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An inquiry into the nature of producers' behavior in a reforming economy

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University of Hawaii, 1990
AN INQUIRY INTO THE NATURE OF PRODUCERS' BEHAVIOR IN A REFORMING ECONOMY

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ECONOMICS

DECEMBER 1990

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ABSTRACT

In chapter 1, two statistical associations are found significant using 1985 Chinese Industrial Census Data: the negative effect of shortages in energy on capital productivity and the positive effect of wage rates on labor productivity.

Chapter 2 is an inquiry into the nature of producer behavior during the reform period in China. The lack of transferability of productive assets, the absence of labor markets and chronic shortages are thought of as basic features leftover from the traditional system. Decentralization of wage and production decisions geared to profits are features of the new system.

Chinese firms in 1984-88 period can be modeled as profit-maximizers with wages and demand for energy and materials as endogenous variables. However, the wage rate cannot move beyond a narrow band specified by a lower and an upper wage-limit. Firms are constrained by the limited supply of energy and materials and the immobility of the labor force and fixed capital. Due to these constraints, idle capital and labor exist in most firms. Increasing utilization rates of capital and labor is then the key to improving firm productivity.
Comparative statics results of the firm model developed in Chapter 2 imply that growth in labor and capital will lead to a corner equilibrium where firms have no choice but operating at wage and energy supply limits, that is, with these key decisions exogenous to the firm.

Chapter 3, in testing this producer theory, derives and estimates of inter-firm Cobb-Douglas production functions using Census Data. Among other uses, this result then is applied to the calculation of labor redundancy in Chinese firms.

An economic theory of socialist reforms characterized by a dualistic pricing system is outlined in chapter 4, based on the producer theory developed in previous chapters.

Finally, a comprehensive summary, chapter 5, provides further and deeper explanations of the two statistical associations found in chapter 1, in the light of the firm model developed in chapter 2 and tested in chapter 3.
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AN OVERVIEW

In 1984, when reforms were changing everything in China's economic and political life, per capita GNP in this socialist country was about 300 dollars, much lower than in the USSR and the East European countries. The Chinese economy is a socialist developing economy.

The existing market based theories and strategies for economic development, whether tried or not yet tried in China, are not effective for a developing economy with socialist characteristics. In such an economy, laborers cannot be dismissed by firms, major productive assets are owned by the State, monopolist sellers, over-demand and low efficiency create chronic shortages and central rationing of shortage goods. Thus, there is little room for private economic competition and free market activities. In other words, almost all microeconomic behavior would be seen as "abnormal" or "irrational" by most mainstream development economists.

The available theories and methods of socialist planning are not suitable either, because reforms have rapidly undermined the basis of central planning. Firms and local governments enjoy autonomous rights in investment decisions, in revenue collection, in selling and buying products and in dividing
retained profits and issuing bonuses and setting wages. All of this has created a "mess" in the annually planned "synthetic balance" and the Five-Year-Plan.

An editorial of People's Daily, the largest newspaper in China, in late 1985 argued that, "reforms are calling for great economic theories." However, Chinese reformists could not spare their time for developing theories. They were totally occupied by various practical, usually "emergency," problems emerging from the reform process. It is now time to think about theory.

A standard way of thinking about an economic theory is to view it at two levels, the micro and the macro, and to divide the microeconomic theory into three parts, consumer theory, producer or firm theory and the combination of the two in a general equilibrium theory. Macroeconomic theory is based on a micro-foundation and models such aggregate variables as money, investment, employment, and demand in a free market economy or models the procedure of synthetic balance in a centrally planned economy. Also, as will be shown in the last chapter of this thesis, macroeconomic theory is used in modeling price formation and resource utilization in a reforming economy.
The first step is to develop an appropriate microeconomic theory. Consumers are about the same everywhere in the world, with different tastes and endowment, and with more or less private ownership of consumer goods. So, production theory is more critical to China's and other socialist countries' reforms.

There are three parts in a standard production theory; the technical constraints or production functions; the economic response of producers, given rules of the game, to changes in prices or other environmental variables; and finally, institutional arrangements within and between producers and their environment.

At this stage of theoretical evolution, the first and the third part of production theory are less advanced in an operational sense than the second part. The second part is mathematically much more developed under the title "theory of the firm". However, recent developments in the new institutional economics have established the frontier of the other two parts in such a way that an operational theory becomes possible (Williamson, 1990). Reforms in China are largely institutional rather than a well-specified game. An economic theory of reforms therefore has a lot to do with institutional changes and their effects. What would be the proper model for Chinese firms during the reform period? This is the central topic of this thesis.
To search for a firm theory, rather than to apply one, three stages in the process are necessary; the search for "stylized facts;" modeling the new theory; application or testing of the theory. The first three chapters in this thesis are therefore organized as follows.

Chapter 1, which starts the search for stylized facts, covers "Two statistical associations observed for single-factor productivities in Chinese large and medium industrial enterprises, 1985." Reforms in these large and medium industrial firms, almost all of which are state-run, are really the core of and the hardest part of socialist reform. In fact, privately-run firms in China only produce less than one percent of GNP. Collectively-run firms produce a larger share than the private ones, but far less than the state-run firms do.

Single-factor productivities are the simplest indicators of firm behavior, requiring the least onerous theoretical foundations. The 1985 National Census on Industrial Firms provides the needed data base, covering all large and medium industrial firms. The year 1985 is also a proper period for our study. Since most reforms were implemented before or in that year, the behavioral pattern of firms observed in 1985 is significantly different from that found in a traditional centrally planned economy. This pattern was not significantly changed again until 1989.
Two important stylized facts are found in chapter 1: the significantly negative effect of energy shortage on capital productivity; the significantly positive association of wage rates with labor productivity.

The two statistical associations imply that the fixed-capital utilization rate may be a function of degree of shortage of energy and key materials and that the labor utilization rate may be a function of wage rate. These "facts" are used in chapter 2 to construct a theory of the firm for China or other socialist reforming economies.

The main contribution of this thesis is in fact the development of a model for the behavior of enterprises in a socialist market-oriented reforming economy. Market-oriented reforms within a Soviet-type socialist system take place in an economy during the reform or transition period characterized by:

1). The co-existence of state-ownership of major productive means and "market-based" incentives to economic activities.

2). The co-existence of central and decentralized decision-making powers (including setting prices).

3). Shortages, as a result of inefficient production and over-demand.
4). Absence of factor-markets; inevitable before divergence of agents' interests and independence of property rights over exchangeable items become lawful.

In the Chinese case, especially in 1985, those features took the form of: 1) the immobility of labor and untransferability of capital, coexisting with profit and bonus incentives in industrial firms; 2) many prices for one commodity; 3) increasingly endogenous wages to each individual firm, with an upper-limit set by the government and the downward rigidity guarded by the workers; and 4) an increasingly serious shortage of energy and key materials, which, with other factors, leads to underutilization of productive capacity.

A model of the firm for the Chinese case is analyzed in chapter 2. Under the market-oriented reform policies, the common interest of managers and workers in the firm is to pursue profits without lowering the wage level, and the common interest of managers and the central planner is for the firm to pursue profits and keep the wage level below an upper limit. The firm, with a given amount of fixed capital and labor stock and given prices, is a "limited" profit-maximizer making optimal decisions about wages and demand for energy and materials, restricted by technical possibilities, shortages of energy and materials and the lower- and upper-limits of wages.
The comparative statics of this model show that the firm would increase workers' wages when nominal capital increases, or available energy and materials increase, and would decrease workers' wages when nominal employment increases. They further show that the firm would increase its demand for energy and materials when either nominal capital or labor increases. Over time, if investment is continuously biased toward the highly-profitable manufacturing industry, rather than the mineral and energy industries, due to the distorted price-system existing in Soviet-type economies, then energy- and material-consumption will increase faster than energy- and basic-material-production. Meanwhile, population growth generates more pressure on firms' labor-utilization-rate. If efficiency in production and in management cannot be continuously improved, then profits and wages payable will grow slowly against the reform-stimulated workers' expectations of wage increases. A Chinese firm would move to a corner equilibrium solution where energy and material demand equals whatever is available to the firm and the wage-level paid is at either a lower- or an upper-limit.

Wage endogeneity is an essential feature of this model of the socialist firm. The conventional model of wage-determination in a developing economy, i.e., the Lewis-
Ranis-Fei industrialization process, really depends on the existence of a labor market. With the labor market missing, wages in urban areas would rise above the subsistence level before the economy reaches a "shortage point." This wage expansion process would occur in a socialist reforming economy. Wages in a traditional Soviet-type economy are centrally planned. As reforms lead to a decentralization of decision-making on wages and profit distribution, wages will increase faster than productivity before a labor market can be introduced to replace the abolished central planner. Understanding this mechanism of wage determination is the key to understanding the Chinese reform. Wages will continue to be endogenous to firms, so long as the reform is not able to introduce competition among firms and managers and among laborers.

The policy implications of this model are pessimistic. If firms after a short period of autonomous decision making will ultimately hit limits set by either the government or a social group, then what is the purpose of market-oriented reforms? The basic purpose of the reform is to let firms run as "independent commodity producers," and let the government regulate indirectly through the market. With the current results firms will still be controlled by either workers' welfare motivation or government's non-profit motivations. The situation is worse the greater the pressure on wage expansion and inflation; that
is, the more expansionary is finance. To find a way out of this situation, reforms need to be deepened to touch ownership structure and to introduce factor markets.

A test of this theory is carried out in chapter 3 by applying the model to the estimation of inter-firm Cobb-Douglas production functions in eleven Chinese industries with Large- and Medium-Enterprise Firm-Level Data from the 1985 Industrial Census. In all industries, the estimates based on the theory yield an improvement compared with conventional Cobb-Douglas production function estimation with the same data.

As a further test, the estimated parameters in the extended Cobb-Douglas production function then are applied to an estimation of labor redundancy in Chinese firms. The result is consistent with other Chinese economists' reports.

There have been many efforts to estimate the unobservable rate of "on-the-job-unemployment" in China. Most such estimates are based on economists' intuition rather than on data analysis. The approach in chapter 3 is the first one that is formal and consistent with intuition.

In chapter 4 an outline of the general theory of socialist reforms is provided. The so-called dualistic pricing system is taken as a feature of a reforming socialist economy. Aggregation leads to two producers, one producing the shortage good, the other producing the consumer good. A central planner
controls part of output of the shortage-good producer and supplies part of the shortage good to the consumer-good producer. Therefore, equilibrium prices in the goods markets are functions of the planned quantity of the shortage good. Reforms can be modeled as a procedure of shrinking the centrally planned proportion of the shortage good. Can resources be more efficiently utilized during the reform? Is inflation inevitable? These questions could be answered by additional research using the analytical framework developed in this dissertation.

Chapter 5 is a summary of the previous chapters. It links together the facts and the theory, giving a comprehensive understanding of firm behavior in a socialist reforming economy. This firm theory and the reform framework based on it could be extended to cover other market-oriented reforming socialist economies because of the generality of its structure.
CHAPTER 1

TWO STATISTICAL ASSOCIATIONS OBSERVED FOR SINGLE-FACTOR PRODUCTIVITIES IN CHINESE LARGE AND MEDIUM INDUSTRIAL ENTERPRISES, 1985

1.1. Introduction

To establish the stylized facts about producers' activities during the reform period, the partial or single-factor productivity of labor and fixed capital in China's large and medium industrial enterprises is analyzed in this chapter. Looking ahead, the empirical evidence, based on the 1985 Chinese Industrial Census, shows three factors are significant in explaining single-factor productivities; the degree of energy shortage, the level of wage rates, and the scale of production.

Improving economic effectiveness and productivity in large- and medium-sized enterprises has long been recognized by Chinese economists as a central target of economic policy (Lu Dong, 1989; Wu Jinglian, 1989). But empirical productivity studies at the firm level are very few.\footnote{[1]} Among those available are

Most productivity studies are at the national level, using time-series data (Wang Haipe, 1989; Chen Kuan et. al., 1988; Gene Tidrick, 1986). In these studies, multiple-factor or total factor productivity is estimated, along with the rate of technological progress. However, the effect of shortages of energy and of key materials and the effect of reforms in the economic system such as in the mechanism of wage determination are not taken into account in these studies.[2] Before a theory of the firm is established from which a regression model for estimating firm production functions, efficiency, or the effects of institutional changes in the economy can be derived, the concept of total-factor productivity in the Chinese economy must be made much clearer.

In the western economic literature, cross-sectional studies, the most frequently used method to analyze firm productivity, were connected to the microeconomic foundation of neoclassical theory as early as the 1940s (see the production function theories of economists like M. W. Reder, 1943; M. Bronfenbrenner, 1944; M. J. Farrell, 1957; Marc Nerlove, 1965; and D. J. Aigner and S. F. Chu, 1968). In these early studies, an "inter-firm production function" or a "frontier production
function" was estimated with cross-section data. In these approaches, the marginal value of factor productivity derived from the production function, following the work of Cobb and Douglas in 1928, was equal to the average productivity of factors, given perfect competition (Bronfenbrenner, 1944).

While in other circumstances, perfect competition can be taken as an approximation of the less than perfect market system in place, this does not even roughly apply for China's far-from-competitive economy. A Chinese firm therefore does not necessarily use its labor and capital effectively. This raises the problem of how to separate the effectively used from the nominally employed factors in the observed firm-level data. Direct application of multiple-factor production function theory and techniques in analyzing Chinese productivity therefore needs careful justification.

