ and } \sum_{i=n, u} \delta_i(\alpha) \leq 1.$$ 

The total outputs produced in industrial sector, $Q_u$, are determined by inputs $x_u$ and the technology that is represented by the production function $f_u(\cdot)$:

$$Q_u = \int_0^1 \delta_u(\alpha) f_u(x_u(\alpha))g(\alpha)d\alpha.$$ 

The outputs produced in agricultural sector, $Q_n$, are determined by latitude location $\alpha$, inputs $x_n$ and technology $f_n(\cdot)$:

$$Q_n = \int_0^1 \delta_n(\alpha) f_n(\alpha, x_n(\alpha))g(\alpha)d\alpha.$$ 

where $\frac{\partial f_n}{\partial \alpha} > 0$ based on the assumption that moving from north to south the land becomes more and more appropriate for agriculture.

Let $P_i$ represent the market price for the commodities produced in sector $i$. Since each province's outputs are small relative to the whole domestic (or world) market, we assume the market prices facing each province are exogenous. Costs in each sector are the expenditures on inputs. Then the total costs are:

$$c = \int_0^1 \left[ \delta_u(\alpha)c_u(x_u(\alpha)) + \delta_n(\alpha)c_n(x_n(\alpha)) \right]g(\alpha)d\alpha.$$
The objective of each province is to maximize the total profit by choosing inputs and the share of land for each sector:

$$
\max_{x_i, \delta} \int_{\alpha_0}^{\alpha_1} \delta_u(x_u(\alpha)) f_u(x_u(\alpha)) g(\alpha) d\alpha + \int_{\alpha_0}^{\alpha_1} \delta_n(x_n(\alpha)) g(\alpha) d\alpha
$$

$$
-\int_{\alpha_0}^{\alpha_1} [\delta_u(x_u(\alpha)) + \delta_n(x_n(\alpha))] g(\alpha) d\alpha
$$

subject to $\delta_i(\alpha, t) \geq 0$ and $\sum \delta_i(\alpha, t) \leq 1$.

The Lagrangian of the spatial optimization problem is:

$$
L = \int_{\alpha_0}^{\alpha_1} \delta_u(x_u(\alpha)) f_u(x_u(\alpha)) g(\alpha) d\alpha + \int_{\alpha_0}^{\alpha_1} \delta_n(x_n(\alpha)) g(\alpha) d\alpha
$$

$$
-\int_{\alpha_0}^{\alpha_1} [\delta_u(x_u(\alpha)) + \delta_n(x_n(\alpha))] g(\alpha) d\alpha
$$

$$
+ \sum_{i=n,u} \mu_i(\alpha) \delta_i(\alpha) + \lambda(1 - \sum_{i=n,u} \delta_i(\alpha))
$$

where $\mu_i$ and $\lambda$ are Lagrangian multipliers. $\lambda(\alpha)$ is the shadow value of land capacity. It can be interpreted as the land rent at location $\alpha$.

The necessary conditions of this spatial optimization problem are:

$$
L_{\delta_i} = \delta_u \left[ P_u f_u(x_u(\alpha)) - c_u(x_u(\alpha)) \right] g(\alpha) = 0 \quad (L1)
$$

$$
L_{\delta_n} = \delta_n \left[ P_n f_n(x_n(\alpha)) - c_n(x_n(\alpha)) \right] g(\alpha) = 0 \quad (L2)
$$

$$
L_{\mu_i} = \left[ P_u f_u(x_u(\alpha)) - c_u(x_u(\alpha)) \right] g(\alpha) + \mu_u - \lambda = 0 \quad (L3)
$$

$$
L_{\lambda} = \left[ P_n f_n(x_n(\alpha)) - c_n(x_n(\alpha)) \right] g(\alpha) + \mu_n - \lambda = 0 \quad (L4)
$$

$$
\lambda(1 - \sum_{i=n,u} \delta_i) = 0 \quad (L5)
$$

$$
\mu_i \delta_i = 0 \quad (L6)
$$

$$
\lambda, \mu_i, \delta_i, 1 - \sum_{i=n,u} \delta_i \geq 0 \quad (L7)
$$

Equations (L1) and (L2) imply that the optimal inputs should be chosen when the marginal revenue equals the marginal cost. The remaining equations are discussed in next sub-section.

### 5.2 The Land Rent

We define $\pi_i(\alpha)$ to be the profit derived from the land used for sector $i$ at location $\alpha$:

$$
\pi_i(\alpha) \equiv [P_u f_u(x_u(\alpha)) - c_u(x_u(\alpha))] g(\alpha),
$$
\[ \pi_n(\alpha) = [P_n f_n(\alpha, x_n(\alpha)) - c_n(x_n(\alpha))]g(\alpha). \]

The profit in the industrial sector is not affected by the latitude location. Thus, \( \pi_n \) is constant across latitude locations. The profit in the agricultural sector increases with latitude since \( \frac{\partial \pi_n}{\partial \alpha} = P_n \frac{\partial f_n}{\partial \alpha} g(\alpha) \) and \( \frac{\partial f_n}{\partial \alpha} \) is positive. The profits generated in each sector at each latitude location are shown in Figure 1. The intersection of \( \pi_n \) and \( u \) is defined to be the switch location.