Estimating multiple-factor productivity requires estimates of production functions. The latter in turn require assumptions about producers' behavior. Due to ineffective use of input, observed input-output data does not necessarily reflect purely technical relationships. How effectively each firm is using its inputs to produce the firm's output depends on the incentives provided to managers and laborers. To do this job, as mentioned in the overview, an appropriate theory of the firm is needed.
On the other hand, an empirical analysis of single-factor productivities requires relatively weaker assumptions than does the total-factor productivity approach. The purpose of estimating single-factor productivity is less ambitious. Usually it is a search, guided loosely by theory, for meaningful statistical connections between productivity and other variables. Economists are well aware that a productivity index is an outcome of a highly complicated process involving many variables, and with many dimensions of causality.

The next section outlines the three dimensions of determinants of productivity in firms, introduces the concepts of shortage and scale economies, and discusses wage determination in Chinese firms. The third section develops the regression models to be used for productivity estimation and deals with measurement problems. The models are then estimated and explained in the fourth section. Conclusions appear in the final section.

1.2. Determinants of Factor Productivity at the Firm Level

Productivity is usually defined as: "a ratio of some measure of output to some index of input use" (Z. Griliches, 1986). Studies of productivity in firms have recognized a great number of variables
related to productivity performance. These variables can be classified into three categories:

1) Technical factors, including
   a) quantity and quality of outputs and inputs,[3] skills of labor and blue-print techniques embodied in the capital.
   b) techniques employed by firms, including the blue-print and the know-how techniques, the technical combination of inputs and outputs, the technically determined scale of production.

2) Institutional factors, including:
   a) those internal to the firm, including all contractual relations within the firm (rules of income distribution among members of the firm, distribution of decision-making power within the firm, terms of responsibilities of firm managers to workers, terms covering workers' right of monitoring managers and the managers' right of bonding workers, etc).[4]
   b) those external to the firm (explicit or implicit contractual relationship between the firm as a party and another party external to the firm; e.g., rights and responsibilities governing assets owned by the State.[5])

3) Behavioral factors (behavior is defined as a person's "economic responses" to the set of constraints given by his environment. "Economic response" means a response that can
be derived from a maximization model with an objective function determined by the person's motivations, with the given set of constraints.[6]

There is obvious interaction among factors in the three categories. For example, quality of inputs say, management effort, is also influenced by asset ownership and the manager's motivation. However, the classification set above is clear enough for practical purposes and general enough to cover all determinants of firm level productivity and efficiency.

The first classification, "technical factors," is designed to conceptualize the relationship between human beings and Nature concerning a firm's production. The second, "institutional," captures the relationships among human beings and the third, "behavioral factors," concerns the driving forces inside an individual.

There are three factors considered by Chinese economists extremely important in firm production. They are:
1) The extent of shortages.
2) Scale economies.
3) Wage rate determination.

The extent of shortages, though generated by a specific institutional arrangement as discussed later, directly effects the utilization of non-shortage inputs. Therefore it comes
under the category of technical factors that lower firm productivity. However, given the supply of the shortage inputs, a better management or a well designed incentive system (such as bonus for energy-saving) could alleviate the extent of shortages. Therefore it is closely related to the other two categories.

Scale economies is usually put into the category of technical factors. However, after the work of economists like Young (1928), Kaldor (1967, 1985), and Yang (1988), it has become clear that scale economies must be accompanied by institutional changes to be effective.

Finally, wage rate determination comes under the category of institutional factors, though it also has a lot to do with other categories. For example, level and growth rate of wages and workers' response to wages effect working enthusiasm and productivity, therefore behavioral factors do matter.

The rest of this section is devoted to the clarification of these concepts.

1.2.1. Shortages

"Shortage" is usually understood as the amount of unsatisfied demand for goods at given prices. There are several points concerning this concept. First, the price must not be free to change, or the shortage disappears. Second, the excess
demand tending to push up the price of a shortage good or service can be decomposed in two parts, the efficient demand, and the over-demand.

If firm behavior is rational, then the amount of demand for a shortage good or service can be derived from a maximization model. But this demand may not be consistent with social optimality. For example, Kornai (1985) found that socialist firms tend to hoard materials and intermediate products at a level of two or three times the level in capitalist firms. This hoarding tendency is resulting from firms' rational consideration on risks of production discontinuity, though it is not necessarily a socially optimal choice. In the following, that part of demand which is consistent with socially optimal allocation is defined as "efficient demand," and the rest of the firm's demand is labeled as "over-demand."

The above definitions lead to a third point related to the concept of shortage, the importance of interaction between firm behavior and government behavior. The price of a shortage good or service, since there is excess demand, must be regulated by the government. Also, if incentive systems are designed so that firms over-demand inputs, then it is the government's responsibility to pursue the socially optimal allocation.

Unless "market-oriented" reform has been successfully completed, it is not realistic to assume that prices are
competitively formed in a Soviet-type economy, nor to assume a traditional centrally-planned price. A proper model for price formation in the transition period from a command to a market economy is a price that floats within a regulated range. If a good is in shortage, then the price will tend to be at the upper bound. If a good or service is not in short supply, its price tends to be determined in the market, or to stay at the lower bound of the regulated range if the market for that good or service does not exist (labor, for example).

For commodities whose prices are at the upper bound of the regulated range an economic rent accrues to the successful buyers since the true value of the commodity exceeds its price. This makes the enforcement of price regulation costly. The buyer can bribe the seller by sharing the hidden rent with him. Workers in the illegal seller-firm will be better-off with the rent shared with the illegal buyer-firm, while legal buyers and sellers may feel worse-off and so may copy the illegal ones. The whole process is an example of "adverse selection," with the "bad" driving out the "good" or legal behavior.

The amount of rent that buyers are willing to pay depends on the value of the shortage good or service to the buyers. The latter depends on the role of the shortage good or service in the production process, and on the target the buyer pursues.
Most shortages involve producer goods; so their demand is derived demand. However, the demand derived from profit-maximization would be different from that derived from output-maximization. If say, the profit-maximizing demand for the shortage good or service is consistent with social optimality, then the social value or "shadow price" of the shortage good or service coincides with the value of that good or service to the profit-maximizing buyer. But this implies that, to the output-maximizing buyer, the value of the shortage good or service must be divergent from the social value of that good or service. Usually, the social value is higher than the individual buyer's value of the shortage good or service. Therefore even if the buyer pays an economic rent to the seller, he still pays less than the efficient or socially optimal price.

In equilibrium, the seller of a shortage good or service should receive a price at the upper bound of the regulated range plus a side-payment, not shown in the firm's account. The latter should be equal to the economic rent less a premium paid to the buyer for risks of illegal practice. Therefore the buyer is paying a price higher than the regulated price but lower than the efficient price. This implies that actual demand for the shortage good or service tends to be over-demand.
Chapter 2 will show that a typical producer in a reforming socialist economy characterized by factor immobility, wage endogeneity, and linkages between profits and workers' benefits would act as a "limited" profit-maximizer. Profit-maximization for such a firm is restricted by institutional constraints, such as the shortages of energy and key materials.

An implication of firms' profit-maximization constrained as described above is that management decisions may not be able to efficiently employ inputs. For example, the price of key materials that the firm uses might be lower than the efficient price (as discussed before). If the profit-maximizer equates the marginal contribution of materials to the actual price paid for the materials, there will be an over-demand for those materials.

On the seller's side of the shortage good market, since the actual price of his product is lower than the efficient price, the profit-maximization that equates the value of marginal product to price of inputs will tend to reduce the demand for inputs and so output below the efficient level.

The above discussion can be intuitively translated into the standard demand-supply context. Since firms are "limited" profit-maximizers, in a limited range there is a downward sloping demand curve, reflecting the price the buyer is willing to pay, and an upward sloping supply curve, reflecting the
quantity the seller is willing to produce at given prices for
the shortage commodity. The equilibrium price must be higher
than the upper-bound of the regulated price, with a gap between
demand and supply. [7] The economic rent, which is equal to the
difference between the equilibrium price and the upper-bound,
is split between the buyer and the seller. If all economic
rents go to the seller in the form of a side-payment, there
will be no gap between demand and supply and so shortage. This
will happen only if violating the price regulation is costless.
Usually, this is not so and the side-payment plus the upper-bound
price is lower than the equilibrium price. Therefore shortage
can be alleviated by side-payment but cannot be eliminated.

Usually, at the beginning of the reform, illegal practices
like bribing sellers are still highly risky in the largely
unchanged old system. As reforms go deeper and begin to radically
change people's behavioral norms, violating the regulated
prices becomes easier. With the new system not fully estab-
lished, it is in this period that reform is in big danger, as
prices of shortage goods and services are pushed up by rapidly
spreading illegal methods of rent-seeking. In fact, inflation
accompanied by corruption has been a characteristic of socialist
market-oriented reforming economies. The existence of shortages
is an important reason.
Shortage effects can be classified as those at the macro-level and those at the micro-level. Macro-level effects include for example, the pressure of pushing up the price level (pp. 556-559, Kornai, 1980; and Zhang Qing-Ren, 1989), the unbalance of the synthetic central plan due to over-demand and under-supply (Ma Guonan, 1988; Zhou Huizhong, 1987), and the trend of centralization in direction of production and in the allocation of the shortage commodities because the equilibrium price would be too high to be socially accepted (Chapter 13, Zhu, 1985; Zhong Shao-Nan, 1989; and State Planning Commission, 1989). Micro-level effects are observed in the household consumption behavior (queue and forced substitution), and in the firm production behavior. The latter will be considered in this section.

Shortages are thought by Chinese economists to be a major cause of the following problems in Chinese firms:

1) Underutilization of productive capacity.
2) Idleness of employees.
3) Rising cost of products.
4) Hoarding of inputs and outputs which are in short supply.
5) Decreasing turnover rate of working capital.
6) Increasing non-productive investments and other expenditures on workers' welfare.
Problems (1) and (2) are closely connected to shortages in materials, intermediate products, energy, transportation services, etc. Of course there are other causes for the under-employment of labor and capital. As will be shown in chapter 2, the incentive system itself is not efficient, the absence of labor and capital market being major reasons for under-employment.

Problem (3) is related to the increasingly higher payment for the shortage commodity during the reform period. There are mainly two reasons for the rapidly increasing prices of the shortage commodities in the reform period. First, prices of the shortage goods are historically lower than efficient (or international market) prices, therefore, raising prices of the shortage goods becomes one of the major targets of market-oriented reforms. Second, the side-payment to sellers may not show up in the sellers' account, for it may go to private pockets. But it usually shows up in the buyers' account, for the firm is not privately owned. Therefore, unit cost of production increases during the reform period.

Problem (4) has been well investigated by Kornai (1980, 1985). The basic reason for firms to hoard inputs which are or are thought likely to be in short supply is the expected risk of shortage-forced discontinuities in production. Other
things being equal, risks of input shortages will result an optimal inventory level of inputs that is higher than if there were no such risks.

Problem (5) is a financial reflection to all the previous effects. Underutilization of capital and labor reduces the level of production without reducing the payment for all nominally employed inputs. The rising cost of inputs and the hoarding of inputs increase the working capital tied up in the production process and in inventories.

Problem (6) is a special response of Chinese firms to shortage of consumer goods and services such as housing, schooling, baby-sitting, and transportation etc. Shortages of these goods and services worries workers much more than the shortage of producer goods. It is a socialist tradition for Chinese firms to take on social functions. The firm typically runs company-buses every working day, baby-rooms, primary or even middle schools, theaters, hotels, and other facilities. The firm usually builds or buys houses for its employees, at a heavily subsidized rental rate. Although after the 1984 reform only 20% of firms' retained profits could be used for "collective welfare," there are hundreds of ways firms can spread non-productive expenditures into production costs (CESRRI, 1985, Report No. 5). In a reforming economy, prices of shortage commodities are influenced by sellers. Reporting
a higher production cost and charging the buyer a higher floating or negotiated price (and side-payment) is easier than making an effort to control costs.

All problems listed above are important to the study of productivity. If single-factor productivity is measured as the net added-value of output divided by the quantity of factor employed, it would be decreased due to problems (1), (2), and (6). Depending on how the firm is able to transfer the increased costs onto buyers, single-factor productivity may be decreased or increased due to problem (3). The importance of problems (4) and (5) depends on share of interest payment in total cost. In firm's net value-added accounting, interest payment is the only cost for possessing more working capital or hoarding more inputs, which usually is lower than 3% of total cost for industrial firms.

In this section, problems (4) and (5) will be ignored, since their importance is secondary compared with other problems. Problem (6) should be studied thoroughly. Firm expenditure on "collective welfare" may count as much as 30% of the cost increase in 1985. However, collecting consistent data on this expenditure is very difficult. The same difficulty rules out study of problem (3). At this moment only problems (1) and (2) can be studied.
Liu Hong (1988) found that in 1986, 30% of productive facilities in the whole economy were idled because of the shortage of electricity. In fact all three forms of energy (electricity, coal, and oil) have been in serious shortage for many years. According to Li et al (1988), 25% of facilities in 1987 could not run normally due to the shortage of energy and transportation. Another estimate (Liu Hueimin, 1989) found that about 40% of productive capacity could not be utilized because of the shortage in key materials, energy, and transportation facilities. The energy shortage is also growing due to the lower growth rate of energy than of manufacturing production.

As noted, transportation is another shortage input. Large amounts of coal could not be delivered to user-firms during the Fourth Five Year Plan period because of inadequate transportation facilities. (Sun Yianzhi, 1989; and Zhu, 1989).

A third shortage is of agricultural products that are key material inputs to industries. Cotton whose growth rate has always been lower than that of yarn before 1982 and after 1984 (Xu Xi-He, 1989; and Li Zuoyian, 1989) is an example.

The fourth important shortage is that of basic producer goods: rolled-steel, non-ferrous metals, cement, timber, rubber, industrial plastics, alkaline products, glass-plates,
and paper. These materials have long been under the restrictive control of central planning, classified as "first class materials."

Among 200 large and medium projects put into production during 1984-1986, less than 30% have reached the designed capacity; over 35% of those facilities are running at only half of their capacities, due to the shortage of materials. Many firms are in the state of "open five days and close two days," or "open four, close three," or "stop to wait for materials," "stop to wait for transport" (Li et al., 1988).

Shortages also have chain effects. For example, steel is a key input that is in short supply, and the steel industry itself is in serious shortage of electricity. The main cause of the reduction in the growth rate of steel production in the first half of 1989 was lack of electricity (Chen Xin, 1989). Further, the electricity industry is in shortage of coal (page. 3, People's Daily, Overseas Edition, May 16, and December 5, 1989). Another example is the shortage of synthetic rubber that is due to the shortage of butadiene. But the utilization rate of productive capacity of butadiene was only 70% in 1986,[8] because of the under-utilization of the ethylene production complex. The latter was caused in turn by the shortage of diesel (pp. 19-40, Sinopec Yearbook, 1988). The
ultimate source of these chain linked shortages, for a closed economy given regulated prices, is in the shortage of natural resources relative to final demand.

A large percentage of key materials, together with the three major sources of energies, was still under central control after reforms in 1984 and 1985. But later reform policies reduced these controls quickly. It is reported that in 1989 about 40% of key producer goods, in terms of value, remained under central control.

However, under the dual-pricing system introduced in 1984, a certain proportion of each key material can be produced and sold after the planned part is fulfilled. Table 1.1 provides the planned prices and the negotiated prices of some producer goods in 1985.[9] The negotiated price is a bargain between buyer and seller, supposedly regulated not to exceed the planned price by 20%. But, as is seen in Table 1.1, the enforcement cost of regulation invalidated the regulation itself.

Some indications of the degree of shortage may be given by the ratio of negotiated price to planned price. The higher this ratio the greater the degree of shortage, assuming similar demand elasticities for all shortage goods and services and similar negotiating strengths between buyers and sellers across industries. Therefore on this criterion, coke, coal, rolled
steel, and aluminium could be in the highest shortage (see Table 1.1).

Shortages also cause idleness of the labor force in the firm. Although the excess labor force in many cases could be used to substitute for capital as well as energy, it cannot substitute for key materials. Currently, China has about 15 to 20 millions of employees who are "on-the-job-unemployed" in firms (CESRRI, 1985; and Lu Xian-Xiang, 1989). This number, representing a conservative estimate, counts for 15-20% of China's urban employment in 1986.

However, the under-utilization of employed labor cannot be attributed only to shortages. There are other important causes, of which the wage rate may be one of the most important. This will be discussed below.

1.2.2. Scale economies

Another important determinant of productivity are scale economies, which can be defined as greater than proportional increases in output than in inputs as all inputs are increased.

However, for the purpose of this study, it is convenient to define scale economies as the reduction in inputs consumed per unit output as the volume of output is increased. For a profit-maximizing firm, this cost-side definition is equivalent to the output-side definition of scale economies.\(^{[10]}\) Since
the inverse of factor consumed per unit output is the productivity of that factor, the existence of scale economies causes the single-factor productivity to change with the output volume.

However in a shortage economy, observed increasing returns to scale may be simply due to a decrease in a constraining shortage. Because shortage is an important factor causing capital and labor under-utilization, a firm in which more shortage goods become available may be able to reduce internal unemployment of labor and capital, which the firm has to pay anyway, and to simultaneously increase gross output.

To exploit scale economies was a major reason for Chinese government support of large and medium firms in 1989 and 1990. However, small firms are institutionally more flexible than large ones. This flexibility has proved helpful to small firms in the transitional period. In fact, capital productivity often is higher in private or collective firms, which usually are small or medium sized, than it is in large, state-run firms. But this is not necessarily connected to scale economies. Since firm level data for small firms are not available, the test of scale economy versus institutional differences cannot be dealt with in this paper.

The data used in this paper are on large and medium firms. Within this size group, almost all State enterprises, scale
economies are expected to have a positive effect on productivity. However, this may not be as great as between large- and small-sized firms if properly measurable.

1.2.3. **Wage settings**

The third important variable in the productivity analysis is the wage rate. Wage rates and their structure in China are changing from being centrally-planned to being market-oriented (Walder, 1987). For statistical purposes in this paper, I will discuss China's wage reforms from the viewpoint of both economics and accounting.

Since there is no labor market in socialist economies, wages are centrally planned in the traditional system. The theory of socialist planning suggests that wage increases should be arranged on the basis of synthetic balance. National income, after reserving a proportion for capital depreciation and accumulation, provides a fund for consumption, of which a large part goes for the public consumption, and the rest goes to workers and government employees as wages. This wage fund then needs to be kept in balance with planned production of consumer goods.

There are six items in the wage accounting: time-wage, piece-wage, bonuses, subsidies, overtime wages, and finally the "other" wages. Of these, the time-wage is quantitatively the most important. The time-wage is based on the tenure,
education and skills of workers, without discriminating between hard-workers and lazy-workers, since workers cannot be laid off either, the time-wage system offers no rewards for present effort, only for past "accomplishments."

Piece-wages on the other hand, are strongly incentive-oriented, usually with favorable effects for younger and stronger workers if the jobs do not require much experience. Bonuses are supposed to be issued according to the work effort, but in practice they are distributed more or less equally. The incentive to managers is too weak for them to handle contentions with workers when bonuses are not equally distributed. There is also little incentive for managers to carefully meter each worker's contribution in production (which usually is very difficult). As Walder (1987) analyzed, the equal distribution of bonuses is the optimal choice to both managers and workers.

Subsidies are mainly distributed according to degrees of danger in various jobs. But also included in subsidies are transportation subsidies, food subsidies, bath and hairdressing subsidies, etc., which are equally distributed. Overtime wages and the "other" category count for a very small part of the total wage.

Before the reform, say in 1978, the time-wage in State-run firms counted for 85% of the total wage, while the piece-wage counted for just 0.9%. During the reform, in 1985, the share
of time-wage was reduced to 59%, and that of piece-wage increased to 12.1%. Similarly, bonuses counted 2.3% in 1978, and 12.9% in 1985, and subsidies counted 6.5% in 1978 and 15.2% in 1985 (p. 131, China Labor and Wages Statistics, 1949-1985).

In addition to wage-income, workers also receive non-wage incomes such as the heavily subsidized housing, health-insurance, transportation facilities, schooling of children, etc., these subsidies being recorded as "collective welfare," or "labor insurance," or "firm and workshop management fees." Mr. Xue Muqiao, a leading Chinese economist, claimed recently that the non-wage income has accounted for 50% of workers' total income. Therefore the economy should be called a "semi-state-supplied economy."

In the accounting sense there are three sources of funds to finance the firm-level distribution of non-wage income. First, are retained profits and other funds, which are very complicated to calculate, but basically, should not exceed 40% of the total profit the firm makes. In the retained profit, 50% is supposed to be used for developing production, 30% for bonuses, and 20% for collective welfare. However, a survey in 1985 found many firms used all their retained profit for bonuses and collective welfare (CESRRI, 1985, Report No. 5).

Second, are health-insurance and labor-welfare fees, which can enter the cost of production. In 1985, this type of cost
was 28.49% of total wages in state-run firms (p. 1004-5, Vol. 8, China Industrial Census Data, 1985). The final sources of non-wage income are the so-called workshop-operation fees (the fees necessary for organizing workshop production. e.g., salaries of workshop managers, workshop-office maintenance) and firm-management fees (including firm managers' salaries, firm-office expenditures). These two kinds of expenditures also enter the accounting of production cost. In fact they were the largest items next to costs of raw materials in 1985. The rate of increase of these fees in 1985 was even higher than that of industrial gross output (p. 62, China Statistical Yearbook of Industrial Economy, 1988).

It is important to note that inter-firm differential in non-wage incomes can be great. Because workers and capital cannot move freely, profitability and financial power are unevenly distributed among firms. To maintain "equity" in real income distribution is, before and in the reform, the responsibility of the government, not the firms. But the government in the reform period found it increasingly difficult to account for and control inter-firm inequality in non-wage incomes. However, in this period, the government was still able to control the inequality of wage-income, which accounted for 50% of total income. This implies that the reported wage
income inequality among firms is much lower than the inequality in workers' wage plus non-wage income distribution.

As market-oriented reforms continue, a greater proportion of the wage is determined at the firm level. The state only directly controls the time-wage, but indirectly regulates other types of wages by a variety of policies, including a tax on bonuses, an upper limit set to bonuses (before 1983), a regulation-tax on wages (after 1984) and the wage-profit linkages introduced in and after 1985.

As is shown in chapter 2, firm behavior in China is deeply influenced by workers' welfare considerations. Thus, new policies linking the collective-welfare fund and the bonus-fund to profits certainly stimulated workers' and managers' profit-motivation.

Working in the opposite direction, is the absence of a labor market. This situation tends to push wages up with profits and to help resist any fall in wages when profits fall. In the latter circumstance, there will be conflict between the government, trying to make the economy at least partly adjust to shifts in supply or demand, and the firm, which gains more from protecting workers' wages than from maximizing "profits."

The firm can find tens of excuses for any reduction in profit, namely, increases in input prices or taxes, poor quality of in-the-plan supplied materials, lack of energy and other
services, financial burdens due to unwilling increases of planned employment, and numerous other factors outside the firm's control. Therefore, the firm does not need to take full responsibility for any losses made, but will have to answer to the work force if wages go down.

The above discussion yields a picture of Chinese wage determination in the transition period. There are basically two components of the total wage, the slow-to-change and centrally controlled time-wage and the more variable and effective one determined at firm-level and resistant to any fall. The government takes the responsibility of maintaining an acceptable equality in inter-firm wage levels while providing some output flexibility in the system; not exactly complementary goals.

Thus, in each production period, there implicitly exists a lower limit and an upper limit to the wage level in the firm. The lower limit is the existing level of wages. Below that limit the manager will stand by workers to bargain with the government, and the wage rate will be allowed to be maintained near the previous wage level. The upper limit is determined in a one-to-one bargaining process between the firm and the supervisory department, based on the firm's contribution to the society which is, under the wage-profit linking policy,
measured in profits and taxes actualized, on the firm's historical wage-level, and on the social average wage-level (for example it cannot exceed five times of the social average wage level). Between these two wage-limits, there is a room for firm managers to make profit-oriented decisions on production and income distribution. This situation will be formally modeled in chapter 2.

The final issue to be discussed is the relationship between the wage level and labor productivity in the firm. If factor markets are perfectly competitive, the wage rate will equal the marginal value product of labor, and will be the same for all firms. As physical and human capital is accumulated in the economy, other things being equal, wages tend to increase. Real wages are determined by the supply of labor, and by the productivity. However, where markets are less than perfect (information costs, in training costs, risk preference, etc. exist), wages may determine productivity.

In a reforming socialist economy, where the labor market is largely missing and firms are state-owned, to provide an incentive to improve efficiency the government can promise a higher wage level to a firm that becomes more productive than before. In China this takes the form either of a profit-wage contract between the government and the firm signed and adjusted on an annual base, or if there not a formal contract, a promise
to the workers of a higher wage if they work harder.

The difference between a competitive market and the wage setting described for China is clear, the former is "hard," the latter is "soft." Workers in China do not have to work harder to keep their jobs or attain their basic needs. They are guaranteed of jobs and basic needs in a socialist system. Workers in a competitive market have to work harder if necessities cannot be ensured. However, those Chinese workers willing to work hard can get a higher payment with reforms. The wage differential between a hard-worker and a lazy worker cannot be great, but, as shown later, is significant. This difference in wages could partly explain the labor-productivity differential among firms with about the same technology and scale of production, though as discussed above, its explanatory power will not be very strong.

1.3. The Statistical Model for Productivity

The relation between factor productivities and the variables discussed, the effects of shortages, of relative wage rates, and of scale economies, will be estimated in this section for each of eleven selected industries, based on cross-section data from the Industrial Census. Symbolically, the relationship between factor productivity and the three variables is:
\[ P = h(S, W, Q). \]  

Where \( P \) stands for productivity, \( S \) stands for degree of shortage, \( W \) for average wage rate of the firm, and \( Q \), gross output, as an index of the scale of production.

A conventional way to estimate this sort of relation is in log-linear form, or:

\[ \log P = a + b \log S + c \log W + d \log Q + \epsilon. \]  

Where \( a, b, c, d \) are constants, and \( \epsilon \) is the error term. When (1.2) is estimated with cross-section data, the coefficients in (1.2) can be regarded as the contribution of each variable to the change in productivity, with other variables kept constant. The inter-firm regression of (1.2) for a sample-industry represents statistical associations among variables considered for a hypothetically "average firm" taking the mean values of variables observed in that industry (Nerlove, 1965).