Equations (L3) - (L7) imply:

\[ \begin{align*}
\delta_n(\alpha) = 0 & \text{ and } \delta_n(\alpha) = 0 \Rightarrow \lambda(\alpha) = 0, \\
\delta_n(\alpha) = 1 & \text{ and } \delta_n(\alpha) = 0 \Rightarrow \lambda(\alpha) = \pi_n(\alpha) \geq \pi_n(\alpha), \\
\delta_n(\alpha) = 0 & \text{ and } \delta_n(\alpha) = 1 \Rightarrow \lambda(\alpha) = \pi_n(\alpha) \geq \pi_n(\alpha), \\
\delta_n(\alpha) > 0 & \text{ and } \delta_n(\alpha) > 0 \Rightarrow \lambda(\alpha) = \pi_n(\alpha) = \pi_n(\alpha).
\end{align*} \]

**Figure 1: The Profit Generated in Each Sector**

In plain English, if the land at location \( \alpha \) is not in use (\( \delta_u(\alpha) = 0 \) and \( \delta_n(\alpha) = 0 \)), then the economic rent at location \( \alpha \) equals zero (\( \lambda(\alpha) = 0 \)). If the land at location \( \alpha \) is used exclusively for industries (\( \delta_u(\alpha) = 1 \)), then the land rent equals the profit generated by the industries at location \( \alpha \) (\( \lambda(\alpha) = \pi_n(\alpha) \)), which must be higher than the profit generated if the land is used for agriculture (\( \pi_n(\alpha) \geq \pi_n(\alpha) \)). If the land at location \( \alpha \) is used exclusively for agriculture (\( \delta_n(\alpha) = 1 \)), then the land rent equals the profit generated by agricultural sector at location \( \alpha \) (\( \lambda(\alpha) = \pi_n(\alpha) \)), which must be higher than the profit generated if the land is used for industries (\( \pi_n(\alpha) \geq \pi_n(\alpha) \)). If the land at location \( \alpha \) is used as both industries and agriculture (\( \delta_u(\alpha) > 0 \) and \( \delta_n(\alpha) > 0 \)), then the land rent equals the profit generated in either sector at location \( \alpha \).
The switch location $\alpha^*$ in Figure 1 is the location where $\pi_u(\alpha) = \pi_n(\alpha)$. To the north of $\alpha^*$, $\pi_u(\alpha) \geq \pi_n(\alpha)$, land should be used for the industrial sector. To the south of $\alpha^*$, $\pi_n(\alpha) \geq \pi_u(\alpha)$, land should be used for the agricultural sector. Thus, the bold curve traces out the land rent.

5.3 The Demand for Food Quota

Industrial technology and inputs vary across provinces. For example, they are higher/superior in Jiang Su than in An Hui. Therefore, the $\pi_u$ curve is higher for Jiang Su than for An Hui. Agricultural technology and inputs also vary across provinces, but the divergence in agricultural sector is perhaps less significant (at this stage) than in the industrial sector. For simplicity, we assume $\pi_n$ is constant across provinces, since what matters are the relative levels of $\pi_u$ and $\pi_n$.

The variance of the industrial sector across provinces implies that optimal land allocation should be different across provinces. Figure 2 shows the difference of land allocation between the two sectors in the two provinces. An Hui, which has lower $\pi_u$ than Jiang Su, should devote more share of land for the agricultural sector.

Imposing a food quota (which equals $1 - \alpha^*$) will force An Hui to decrease (relative to the optimum) the share of land devoted to agriculture. Likewise, Jiang Su will be forced to use more share of land (than optimal) for agriculture. To some extent, this demonstrates the inefficiency embedded in the old Governor’s Grain bag System. In this situation, efficiency can be improved for both provinces if they trade quota with one another.

For An Hui, in the area between $\alpha^*$ and $\alpha$, the land rent would be higher if the land is used for agriculture rather than industrial. Buying quota from Jiang Su will allow An Hui to move from $\alpha$ to $\alpha^*$. An Hui's willingness to pay for each unit of quota, which is the net gain $\pi_n - \pi_u$, is decreasing from $\alpha$ to $\alpha^*$. In other word, as the quantity of quota increases, An Hui's willingness to pay falls. Thus, $\pi_n - \pi_u$ represents An Hui's demand for quota.