The measure of capital productivity (\( P_K \)) is measured as the ratio of the net value of output (\( Y \)) or value added of the firm over the net value of observed fixed capital (\( K_O \)) or capital stock, that is \( Y/K_O \). And the measure of labor productivity (\( P_L \)) as the ratio of \( Y \) over the observed total employment (\( L_O \)), that is \( Y/L_O \).
There are problems with this capital measure. For example, the "useless" facilities due to mis-allocation are included in this measure. Also included are assets that are non-productive, at least in the firms' main industry, such as housing for workers, shops and other service facilities. However, for most firms, the "useless" facilities cover less than 10% of total fixed assets (Liu, 1988).

Another problem is caused by the real depreciation rates of fixed capital in different firms. Assets are depreciated and accumulated at fixed linear rates by types. But in fact firms with higher utilization rates consume their fixed capital faster than firms with lower utilization rates. The absence of a capital market makes capital evaluation more difficult than in a market economy.

A third major problem with the capital measure used is a result of inflation as discussed by Chen Kuan et al (1988). A high rate of inflation reduces the purchasing power of capital replacement fund, and affects the real value of fixed capital built during the inflation period.[11]

One problem with the labor measure used is that there are "redundant" employees in most firms. Also, there are non-productive employees in most firms, such as nurses in firms' kindergartens, and those who are not working for the firm but for the government or for social institutions and are paid by
the firm. However, the number of redundant workers, to a large degree, depends on the wage incentive system. Redundant employees may find themselves doing very productive work if the returns are high (Luo, 1988; White, 1988; Yu and Qu, 1989; Xin and Xu, 1989).[12]

The problem with the net output measure arises from the dual-pricing system under which firms are allowed to sell a proportion of output at "floating" or "negotiated" prices. Even though the sample firms have been classified in a four-digit system, there still exists the possibility that firms producing the same kind and amount of outputs at the same cost show different net value. In addition, firms face the dual-pricing system in input-market.

However, properly chosen sample industries might alleviate this problem. Table 1.2 gives the proportions of out-of-plan sales in 1985 for 33 broadly-classified industries corresponding to groups of industries in the four-digit classification.[13] This table shows that in most industries the government controlled about 70% of the output in 1985. Since the large and medium firms used in this study were more controlled by the government, the out-of-plan sale of these firms may be smaller than 30%. Therefore the effect of price diversification on the measure of net output may be weak, and not cause a systematic bias across firms.
Although both energy and material shortage and the shortage in transportation facilities should be studied, for most industries the value of shortage materials cannot be separated from the non-shortage materials in the data. And there is no data available on transportation services at the firm level. The only available data are those on energy consumed. Thus, this study is restricted to measuring the effect of energy shortages only. The total effect of shortages is then greater than the results presented simply.

The degree or extent of shortage in energy should be measured as the proportion of unsatisfied demand in total amount demanded. However, the amount demanded is not observable. As an alternate variable, the amount of fixed capital is used, since demand for energy is usually positively proportional to amount of fixed capital. The degree of shortage in energy therefore is measured by the ratio of \( K_0 \) over either the firm's consumption of electricity (EL) in terms of kilowatts, or its consumption of total energy (EN) in terms of tons of standardized coal. In the following analysis \( S_1 \) will stand for the degree of electricity shortage, i.e., \( S_1=K_0/EL \); and \( S_2 \) for the shortage of energy as a whole, i.e., \( S_2=K_0/EN \); \( S \) will stand for the general shortage in a conceptual sense. \( M \) will stand for the quantity of either electricity or energy as a whole, correspondingly, \( S \) will stand for either \( S_1 \) or \( S_2 \), i.e., \( S=K_0/M \).
Measured in this way, $S$ will decrease as $M$ is increased, or increase as $K_0$ is increased, therefore reflecting the relative extent of energy shortages. However, this measure, $S$, cannot reflect the absolute amount of shortage. Using cross-section data, $S$ will reflect inter-firm differences in energy or electricity consumed per unit of fixed capital. A firm with a high value of $S$ is expected to experience a more serious energy shortage than a firm with a low value of $S$, other things being equal.

It is assumed here that all firms are using about the same technology (but may have different combinations of "nominal inputs"), and all firms behave the same way. This implies a positive sign of $M$, or a negative sign of $S$, in the regression. But it does not imply that transferring energy quota from a firm with a low degree of shortage to one with high degree of shortage can improve efficiency. The efficiency criterion requires modeling differences in firm behavior and technology instead of assuming them away.

The gross value of output ($Q$) is used as an index of the firm's scale of production. This measure also is affected by the dual-pricing problem, which is handled by selecting samples from four-digit industries, with the assumption that there is little variation among firms within an industry in the share of output sold at market prices.
Finally, the wage rate is measured by the average total wage ($W$). This is the ratio of the firm's total wage over $L_0$. Total wage differs from the wage in that the former includes all non-wage expenditures of the firm on workers' welfare (p. 672, Vol. 1, P.R.C. 1985 Industrial Census Data). Although total wage is a better statistic than wage expenditure, it still excludes some kinds of workers' income (Song Chang-Qing, 1989). Therefore the average total wage is smaller than the actual income of a worker.

The error term $\epsilon$ is assumed to be a normally distributed random variable with zero mean and finite variance.

Based on section 1.2 and considering all the above definitions and assumptions, equation (1.2) can be written as:

$$\log\left(\frac{Y}{K_0}\right) = \alpha_K + b_K \log S + c_K \log W + d_K \log Q + \epsilon_K,$$

(1.3)

$$\log\left(\frac{Y}{L_0}\right) = \alpha_L + b_L \log S + c_L \log W + d_L \log Q + \epsilon_L.$$  

(1.4)

The constants in these equations would be either positive or negative, since there is no a priori basis for foretelling their signs. Assuming there is idle fixed capital and labor within the firm due to shortages of energy and inefficiency in the wage-determination system, expectations about the coefficient-signs are discussed in the following.
The sign of $b_K$ in (1.3) is expected to be negative. Because an increase in $M$ will decrease $S$ in the firm while increase net output $Y$. Therefore $Y/K_o$ will increase, with $K_o$ being kept constant. If $K_o$ increases while $M$ is kept constant, then $S$ will increase, and the firm's net output may or may not increase. With an ignorable amount of interest payments, net output will not be changed by keeping more idle fixed capital in the firm. Therefore $Y/K_o$ will decrease, again yielding a negative sign of $S$ in (1.3).

Coefficient $b_L$ in (1.4) may be negative or insignificantly different from zero. If the reduction of $S$ is caused by an increase in $M$, then $Y$ will increase with $L_o$ kept constant. Therefore $Y/L_o$ will increase with the decrease of $S$. If the reduction of $S$ is due to a decrease in $K_o$, then $Y$ and so $Y/L_o$ may not change with $S$. Therefore $b_L$ could be zero.

The coefficient $c_K$ in (1.3) and $c_L$ in (1.4) are expected to be positive. An increase in wage $W$ will induce more effective labor input, so will create an increase in net output $Y$ with $K_o$ and $L_o$ unchanged, yielding a positive sign of $c_K$ and $c_L$. An exception to this expectation is if capital is extremely intensive in products. In this case, an increase in wage may not affect capital and labor productivity, since the latter will be dominated by energy and material shortage.
Finally, the sign of $d_K$ and $d_L$ will be positive if economies of scale exist in the industry, and will be zero if they do not. Economies of scale, as discussed before, reduce the unit cost of production with an increasing volume of output. Therefore an increase in $Q$ will yield an increase in $Y$, and so in $Y/K_0$ and $Y/L_0$.

Notice that usually, economies of scale involves embodied techniques requiring new capital or reorganization of production made economic as output increases. However, for the large and medium sized firms in 1985, since most were built in the 1953-1970 period (p. 536, Vol. 1, 1985 Chinese Industrial Census Data), such differences are less important than the differences in the firms' efficiency in using available inputs. In the economy of scale context, this arises from increased possibilities for specialization as output increases. In Chinese firms differences in output may reflect differences in availability of energy (captured by $S$), of utilization rate of labor (captured by $W$), or in degree of specialization, extent of non-measured shortages, extent of other non-measured factors affecting labor and management productivity (all captured by $Q$). Thus, confronted for the inherent relation between $Q$ and $Y$, the coefficient of $Q$ can be used to get information about how firms in each industry improve their efficiency through specialization and division of labor.
Through reorganization of production and specialization, firms are able to produce more efficiently with given materials, energy, and effective labor and capital, and so to have a greater net output. Production expansion through a deeper level of division of labor and specialization is called "intensive expansion," distinguished from "extensive expansion." The latter is realized through investment in $K_0$.\footnote{14}

It should be noted that equations (1.3) and (1.4) are not based on any type of production function. Estimation of these equations is simply a test of the empirical relationship between factor productivity and $S$, $W$, and $Q$. All other variables discussed in section 1.2 are assumed constant for all firms or obeying the random distribution represented by the error term $\epsilon$ in equation 1.3 and 1.4.

It is possible that equations (1.3) or (1.4) are not well specified. There could be other specifications that improve the estimation if (a) more data, (b) a well developed production theory were available. For example, inclusion of variables measuring shortage of materials and of available transportation services will certainly improve the estimate of capital productivity, inclusion of an index of intra-firm wage difference would improve the explanatory power of equation (1.4), and inclusion of a measure on the share of out-of-plan sales for each firm will improve the estimates of both (1.3) and (1.4).
1.4. Data Issues, Estimation, and Main Results

The firm level data are from Vol. 2 of Large and Medium Enterprises Part, 1985 Industrial Census Data (State Statis-tical Bureau, 1987). The Census covers all 2,494 large sized and 5,791 medium sized firms in 1985. All of those firms are classified into three hundred industries in a four-digit system.[15] On the data card of each firm, there are 34 items showing general information on value of output, capital and labor, profit, wages, energy, electricity, and water consumed. And, there are several items on technical economic performance.

The selection of sample-industries is based on the author's understanding of the general situation in the 1985 Chinese economy. According to this understanding, industrial firms can be classified into four categories. Category I is composed by firms in which energy consumption per unit of output is technically low (and that are labor intensive in production) and the main products are not in short supply. Category II contains firms in which production is not energy intensive (but material intensive) and the products are in short supply compared with the demand. Category III and IV are featured by energy-intensive production, but products of III are not in shortage while those of IV are. The following are examples of the four categories.[16]

I: Television, Bicycles, Cotton Spinning.
The differences in energy or labor intensities and in shortage of products may or may not affect estimates of equations (1.3) and (1.4) in these industries. But this sample-selection method allows a comparison of the estimates between industries with serious shortage of energy and industries without, and between industries whose products are in shortage and those whose products are not.

For example, patterns of capacity utilization in categories I and IV are different due to different demand-supply relations. In fact in 1985, firms in category I faced much stronger competition on the product market than firms in category IV. Productive capacity in firms of category I such as Black & White TV assembling was seriously under-utilized (the utilization rate of B&W TV in 1985 was under 50%) due to excess supply at the regulated selling prices, while capacity in firms of category IV such as Thermal Power Stations or Coal Mining industry was over-utilized (i.e., facilities are depreciated faster than normal speed) due to over-demand at prices planned too low. The full-capacity utilization in firms in category IV may invalidate the relation between Q and Y as discussed
above, because now there is no idle equipment available for the intensive production expansion. Therefore, coefficient of logQ in the category IV industries may become zero.

Another example is the expected difference in the coefficient of logW in equation (1.3) between category I which is labor intensive and categories II, III, and IV which are capital intensive. A wage increase may increase capital and labor productivity in the category I firms, but may not, as discussed in section 1.3, in capital-intensive firms such as Paper, Metal Cutting Machine, or modern Sugar Refining industry (in 1985, energy shortages in these industries are very serious). Serious shortage of energy reduces the amount of effective productive-capital. Constrained by an almost fixed combination of labor and capital, the firm cannot improve the productivity simply with a wage rate increase.

A third example is the effect of energy intensity of production on the estimate of equation (1.4). Energy expenditures of industries such as Thermal Power or Alkaline in the list account for more than 10% of the total production cost.[17] For these industries, energy or electricity consumed may be significant even in the regression of labor productivity as expressed in (1.4).

Finally, it should be noticed that the estimates of (1.3) and (1.4) in industries of the four categories do not necessarily
differ in every aspect. Shortages in energy or electricity are significant in (1.3) for every industry as will be shown. So is the coefficient of logQ in (1.4).

From each category the industries which contain over thirty sample firms were selected. From these industries, representative industries were picked up as our sample-industries.

Their representativeness is based on the large-industry classification which classifies Chinese industries into (a) heavy industry with mineral products as main inputs, (b) heavy industry with industrial products as inputs, (c) light industry with agricultural products as inputs, and (d) light industry with industrial products as inputs. The sample industries chosen come from all these categories.

The plastics industry was selected although it has only 22 sample firms, because its technological progress has been very fast and influential to other industries.

The eleven industries listed above in the four categories are then the sample industries used in the study. All firms in the eleven industries have been chosen as samples. There are in total 516 firms.

Among the 34 items listed in the data card for each firm, the following are used in the empirical analysis: net value of industrial output in current prices (Y), gross value of
industrial output in current prices (Q), net value of fixed assets at the year end (K₀), the average annual employment (L₀), and the energy variables EL and EN introduced before.

The error terms in equations (1.3) and (1.4) are assumed to possess all properties of the classical regression model. The log-linear estimates of capital productivity for each industry are reported in Table 1.3, and that of labor productivity in Table 1.4. From these tables the following points can be made.

First, the scale index Q is significant in eight of the eleven industries in Table 1.3 and all industries in Table 1.4. The three in which Q is not significant are Coal Mining, Paper, and Steel Rolling. All are producers of highly short aged goods, with high capital utilization rates. As discussed above, scale economies in these industries may not be able to enhance intensive production expansion. The inter-firm difference in Q only reflects different degrees of the extensive production expansion, yielding an insignificant coefficient of logQ in the regression of (1.3).

The results generally imply that by increasing the scale of production, one may expect an increase in capital productivity. For example in Thermal Power, a 1% increase in the scale may cause an 0.17% increase in the average net output
of capital input. This number for Plastics is 0.44% which of course implies that scale economies are greater in the latter industry.

A third observation on the role of scale economies is the highly significant negative correlation between Q and capital productivity in Sugar Refining. Sugar making is energy intensive production. Therefore, among possible constraints, energy availability may be the most serious bottleneck for Sugar Refining. This interpretation is also suggested by the highly significant effect of S2 on capital productivity in Sugar Refining. However, this is not enough to explain the negative effect of Q in Sugar Refining, unless energy was rationed among sugar-makers less than proportionally to their relative capital.

As to effects of wage rates in Tables 1.3 and 1.4, a remarkable result is the high elasticity of productivity with respect to wage rates. For many industries, a one percent increase in wage rate is associated with labor and capital productivity increases of more than one percent.

It could be argued that it is the higher productivity that brought the higher wage rate. In 1985, the policy in China, as discussed before, was to link wage rates with profits. Before a firm can realize a profit at the market, it has to produce its products at a unit-cost lower than the market
price. In order to produce more output with the limited supply of shortage materials and energy, a Chinese firm first has to pay the workers a higher wage rate to improve their productivity. A higher wage rate therefore provides leverage to improve factor productivity and efficiency.

Perfectly competitive factor- and product-markets will force firms to pay and workers to receive a wage matching the value of labor's marginal product. On the other hand, managers at the workshop-floor in Chinese firms need to "softly" persuade workers to finish daily jobs assigned. With the autonomous right on bonus-issuing, this persuasion becomes more effective but still soft in the absence of a labor market and of inter-firm competition. If for most firms, an increase in piece-wages and bonuses can help the managers in persuading workers to do jobs more efficiently, the data will show a significant connection between wage rate and labor productivity. If for some firms or for some workers in each firm, this "soft" mechanism does not work, for example, the increase in wage income is negligible to workers compared with their non-wage incomes, then the wage-productivity association will be less significant, unlike in a market economy. In fact, a firm with lowered labor productivity may still maintain a high wage level if its previous wage level is high, as discussed in section 1.2.3. The report of State Planning Commission (1990) in evaluation
the wage-profit linking policy concluded that the policy effectively stimulated labor efficiency, but tended to lose controls on wages. This is the "soft" side of the policy.

Thus, wage increases help, but not always, in improving productivity in Chinese firms. It is also possible that higher wages result from differences in inter-firm productivity resulting from differences in the management techniques applied or differences in degree of non-measured shortages, etc. Since the first two can be largely ruled out by similarity in planned equipment allotment and in management training in firms in an industry, if differences in non-measured shortages can be assumed less important, then the variation of productivity with wages can be mostly attributed to the effects of wages on productivity. However, the empirical results presented cannot distinguish the direction of causation.

The wage rate is not significant in three equations in Table 1.3 (Cutting Machine, Sugar, and Paper). It is also not significant for Cutting Machines in Table 1.4. In these industries, there are other bottlenecks to the improvement of factor productivity. One of the most serious is the shortage in electricity and other sources of energies. As pointed out before in this section, very serious shortage of energy may restrict the amount of effective capital input so that an increase in effective labor will contribute nothing to the net
output, assuming a fixed combination of capital and labor in the production (which is realistic for large and medium sized Chinese firms). The reason that energy shortage was very serious in these three industries in 1985 is that energy rationing policy in that year was more favorable for other energy-intensive industries such as Thermal Power, Coal Mining, Alkaline, and Plastics, which are strategically more important than Sugar, Paper, or Cutting Machine.

The energy shortage in the Metal Cutting Machine industry may not be as serious as in Sugar Refining and Paper, since there was another bottle-neck which was even more effective in invalidating the wage effect on labor and capital productivity. That is the shortage of key materials such as cast iron and a variety of steel products, which are used very intensively in making metal cutting machines. This factor may help explain the total disappearance of the wage rate in the regression of (1.3) and (1.4) for the Metal Cutting Machine industry, as shown in Table 1.3 and 1.4.

In sum, the results reported in Table 1.4 clearly support a simple but strong association between labor productivity and wage rates. Basically, higher wages have worked to raise productivity and profits, but in a limited way (look at the small R squares in Table 1.4).
Turning to the effect of the degree of shortage, one fact worth noting is the significance of either $S_1$ or $S_2$ in every equation in Table 1.3 and 1.4. Since $S_1$ counts only for electricity consumed, and $S_2$ counts for all forms of energy, it is expected that $S_1$ and $S_2$ are correlated to a high degree. Therefore when one of them becomes significant in the regression, the other usually becomes null. There are three exceptions, Cotton Spinning, Alkaline, and Plastics, in these industries both $S_1$ and $S_2$ are significant for capital productivity. Electricity is a relatively small part of the total energy consumed in these industries; a lot of hot water, gas, coal and coke being used in the production of, say alkaline, polystyrene, polysulfone, and yarn.

While the three variables, $S$, $W$ and $Q$, explain the capital productivity differential among firms quite well, based on $R$ squares, they do not do well in explaining the differential in labor productivity. One possible reason for the weaker explanatory power of the model in labor than in capital productivity differentials is that there are many other institutional factors affecting labor productivity, and these are excluded from the model. For example, the variables in the model do not reflect the effects of geographic location or variation in non-wage benefits between firms.
1.5. Concluding Remarks

Two stylized facts emerge from this chapter. First, wage rates were found to be significantly positively associated with labor productivity. This association is consistent with the depicted effect of the institutional reform which linked wages to profit in 1985 and provided an incentive to improve efficiency of labor for the sake of profits and higher future wages. Second, shortage of electricity or energy as a whole was found to be significantly negatively correlated to capital productivity. One explanation is that because energy constraints idle a significant share of nominal fixed capital from time to time, the utilization rate of these assets depends on energy availability.

Two closing warnings are necessary. Many industries have not been analyzed in this paper. Analysis of these industries might reveal different patterns of single-factor productivity. Also, a thorough study should include an analysis of small-sized firms. They are usually operating under quite different institutional arrangements.

To conclude, the analysis and results presented here constitute a preliminary study building toward a theory of producer behavior in a reforming economy. In this sense the purpose of this chapter is to find "stylized facts" in producer's behavior. The effort in explaining the details of institutional
aspects (section 1.2), measurement problems (section 1.3), and the results (section 1.4) is to make the stylized facts found more reliable and understandable.
CHAPTER 2

A MODEL FOR CHINA'S INDUSTRIAL FIRMS DURING THE TRANSITIONAL PERIOD

2.1. Introduction

In Chapter 1 two facts are found significant in Chinese large and medium firms. One is the effect of energy shortage on capital productivity, the other is the effect of wages on labor productivity. In this chapter these two facts will be further explained in terms of a firm model. This model will show that inter-firm wage differences which partly explain the inter-firm differentials in labor productivity are due to the endogeny of wages to firms during the reform period. It also will show that the wage differential cannot be great because of the pressure from workers and from the government. In fact, an implication of the comparative statics of the firm model combined with the Chinese economic reality is that as capital investment goes on and population grows, firms will finally hit the wage limit and the limit of energy and material available. These limits are set from outside the firms. This
means the reform needs to go deeper or firms will behave as if directly regulated from the outside as before. i.e., firms will reach a corner equilibrium where they are left no choice.

It is well known that under a set of more or less ideal conditions an equilibrium exists in a competitive economy. Comparative statics of the equilibrium model result in a set of refutable propositions. These tools are ready for application, so long as the equilibrium under consideration exists, and their application to a non-market economy could be as fruitful as in market economies if equilibrium states can be properly modeled and understood.

In this paper, an effort is made to model the Chinese firm behavior in a way that the conventional economic tools can be used to analyze and draw propositions from the model. According to the broad definition of economics, that economics is the study of rational choices over ends against limited means, rational choices are made everyday in Chinese firms, though in quite different circumstances than in Western firms.

In order to capture the key institutional features of Chinese firms during the transition from traditional central planning to the post-reform system, a typical period in which the old system has been partly replaced by the new system and the new institutional arrangement has become more or less familiar to the people whose behavior is modeled must be
selected. Within this period the discussion will then focus on a typical Chinese firm, which may not exist in real life, but contains features observed in most Chinese firms.

The period chosen is from 1985 to 1986. The economic system reform was broadly and deeply implemented in urban areas in late 1984 and early 1985. The behavioral pattern of Chinese firms during the transition period was shaped mainly in 1985, and not changed again until 1989. This 1985 pattern is dominating firms even now. Finally, a complete data bank at the firm-level from the 1985 Industrial Census is available to the author.

The characteristics of the typical firm are hypothesized from observations of large- and medium-sized state-run firms. Contradictions between the old and the new economic systems are sharper and longer lasting than those in private, collective, or small-sized firms.

Usually, private and collective firms are not large-sized, but they are numerous. In 1985, according to Industrial Census Data, over 90% of the surveyed firms were small and medium sized. Most were collectively owned, since the private economy has never been important in terms of industrial output; its share of the output being less than 1% in 1988, the tenth year of the reform. Because of their size, small or medium firms are under much looser control of the central planners. They therefore enjoy a more thorough autonomy in the reform period.
There exists a large body of literature on Chinese firms, mostly written and published in Chinese. Topics dealt with in these articles are concerned with the relationship between the firm and the government, the responsibility system, ownership structure, goals of firms, productivity and efficiency, technological progress, pricing behavior of firms, managers' behavior, workers' welfare requests, and net earning distribution among individuals, firms, and between firms and the State. However, no formal model is developed in this literature.

On the other hand, two types of firm models are well known to the western students of socialist economies. One covers the so-called labor-managed firms (Ward, 1958; Domar, 1966; Vanek, 1970; Meade, 1972; Jensen and Meckling, 1979; Bonin and Putterman, 1985; Ireland and Law, 1988). Another concerns centrally planned firms. Hypotheses made for centrally planned firms include the gross-output-maximization assumption (Kornai, 1980), the "second economy" assumption (Ericson, 1984; Katz and Owen, 1988), and the "ratchet effect" model (Weitzman, 1980; Bain, Miller, and Thornton, 1987). All these models make some sense to Chinese firms, but none works well in explaining firm behavior in China. The assumptions made in these models are quite unsuitable for the reforming Chinese economy. For example, there is no shortage in the labor-managed firm model;
and there is no profit-incentive in the centrally-planned firm model. Both are very important to Chinese firms during the reform period.

For a thorough inquiry into the nature of producer behavior in the Chinese reforming economy, it is necessary to investigate the key institutional factors in Chinese economy.

There are two long-term institutional features which together make the Chinese economy unique. The first feature is the Soviet-type socialist system, which is the absolute exclusion of private-ownership of productive assets. This feature makes economic behavior in China fundamentally different from what it was before 1949, and also different from such market-based economies as Japan and Korea. The second feature is the mechanism of employment and wage determination that China created to solve its population and economic development problems. While the first feature separates China from market-based countries, the second feature distinguishes China from other Soviet-type socialist economies.

In a broader sense, it is the transplant of a Soviet-type socialist system into a less developed East Asian country that results in the uniqueness of the Chinese economy.

The first institutional feature mentioned above has caused a well known phenomenon called "shortage." Chronic short supply of all goods, but especially producer goods, at given prices,
and the necessary accompaniment of the latter --- the under-utilization of installed productive capacity and other inputs that complement the "shortage" goods --- are the central concerns of planners in all Soviet-type socialist economies.

Another well known phenomenon resulting from the Soviet-type public ownership of productive assets is the absence of a capital market and the extremely low transferability of productive assets after an originally planned allocation.

The second institutional feature, the mechanism of employment and wage determination, has greatly reduced unemployment rates since the 1950s, but also greatly reduced labor force mobility and forged the "iron rice bowl" employment system. The absence of a labor market in China will be more sustainable than it is in USSR or Eastern Europe, for unemployment is not only inconsistent with the nature of socialism but also not favored by Chinese cultural and social norms.

During the reform period, institutional reforms introduced two new features to the Chinese economy. They are the introduction of profit-incentives in firms and the endogeny of wage rates within firms. These new features, profit-motivation and wage endogeny, together with the long-term institutional features, the chronic shortage and the missing factor markets, allow a "unique" firm model to be set up in this chapter, clearly distinguished from other socialist firm models.
2.2. Chinese Firms during Reform Period

In their introduction to the report, *Survey on Chinese Urban Economic System Reform*, conducted in 1985, Chen et al (1987) pointed out: "China's economic mechanisms in the 'switch over' period are more complicated than either the traditional model of the Soviet Union or the mature market economies of Europe and North America. Therefore, in our attempt at exercising effective macroeconomic control, it would be far from adequate to adopt the methods of the traditional model or to introduce the macroeconomic indicators of the developed countries, before our microeconomic mechanisms have been correctly understood." In other words, the Chinese microeconomic institutions are complex because they are in a transitional period.