By the same token, for Jiang Su, the land rent would be higher if land is used for industrial between the area of $\alpha$ and $\alpha^*$, indicating that Jiang Su would have incentives to sell quotas. Moving from $\alpha$ to $\alpha^*$, Jiang Su's amount of quota falls, and its willingness to accept, which is the net gain $\pi_u - \pi_n$, falls as well. Therefore, $\pi_u - \pi_n$ is an increasing function of quota and traces out Jiang Su's supply of quota.

The equilibrium price of the quota trading in the market can be determined by the aforementioned demand and supply. This price must be somewhere between $\pi_u(\alpha^*)$ and $\pi_n(\alpha)$ for An Hui, and between $\pi_u(\alpha)$ and $\pi_n(\alpha^*)$ for Jiang Su. The efficiency gain for each trader would be the area between curves $\pi_n$ and $\pi_u$ starting from $\alpha$ to the left for An Hui and to the right for Jiang Su for the amount of quota traded.
6. Conclusion

This paper proposes a grain quota policy that borrows heavily from the emissions literature. We believe if the provinces are allowed to trade the “quotas” (much like the emissions permit trading), it will be welfare improving. In addition, it will have the positive side effects that can potentially alleviate many problems that are plaguing China. The central government maintains goal of “feeding the Chinese population”, while reducing its financial burden as there will be no need to subsidize the grain farmers. By the construction of our proposed policy, the MIP (richer industrialized provinces) will be subsidizing the poorer agricultural provinces (LIP).

This, in turn, creates another set of benefits. As described in Section IV, the MIP will be paying a price that is lower than what it would cost if they were to produce the grain themselves. And if this is not reason enough, the MIP is now free to pursue higher value-added industrial production where they enjoy the comparative advantage. This tradable quota system will
transfer part of the wealth from the MIPs to the LIPs, which will potentially slow down (if not partially reverse) the regional inequalities.

With this “subsidy” flowing in, the grain farmers in the LIPs will be able to make a better living, hence attracting more farmers to stay home and engage in agricultural activities. This may stem the tide in the migration flows. In addition, as the grain farmers become richer, their demand for consumption will rise, which will have a spillover effect into commerce and even into light industrial sectors. This will further reduce the regional inequality of earning and benefit the finances of the LIPs with more jobs and an increased tax base. It will also allow the central government to perhaps phase out the grain price subsidy and reduce fiscal deficits.

If this policy is implemented in conjunction with efforts to increase agricultural research, propagation of new innovations (hybrid and genetically modified varieties, improve crop rotations, etc.),

improved rural financial infrastructure, and other related reforms,

the benefits will be multiplied. These complementary efforts will aid in lowering the MC of the LIPs, which will increase the size of the quota trade and expand the gains for all provinces.

As a final thought, we would like to point out that China is often called the factory of the world, and a new terminology has been coined specifically for China: an industrialized developing nation (Bao, Hou, Li, and Wang 2010). These clearly state that China is now an economic power in the world, but it be truly a major nation in the world, it also has to take its share of responsibility towards the welfare and stability of the world. In this aspect, can China afford not to have high confidence that it can feed her people without putting too much of strain on the fragile world food market? As bad as the world grain price was in 2007 and 2008, if China had major crop failure (or market failure, if government was to completely withdraw from the grain market as some scholars have suggested) failed and had to go to the world market to import substantial amounts of grain, one would shudder to think of the consequence.

Endnotes

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2. It is estimated that 30 million perished in the great famine of 1958 – 1961.

3. For example, the real per capita GDP has increased more than fivefold between 1978 and 2000.

4. Documentary evidence show that the Chinese reformers clearly had a "capitalistic" blueprint in mind, at the latest, in 1984. This is evident in the Central Committee (1984).

6. Based on more pragmatic assumptions, China estimates its population will peak at 1.6 billion.

7. In 2004, after a three-year investigation, the Ministry of Land and Resources designated 108.9 million hectares, out of the country's 127 million hectares of arable land in 2001, as basic cultivated land. According to the ministry, China needs at least 106.7 million hectares of cultivated land to feed its future theoretical peak population of 1.6 billion.

8. This led to a sharp rise of grain prices, coupled with over-investment, the inflation rate increased sharply in 1994 (Chang and Hou 1997), causing fear of a repeat of 1989. This led Premier Zhu Rongji to fire the Governor of the People’s Bank of China and assumed direct monetary control.

9. To demonstrate the gravity of the issue, the 2007 grain subsidy was “only” 51.4 billion yuan ($6.9 billion), which was a 66% increase from a year ago!


11. For a discussion of China’s efforts on GM (Genetically Modified) crop varieties, refer to Hou (2008). This still faces significant opposition in China, much like the “frankenfood” battle in EU.

12. Refer to Hou and Hou (2005) for examples of proposals of this nature.

References