This paper attempts to set up a firm model based on the fundamental facts that cannot be ignored as long as the institutional arrangement generating those facts has not been significantly changed. Some less important facts then can be considered and combined with the basic model to more fully describe different aspects of Chinese firms in the transition. The following discussion tries to provide some details of the institutional features listed in the introduction and to view them dynamically.
The first long-term institutional feature is the Soviet style property structure. Unlike in a market-based economy where private firms stand as counterpart of the public sector, the core of Soviet-type socialist property structure is the exclusion or restriction to "illegal" activity of private competitors and production. Hayek (1939) noted fifty years ago, that either a perfectly capitalist or a perfectly socialist system is effective, but that any mixture of the two is not. Today this opinion is still correct for a socialist economy, complete control over every corner of the economy is a necessary condition for effective central planning of the system. The mess and disorder in China's reform period gives support to this conclusion. However, the development of capitalist economies since WWII has shaken Hayek's proposition for the capitalist system.

There are controversies among socialist economists over whether or not the low efficiency observed in socialist firms can be attributed to public ownership. Low efficiency is directly related to lack of effort in reducing production costs. The latter could be attributed to the lack of market competition either and between firms (as viewed by some radical reformers), or to the immaturity of the planning system (as viewed by the conservatives), or to distorted prices, or inadequate incentives to firm managers (as viewed by some
moderate reformers), etc. For the purpose of this paper, it suffices to recognize that the existing planning system, as the managing agent for the whole society that owns all the assets, has not yet found a way to make firms efficient in their production. This means, given demand and the endowment of natural resources, actual production is far less than optimal (or that, given the resources actually measured as employed, actual production is far less than the potential production with those resources).

The Soviet-type ownership system is also considered to generate an "expansion drive" in firms.\(^1\) The expansion drive of socialist firms differs from Williamson's "managerial discretion" of capitalist firms in that the profitability of firms in a market economy is at least one of the outcomes of most concern in managers' production and financial calculations. But, a socialist firm, no matter if it makes a loss in the expansion, cannot go bankrupt because the State is the unique owner of firms and has no way to transfer ownership to another party. Also, the State cannot allow loss-making firms to shut down, it has to take full responsibility in the "direct combination of labor and productive means."\(^2\) Being employed by the State is a basic right of workers who share the public ownership of firms. Finally, though a loss-making manager could be displaced,
in most cases the reason is not for any loss made, but for not meeting plan targets or for being corrupt.

All the above behavioral and institutional aspects contribute to the so-called "soft-budget constraint" of socialist firms. There is no "hard constraint" to firms' expansion activities. A serious problem resulting from the soft-budget constraint is the so-called "over-demand" for materials which are necessary in building or running fixed assets.

As defined in Chapter 1, a firm's demand for goods and services can be decomposed into two parts. One part that is consistent with socially optimal allocation is called "efficient demand" and the rest of the firm's demand is called "over-demand." However, Chapter 1 did not explain why firms over-demand. The excess of equilibrium price over the regulated price of a shortage commodity, as discussed in Chapter 1, is not the cause but a result of the over-demand. The direct cause of over-demand is the soft budget constraint to firms (Kornai, 1980), which cannot occur in a completely centrally planned economy where no autonomous rights are assigned to firms, nor in a perfectly competitive market economy where competition drives out inefficient firms. The "softness" of firms' budget-constraint can only happen in a reforming socialist economy where firms are still "state-owned" but partly making independent decisions in production and distribution. In a
reforming socialist economy, firms with autonomous rights are able to pursue their own targets (firms' own target will be modeled in this chapter) with the "state-owned" assets and the "state-fed" workers. As will be shown in this chapter, this separation of ownership from the rights-of-use, in the absence of labor and capital markets, generates over-demand in a reforming socialist economy.

The existence of low efficiency in production (producing less than potential output with given resources) and of over-demand for goods are the main causes of the shortage phenomena in socialist economies. Over-demand has been well-investigated by Kornai (1980) and under-supply (defined as the difference between the amount that firms actually supply and the amount they could supply if more efficiently using given resources) has been thoroughly discussed in the latest book by the Chinese economist, Ma Qing-Quan (1989).

A common aspect of shortage in a socialist and in a capitalist economy is that any observed shortage must be in form of rationing by some "quantity rules" with price fixed or limited for some reason.[3] But in a socialist economy the shortage is chronic and self-reenforcing (Kornai, 1980), while in a capitalist economy it is not.

If the government frees prices of the shortage goods in China, firm-buyers with a "soft-budget constraint" and firm-
sellers with monopolist market power will push the price up to a socially unacceptable level. Prices of key materials in short supply therefore must be controlled by the central planner. As a result, the short supply of those materials becomes "chronic."

Another important outcome of the Soviet-type socialist system is the lack of transferability of the ownership or the rights of use of fixed assets. In a market economy, the capital market moves investment funds from less efficient to more efficient uses.

However, the missing capital market in China cannot be attributed simply to the ruling out of purchase or sale of state assets, it has a deeper reason embedded in the ownership structure. Since firms are just the users but not the owners of state assets, the key problem is who pays for purchasing assets on the market. Suppose firm A wants and is allowed to buy an asset from firm B, if the State pays for it, the buyer and the seller of the ownership rights will be the same, the government, and it becomes just an accounting entry and an alternate version of central planning. On the other hand, if firm A, uses retained profits or arranges it own credit, the question will become "can firm A, and in what form, own the asset?" There is no answer by now to this question. [4] Before
the problem can be solved in practice, it is justifiable in our model to assume that assets cannot be transferred.[5] Asset immobility or the lack of a capital market generates an uneven distribution of productivity among firms in the same industry. The level of modernization of firms in terms of equipment and machineries depends on which supervisory department the firm belongs to, and how powerful that department is in bargaining with other planning authorities. In many cases a firm-level project has to be supported by top leaders at various levels of governments to be successful. However, a long-term competition for the State-budget-money among these powerful supervisory departments makes modernization levels of firms under these departments more or less the same.[6]

As discussed above, the mechanism of employment and wage determination is the second key institutional feature and the one indigenous to China. In China the pressure to provide employment is reinforced by cultural and social norms. A deeply rooted Confucian principle is the obligation to the family. This is really the highest value to a Chinese, even managing a country is thought an extension and analogy to keeping a family.[7] Two behavioral norms result from this principle. One is the priority given by individuals to the welfare maximization of their families. Another is the preference for
large families. Both contributed to the high population and labor force growth rate in China.

Socialist China, like many developing countries in the early stages of development, adopted the dual-sector approach, heavily drawing resources from the traditional to the modern sector. However, the mechanism of transferring resources in China was fundamentally different from that of a market-based developing economy.

In a dual-sector economy with either a formal or Todaro's informal labor market, as is described by Ranis and Fei (1961), urban wages are kept near the subsistence level until the economy reaches a labor "shortage point." Until this time the excess of the marginal productivity of labor employed in the modern sector over the subsistence level wage of labor can be used to finance capital investment. However in such an economy, as Todaro (1969) found, people still want to migrate from rural to urban areas. Despite high unemployment rates in the urban area, they expect, in waiting for jobs, a better life than at the subsistence-level in rural areas. Todaro's theory therefore relies on the existence of the equilibrium of rural-urban migration. In this equilibrium, an expected high unemployment rate balances out the benefit of rural-urban migration.

The establishment of a Soviet-style property right structure in China does not allow a laborer, as an owner of
productive assets, being unemployed, thus ruling out the equilibrium between unemployment rate and the rural-urban migration. This means, laborers living or being allowed to enter in the urban area have to be employed.

After being employed in Chinese State-run sectors, the welfare of workers and their families is rapidly improved over that of their relatives in rural areas. The absence of a labor market allows workers in State-run enterprises to bargain for higher income and improved working conditions. This higher urban welfare could attract more rural labor force to urban areas, resulting in a high unemployment rate. However, to avoid this situation, the Chinese government has very strictly controlled rural-urban migration since 1954 by a residence-registration system which is combined with a food rationing system. Without the food-stamps issued only to registered urban resident, a rural resident cannot purchase food in urban areas. After 1954, State-run firms lost the autonomous right of hiring and laying off workers. The central planning authority assigned new workers to firms and usually did not allow these workers to be laid off (Wang Haipe, 1986). Migration control, while helping solve the unemployment problem, helped also in forming the so-called "iron rice-ball" employment system in urban areas.
In addition to the government control of migration, Chinese firms played an important role in reducing labor mobility. Firms in China function in two spheres, organizing production and fostering the welfare of workers. Welfare of workers' families is at the center of a firm's social functions. Workers' committees in a large firm usually take care of rationing houses, living subsidies, coupons for consumer durables, quota of kindergarten entries, etc. The manager takes care of employment opportunities of dependents in workers' families. Usually, job-tenure is an important criterion in this kind of welfare distribution. Partly because a Chinese firm is like a big family, a senior member in the family has the priority in welfare distribution, while a new member usually lacks either reputation or personal connections in the workers' committees.

The principle of distributing welfare according to job-tenure is consistent with the egalitarianism of income distribution in Chinese firms, provided every worker will soon or later become "senior" in the firm unless he moves to other firms.

Workers in Chinese firms are much less likely to move than those in the western firms. Because some of the most important consumer goods, such as housing and kindergarten quota, are rationed by firms according to job-tenure and other criteria.
Workers' promotion in wage levels and in the management hierarchy also depend on their job-tenure. Finally, many niceties a senior worker can get from a customized environment are not existent if he moves to another firm where he lacks personal connections. All these factors impose a heavy cost on switching jobs from one to another firm.

Therefore, both rural-urban and inter-firm movement of the labor force are absent in China. These outcomes are the result of the socialist approach to industrialization in a dual-sector economy and of the family-like firm structure observed in China and Japan.

In the Soviet Union and the East European countries, the labor force, as a scarce resource, is allowed to move freely, and so is more effectively utilized in the economy. However, a true labor market does not exist in these economies, because in some cases (reform period), managers of firms failed to resist workers' request for higher wages, or in other cases (pre-reform period), because wages were still largely centrally planned. A more important reason for the missing labor market in these economies is the existence of Soviet-style ownership of productive assets. Every laborer has the priority of being employed in his own firms.
In sum, the absence of a labor market is a long-term institutional feature of the Chinese economy, it is, though as a less serious problem, also a long-term institutional feature of other reforming socialist economies.

The lack of transferability of capital and the immobility of the labor force have resulted in unevenly distributed labor productivity among firms. They also result in inequality in income distribution among workers whose wages and family welfare are tied to their firms. However, the central government, over the long period from 1956 to 1983, built a restrictive wage control system under the joint-management of the Ministry of Labor, the State Planning Commission, and the Ministry of Finance, and effectively controlled wage rates at unified levels to prevent the wage rate, in the absence of a labor market, from growing too fast.

In manufacturing industries, wages were ranked at eight levels after the wage system reform in 1956 (before 1956, there were more than 35 wage levels in industry), within each level there were some sub-levels concerning physical aspects of jobs (Wang Haipe, 1986). A worker of eighteen years old can expect his wage rate being promoted, as his experience and skills grow, to the highest level when he is about fifty years old. Many workers retired before they can reach wage level eight.
Retired workers can receive annuities at about 80% of the wage earned in the last year on jobs.

In fact the Chinese government successfully froze the real wage rate from 1952 to 1983. The highest average real annual wage rate during this period was observed in 1957, 127.9, taking the wage rate in 1952 as 100. In 1983, the real annual wage rate was 126.7 (p. 151, China Labor and Wages Statistics, 1949-1985).

The control of rural-urban migration and of urban wage rates allows China's industry to employ workers at a wage rate lower than value of labor's marginal productivity. The excess profits then can be re-invested into the stock of productive capital. As long as the central planner can transfer cheap labor force from rural to urban areas, this industrialization process will go on as it does in a market-based dual-sector economy.

Central control of wage rates was dramatically weakened after late 1984. At that time, the third plenum of the 12th CCP Congress claimed: "China's socialist economy ought to be a planned commodity economy based on the public ownership," and concluded: "the core of this systemic reform is to vitalize the firm." (State Planning Commission, 1988.) Firms have been vitalized by many autonomous rights. For one, the power of determining bonuses, piece-wages, many kinds of subsidies, and
overtime-wages has in fact been transferred to firms. This change in wage determination has not been accompanied by the introduction of a labor market or the abolition of central control of population movements. It inevitably leads to an expansion of urban wages. At the end of 1988, two economists in China warned people that "wages are eating profits" (Dai and Li, 1988). In fact, the average real annual wage rate, taking 1952 as 100, was increased to 145.6 in 1984, 165.9 in 1986, and 196.2 in 1988 (p. 151 and p. 135, China Labor and Wages Statistics, 1949-1985, and 1978-1987; p. 64, State Statistical Bureau, 1990).

The government and planning authorities have noticed the trend of wage- or consumption-expansion. Many regulations issued in 1985 and 1986 were targeted at controlling illegal increases in wages, bonuses, in-kind payments, and subsidies. But those regulations are widely ignored in practice, they are thought to be "soft regulations" compared with output quota and profit targets. Given the social and cultural environment which is unfavorable to laws or any impersonal government regulations, the issue needing explanation is, why the government can effectively control wages before reform but cannot do so during the reform.

The reform of state-run firms during 1982-1988 period began with a series of policies assigning more autonomy to firms.
After 1982, state-run firms were allowed to retain a proportion of profit. Fifty percent of the retained profit is to be directly invested in productive projects, 30% of retained profit can be used as fund for bonuses, the last 20% is for funding expenditures on collective welfare. However, in the 1985 survey of economic system reforms, Chen et al (1987) found that most of the retained profit was used for workers' welfare and bonuses, and only bank loans were used to finance productive projects in firms.[8]

After the reform of the state planning system in 1984, Chinese firms were allowed to sell part of their products (out-of-plan products) at market prices, and purchase almost all goods, except for 64 key producer goods, from markets. In case their money supply is short, barter is the major way to get shortaged goods. As noted, those 64 key producer goods in the most short supply have to be controlled by the central planners, otherwise prices would be in equilibrium at an unacceptably high level at the first moment they are freed. The allocation of key producer goods among firms is tied to the centrally planned proportion of firms output (For a discussion and modeling of this dualistic system, see Byrd, 1989). Other types of goods which are not in very short in supply are usually controlled and allocated by local governments. For
example, agricultural products such as cotton and silkworm cocoon, local industrial products such as fertilizer, cement, and coal produced in local firms. [9]

During late 1984 and early 1985, the government tried to control rapid growth of real wage rates. Since direct planning control was thought inconsistent with the reform spirit, indirect controls were implemented; that is the "linkage of a firm's total wage to its total profit (Gongxiao Guagou, in Chinese saying)." Under this policy, the growth rate or level of total wage in a firm is controlled in proportion to the growth rate or level of profits made by the firm. It is not clear if the wage-profit linkage has effectively controlled wage rate growth (Xin and Pan, 1989; Guo Fei, 1989; Wu Jinglian, 1989; Dai and Chen, 1990), but this policy clearly ended the long period of centrally planned income distribution. [10]

The reform since 1979 has brought Chinese firms many autonomous rights. These rights can be classified into three categories, rights over the allocation of labor, over the allocation of materials and productive means, and over the allocation of financial resources. However, given the institutional constraints discussed above, the rights of firms in allocating labor, energy and key materials, and fixed assets is seriously limited because of the absence of factor market
and chronic shortages. What is left as a change is therefore the autonomous right of firms on financial resources.

Before the reform, productive activities of state-run firms were financed almost totally by the planning authority via administrative departments at different levels. Any expenditure over five hundred Yuans (less than two hundred U.S. dollars) had to be budgeted and reported to supervisory departments of the firm. And, there was no cash payment in such a transaction, everything being handled in the firm's accounting office, the supervisory office, and the bank. The only large amount of cash allowed into the firm was for the employees' salaries, issued once a month. Working capital was planned and supplied at a pre-fixed level, usually proportional to the amount of fixed capital.

The profit-retention system introduced in 1979 allowed, for the first time, a large amount of cash to flow into firms. Later in 1984, reform of banking system removed the final controlling power of the central government over cash flows. This fundamental change resulted in wage endogeny and later in inflation and corruption in China.

As long as the government cannot control cash flow or in terms of macroeconomics, the money supply, it will not be able to control the trend of wage expansion. So far reform has not significantly changed the public ownership structure or the
lack of competition between employed and unemployed laborers. There are thousands of legal or illegal methods at the firm level to channel the cash flow from productive usage to workers' consumption; there is no strong incentive for managers to resist workers' welfare requests.

A typical Chinese firm in the reforming economy can be hypothesized as composed of a manager and a worker. The worker supplies labor, receives a fixed amount of wage from the government and a variable amount of wage from the manager, as has been described in Chapter 1. And, the worker is concerned only with how to maximize his own utility which is a function of consumer goods and leisure.

The manager is concerned mainly with two activities, organizing production and the firm's social life (or workers' welfare). His salary is not allowed to greatly exceed the worker's (the ratio of a manager's wage rate over a worker's is about 1.5, not allowed to exceed 3.0).

Since wage difference between a manager and a worker is not large enough for managers to perform these two activities, there must be other reasons to keep managers from not changing jobs. Three reasons are important in explaining Chinese managers behavior. First, most managers assigned by the government are members of the CCP, politically obeying the Party's command to do well whatever jobs the Party assigns. It is dangerous
and not worthy in the long-term for these managers to go against the Party's wishes. Second, most managers are senior workers in their firms, promoted from the bottom level of the hierarchy system, expecting further promotion and feeling obliged to improve the welfare of the firm-family members. Third, according to Liu Zunyi's (1990) comparative study on four Chinese-ethnic economies (Taiwan, Hong Kong, Singapore, and China), Chinese are culturally more willing to control than to be controlled by others. The Confucian view on man's career is to do well consequently in cultivating the personality, keeping the family, managing the State, and controlling the "world." Therefore being a manager is a proof of man's success in the society.

For these reasons the manager in this hypothesized firm derives motivation for and benefit from his activities, but he will also gain by minimizing the effort on his part to maintain an "acceptable" level of production and of workers' living standards or satisfaction of workers.[11]

One implication of the manager's effort-minimizing behavior is not to bargain with workers to accept wage decreases if the firm is less profitable and the wage level should go down, but to bargain with the supervisory department to not cut the firm's wage fund. The latter usually is easier because the supervisor will not lose his own money by maintaining the
firm's wage level, what he needs to do is to bargain with his supervisor, etc. This "softness" is due to State ownership. Another implication of effort-minimization is to distribute bonuses more or less equally, that is, irrespective of performance. Handling the contentions arising from an unequal distribution could be costly to managers when managers and workers are not free to move (Walder, 1987).

The manager's production target can be divided in two parts, the quantity quota set by the central planners, and the profit target that is linked to the welfare of his workers and himself. Market-oriented reforms will inevitably reduce the weight of the planned quota while strengthening that of the profit target. Without making a profit it will be much harder to bargain for wage increase.

The manager makes decisions in production and determines how large a proportion of the expected retained profit will be spent on improving workers' welfare and on bonuses and wage increases. The manager will have to make a greatly increased effort to deal with workers dissatisfaction if wages fall below the lower-limit which is near the previous wage level of the firm. On the other hand, raising wages to a level higher than the upper-limit is dangerous too, since the firm could be penalized by the government as a "model firm" of illegal wage increases. Within these two limits, making more profits will
make it easier to improve workers' welfare, to bargain with the government for wage increases, and to fulfill the planned profit and tax target. Therefore, a "limited" profit-maximization will be the manager's target, given the effort that he is willing to make for the salary and other benefits he receives.

In maximizing profits, there are not many variables the manager can control in such a typical firm. The wage is one, demand for energy and materials is another. The latter was centrally controlled before the reform, being linked closely to the planned output quota.

The reform promotes profit-motivation in firms, and allows multiple prices for one good. Firms are allowed to sell outputs and purchase inputs on the market at market prices, provided the planned quota is fulfilled. However, for energy and some key materials, as discussed in Chapter 1, the supply is in serious shortage so that firms' demand cannot be met even at the highest allowable price. Therefore managers usually demand as much as what is supplied for the shortage good and services, hoarding them as inventories, user permits or coupons.

The control power of managers over wages is also limited. First, about fifty per cent of the wage is controlled by the central planner as mentioned in Chapter 1. Second, the distribution of the other fifty percent of wages has to be more
or less equal among workers, in order to avoid serious conflicts. Third, workers' resistance to a fall in the average wage can be very strong and negative. For example, a large proportion of the bonus is paid out as "year end bonus," a reduction of which may dramatically lower workers' productivity in the next year.

Therefore the manager's pursuit of a profit-target is based on two implicit contracts, the one between himself and the workers, and the one between himself and the government. These contracts make him a "dual agent" of the workers and of the government. The manager's pursuit of profit is constrained by the requirement that both of these "principals" feel better-off. For example as total profit increases, more profit retained in the firm may be used to finance more workers' housing or other non-wage benefits, at the same time more profit handed to the government may help alleviate fiscal difficulties. On the other hand, pursuing profit will not be allowed by principals if, for example redundant workers need to be laid off or their wages to be reduced by, say, 20%, or at the other extreme, the skilled workers need to be paid five times higher than the social average, raising many worries for government.

In sum, the typical firm, in its profit pursuit, is constrained by its technical or production possibility set, the shortage of energy and materials supplied, immobility of labor
and capital, a lower-limit of wage level for each production period, and an upper-limit of wage level set by the supervisory department (see Chapter 1).

Regardless of all those limitations to manager's profit pursuing behavior, one thing worth noting is that the reformists have been trying hard to widen the area of profit-oriented activities and to limit both workers' and government influence on firm decisions. One result is that firms' profit-motivation is increasingly protected and promoted by economic policies.

The replacement of the old system by the evolving new one is a dynamic process with its speed varying greatly across firms. For this reason, to test a firm model with cross-section data is difficult unless institutional variables can be controlled.

2.3. Modeling Chinese Firms in the Reforming Economy

Now let us consider a typical Chinese firm during the reform. Decisions are made by the manager, who maximizes profit or the "residual" after all necessary and "unnecessary" payments, subject to technical and institutional constraints. The residual being maximized is:

$$\max_{(W,M)} J = Q - rK_0 - WL_0 - pM$$ (2.1)
As argued, the wage rate \( W \) here is endogenous and equalized among all workers. Capital price \( r \), and material price \( p \) are given, and quantities of nominal capital \( K_0 \) and labor \( L_0 \) are fixed. \( M \) is the firm's demand for energy and materials. \( Q \) is the output.

This firm is producing a single product, measured in real terms, \( Q \). The productive inputs are measured in effective quantities, capital, \( K \), and labor, \( L \), instead of nominal quantities, \( K_0 \) and \( L_0 \). This reflects the assumption that labor and capital could be idle in the firm due to shortages of energy and materials, factor immobility, and the limitations of wage incentives as discussed in Chapter 1 and in section 2.2.

The technical relation between inputs \( K \) and \( L \) and output \( Q \) is therefore defined in terms of effective variables:

\[
Q = F(K,L), \quad \frac{\partial F}{\partial (.)} > 0, \quad \frac{\partial^2 F}{\partial (.)^2} \leq 0. \quad (2.2.a)
\]

The positive and decreasing marginal output of effective capital and labor expressed in (2.2.a) is generally found empirically, though it may not be observed when effective variables cannot be separated from nominal ones.

Another production function assumption that needs to be made concerns the interaction between \( K \) and \( L \) in the production procedure. Usually in macroeconomic analysis, capital and labor
in developing economies tend to be regarded as substitutes. But in short-run, at the industrial firm level, technology is usually designed in blue-prints when plants were built, especially for the large- and medium-sized. Although, there is always some scope for substitution between labor, capital and materials, the profit-motivation may not be strong enough for the manager to exhaust the advantages in such a substitution.

In this model, K and L are assumed to be complementary to each other, namely:

\[
\frac{\partial^2 F}{\partial K \partial L} > 0. \quad (2.2.b)
\]

A third assumption on production function is:

\[
\left( \frac{\partial^2 F}{\partial K \partial L} \right)^2 \leq \frac{\partial^2 F}{\partial K^2} \frac{\partial^2 F}{\partial L^2}. \quad (2.2.c)
\]

The meaning of this assumption is that the firm's technology, or the purely technical relation between K, L, and Q, can guarantee a capitalist, competitive, profit-maximizing firm to reach an equilibrium point. In other words, it is exactly the second-order condition in the standard profit-maximization firm theory. Unless the purely technical relation has been extremely distorted, most Chinese firms should satisfy the above assumption.

The relations between effective and nominal inputs are modeled by:
Where \( \eta \) and \( \xi \) are proportions of effective to nominal inputs, also called "utilization rate" of capital and labor respectively.

From the analysis in Chapter 1, it is clear that utilization rate of fixed capital depends on two variables, the nominal quantity of fixed capital in the firm, and the available amount of energy and materials which are complementary to the capital in production. Given the amount of energy and materials, the larger the nominal fixed capital is the lower the utilization rate will be. Given the capital stock, more energy and materials available will correspond to a higher rate of capital utilization, provided the demand condition (which usually exceeds the supply) across firms in this industry is not changed. That is:

\[
\eta = \eta(M, K_0), \quad \frac{\partial \eta}{\partial M} > 0, \quad \frac{\partial \eta}{\partial K_0} < 0. \tag{2.4.a}
\]

In order to derive more specific results from the model, further assumptions are made on second-order derivatives of the utilization rate:

\[
\frac{\partial^2 \eta}{\partial M^2} \leq 0, \quad \frac{\partial^2 \eta}{\partial M \partial K_0} \geq 0, \quad \eta + K_0 \frac{\partial \eta}{\partial K_0} > 0. \tag{2.4.b}
\]
The negative sign of second-order derivative of $\eta$ to $M$ simply means a decreasing marginal effect of $M$. The positive sign of cross-derivative of $\eta$ to $M$ and $K_0$ implicitly assumes that an additional unit in $K_0$ will increase the marginal effect of $M$ on utilization rate of capital, since the increase in $K_0$ makes $M$ more scarce and would be used more effectively. Symmetrically, a marginal increase in $M$ will alleviate the negative marginal effect of $K_0$ on the utilization rate.

Finally, the third relation is necessary for comparative static results to have definite signs. The meaning of it becomes clear if we take derivative of effective capital $K$ with respect to nominal capital $K_0$:

$$\frac{\partial K}{\partial K_0} = \eta + K_0 \frac{\partial \eta}{\partial K_0}.$$

Therefore we are assuming in fact that an increase in nominal capital will always cause an increase in effective capital, though the increment will be less and less as the degree of energy and material shortage increases.

A special form of $\eta$ satisfying (2.4.a) and (2.4.b) is:

$$\eta = \eta \left( \frac{K_0}{M} \right).$$

It is very useful in empirical studies such in Chapter 1 and later in Chapter 3, while the general form of $\eta$ in (2.4.a) makes theoretical analysis simpler and clearer.
The utilization of labor force can be regarded as a function of wages as explained in Chapter 1, or as derived from a consumer-choice model in which the worker makes decisions on effort (or leisure) and income demanded, in response to each given wage rate hypothetically offered by the manager.

Given eight hours a working day and six working days a week, the effectively used labor time and the utilization rate of the nominal labor force are assumed to increase by decreasing amounts as the wage rate increases. That is:

\[ \xi = \xi(W), \quad \frac{d\xi}{dW} > 0, \quad \frac{d^2\xi}{dW^2} \leq 0. \] (2.5)

Notice that the elasticity of effort to the wage rate may change in the next period as wage rate increases in this period. Many managers have found that the stimulating effect of payment, say, a five-yuan bonus for one working hour, is rapidly decreasing as people become richer than before.

The restrictions on energy and materials available and on wages are expressed as

\[ W_0 \leq W \leq W_1, \quad M \leq M_0. \] (2.6)

Where \( M_0 \) is the upper-limit of energy and materials the firm could get from outside, \( W_0 \) is the lower-limit of wages, seriously guarded by workers, and \( W_1 \) is the upper-limit of wages regulated by the government which is sensitive to a high degree of
inequality in income distribution. In the W-M plane, the area below M₀ and between W₀ and W₁ is the "feasible set" or "choice space" where the manager is able to control the firm.

Summing up, we have the firm model as:

\[ \max_{\{\nu, M\}} \{ J = Q - rK_0 - W L_0 - p M \} \]

s.t. \[ Q = F(K, L), \quad \frac{\partial F}{\partial \nu} > 0, \quad \frac{\partial^2 F}{\partial \nu^2} \leq 0, \]

\[ \frac{\partial^2 F}{\partial K \partial L} \geq 0, \]

\[ \left( \frac{\partial^2 F}{\partial K \partial L} \right)^2 \leq \frac{\partial^2 F}{\partial K^2} \frac{\partial^2 F}{\partial L^2}, \]

\[ K = K_0 \eta, \quad L = L_0 \xi, \quad 0 \leq \eta \leq 1, \quad 0 \leq \xi \leq 1, \]

\[ \eta = \eta(M, K_0), \quad \frac{\partial \eta}{\partial M} > 0, \quad \frac{\partial \eta}{\partial K_0} < 0, \]

\[ \frac{\partial^2 \eta}{\partial M^2} \leq 0, \quad \frac{\partial^2 \eta}{\partial M \partial K_0} \geq 0, \quad \eta + K_0 \frac{\partial \eta}{\partial K_0} > 0, \]

\[ \xi = \xi(W), \quad \frac{d \xi}{d W} > 0, \quad \frac{d^2 \xi}{d W^2} \leq 0, \]

\[ W_0 \leq W \leq W_1, \quad M \leq M_0. \]

This model can be easily extended to multiple-price cases. For example, M can be split to M_p and M_m, materials supplied under the central plan and those purchased from the market. If the planned price for M_p is lower than the market price for M_m, it is obvious that firms will want all available M_p and allocate M as if all M is purchased at the market price. In
the same way, can be split to include a planned- and marketed-part at different prices, and firms will, if the planned price is lower than the market price, supply as little as possible of the planned part.

The Lagrangian of the optimal solution is:
\[
L = F(K_0, \eta(M, K_0), L_0, \xi(W)) - rK_0 - WL_0 - pM
+ \lambda_0(W - W_0) + \lambda_1(W_1 - W) + \mu(M_0 - M).
\]

(2.7)

The first-order conditions for interior solution to the model are:
\[
\frac{\partial F}{\partial L} \frac{dK_0}{dL} - L_0 = 0.
\]

(2.8)

\[
K_0 \frac{\partial F}{\partial K} \frac{d\eta}{dM} - p = 0.
\]

(2.9)

Any solution to (2.8) and (2.9) satisfying the second-order condition:
\[
A = (a_{ij})_{2x2} < 0,
\]

(2.10)

will be optimal and unique. \(A\) in (2.10) is the matrix of second-order derivatives of \(J\) with respect to \(W\) and \(M\) (see Appendix 2 for the expression of \(A\)).

Let the optimal solution be \((W^*, M^*)\), their meanings in (2.8) and (2.9) are obvious. For (2.8), a unit increase in wage rate will cost the firm \(L_0\) units of total expenditure, which composes the marginal cost of wage rate. On the other hand, a unit increase in wage rate induces more effective labor
input which yields a marginal benefit to the firm equal to \( L_0(\partial F/\partial L)(d\xi/d\omega) \). At the equilibrium (2.8) will hold. For (2.9), the marginal cost of material is \( p \), and marginal benefit is represented by the first item in (2.9), equilibrium holds at the equality between the two.

Let \( \bar{\alpha} = [K_0, L_0, M_0, p, W_0, W_1] \) be the parameter vector, and \( \bar{x} = [W', M'] \) the optimal solution, then \( \bar{x} \) is a function of \( \bar{\alpha} \). Let \( D_{\bar{x}} \bar{x} \) represent the small changes in optimal solution corresponding to small changes in parameters. Comparative statics of the firm model gives the matrix equation (see Appendix 2):

\[
A \times D_{\bar{x}} \bar{x} = B, 
\]

\[
B = (b_{ij})_{2x5}. 
\]  

(2.11)  

(2.12)

Where the expression of matrix \( B \) is given in Appendix 2.

The comparative statics results derived from (2.11) can be stated in three categories. Results in the first category are trivial for the model, they state that the wage rate and the firm's demand for \( M \), if not constrained by boundaries, will be independent of changes in the boundaries \( M_0, W_0, \) and \( W_1 \). This is directly implied by assuming an interior solution to the model.
The results in the second category are concerned with the definitely non-zero signs of changes in $W^*$ and $M^*$ when the price of $M$ changes. There are five of them. One says that the wage rate will decrease if the price of $M$ increases. The second says demand for energy and materials will decrease if the prices increase, a basic law of demand derived from profit-maximization. These are stated as:

$$\frac{\partial W^*}{\partial p} < 0, \quad (2.13)$$

$$\frac{\partial M^*}{\partial p} < 0. \quad (2.14)$$

The third and the fourth state that wage rate will increase when the nominal stock of fixed capital increases, and that demand for energy and materials will increase when nominal employment of labor increases. i.e.:

$$\frac{\partial W^*}{\partial K_0} > 0, \quad (2.15)$$

$$\frac{\partial M^*}{\partial L_0} > 0. \quad (2.16)$$

The meaning of these four results (equations (2.13), (2.14), (2.15), and (2.16)) is clear in the firm model. For example, if $K_0$ increases, by assumption (2.4.b) $K$ will necessarily increase, therefore the demand for effective labor will
increase, that leads to (2.15). If \( L_0 \) increases, by (2.5) \( L \) will increase, therefore demand for \( K \) will rise, so will the demand for \( M \). This is (2.16).

The fifth result in this category is:

\[
\frac{\partial W^*}{\partial L_0} < 0. 
\]  
(2.17)

This is a distorted law of demand for labor. Firms are wage-makers, and labor supply is fixed. When more nominal labor is supplied, more effective labor will be available at the current wage rate, therefore wage rate tends to be pushed down by profit-motivated managers. However as has said, this profit-maximizing choice is limited by a lower wage boundary \( W_0 \). It is probable that as number of employees increases, the pressure of maintaining previous wage rate becomes higher. As a result, previous wage rate becomes the current lower boundary, preventing wage rates from falling.

Category three of the comparative static results contains one result, of which the sign is indeterminate, namely: \( \partial M^*/\partial K_0 \). It is hard to derive consistent assumptions to guarantee a definite sign. However, by economic intuition, the sign usually should be positive, since an increase in \( K_0 \) causes more or less an increase in \( K \), the latter requires more \( M \), i.e.:

\[
\frac{\partial M^*}{\partial K_0} > 0. 
\]  
(2.18)
Besides the interior solution, there are many corner solutions to the firm model. They are derived from the Kuhn-Tucker conditions given in Appendix 2, and listed here:

\[ W^* = W_0, \quad M^* < M_0, \quad (2.19) \]
\[ W^* = W_1, \quad M^* < M_0, \quad (2.20) \]
\[ W_0 \leq W^* \leq W_1, \quad M^* = M_0, \quad (2.21) \]
\[ W^* = W_0, \quad M^* = M_0, \quad (2.22) \]
\[ W^* = W_1, \quad M^* = M_0. \quad (2.23) \]

In all five cases the equalities (2.8) and (2.9) may be violated, with marginal cost greater than marginal benefit or vice versa. For example, if (2.19) holds, the first-order condition becomes:

\[
L_0 \frac{\partial F}{\partial L} \frac{d\xi}{dw} - L_0 + \lambda_0 \leq 0, \quad \lambda_0 \geq 0, \quad (2.24.a)
\]
\[
K_0 \frac{\partial F}{\partial K} \frac{d\eta}{dM} - p = 0. \quad (2.24.b)
\]

(2.24.a) means the marginal cost of labor may exceed the marginal benefit of labor for the firm; i.e., the firm would have set the optimal wage rate lower than it is now had there been no lower limit such as \(W_0\). The marginal cost or foregone profit of the firm due to a marginal increase in \(W_0\) is \(\lambda_0\) which is non-negative.

The first-order conditions for case (2.20) are:
The meaning of (2.25.a) and (2.25.b) is similar to that of (2.24.a) and (2.24.b), except that \( \lambda_1 \) in (2.25.a) reflects the firm's foregone profit by paying workers the upper-limit wage rate, i.e., the firm would have paid a higher wage rate had there been no upper limit \( w_1 \).

The first-order conditions for the corner solution (2.21) are:

\[
L_0 \frac{\partial F}{\partial L} \frac{d\xi}{dW} - L_0 + \lambda_1 \leq 0, \quad \lambda_1 \geq 0, \tag{2.25.a}
\]

\[
K_0 \frac{\partial F}{\partial K} \frac{\partial \eta}{\partial M} - p = 0. \tag{2.25.b}
\]

Since \( \mu \), the shadow price of \( M_0 \), is non-negative, the firm may not be able to equate the marginal output of \( M \) to price, \( p \), as shown in (2.26.b). A positive \( \mu \) means that the firm would have demanded more than \( M_0 \) at given price \( p \) had there been no limit set on energy and materials supplied.

For cases (2.22) and (2.23) the firm has no choice.

There are no second-order conditions for a corner solution to be the optimal. Both concave and convex functions could have maxima at the boundary in the constrained domain, while showing opposite signs of the second-order derivative matrices.
Also true is that there is no comparative statics for variables at the corner solutions. Because a small change in model parameters will either cause no change in variables at the corners, or move the corner solutions into the interior solution. For the former, the derivatives of variables at the corner to the parameters are zero. While for the latter, they become identical to the comparative statics of the interior solution.

2.4. A Brief Discussion on the Efficiency of the Firm

The necessary conditions (2.8) and (2.9) imply that the typical Chinese firm is not efficient, even if there is no price distortion in the economy. Although a mathematical proof of this conclusion is long and omitted from the text (it is provided in Appendix 2), an intuitive proof can be given here.

From (2.8) it can be seen that marginal output of effective labor in an interior optimal solution is in fact equal to marginal cost of improving the labor utilization rate. Since the number of workers cannot be zero, (2.8) is equivalent to:

\[
\frac{\partial F}{\partial L} = \frac{dW}{d\xi}.
\]  

(2.27)
The right hand side of (2.27) is the additional wage paid to obtain an additional unit increase in the labor utilization rate.

Here the variable is wage, compared with a capitalist firm to which the variable is nominal labor. If, as shown in Appendix 2, a hypothetically existing general equilibrium in the Chinese economy can be taken as the standard of efficient allocation, then the equilibrium of a capitalist firm model could be a good reference for evaluating the efficiency of a socialist firm, because. As Arrow and Debreu have proved, the perfectly competitive equilibrium is necessarily an efficient allocation. In a typical capitalist firm the marginal output of effective labor which is the same as nominal labor is equal to the ratio of the wage over price of the output which has been set to unity.

Therefore there are two sources, at least, of inefficiency of labor allocation within a Chinese firm. First, there is the divergence between nominal and effective labor. Second, there are the inefficient wages paid to the effective part of the labor force.

For the second source of inefficiency, if it is assumed there is no idle labor, i.e., \( L = L_0 \), the manager may still pay a wage higher or lower than the efficient wage for each unit of effective labor, depending on the elasticity of labor.
utilization rate to wage rate. For example, in the early period of the reform, the effective part of labor force may have been paid much less than their efficient wage because of the high elasticity of workers' effort in response to changes in wages. However, the emotional stimulation of new policies could not sustain this situation for long. In recent years in fact, firms often need to pay several times earlier bonuses in order to maintain the same level of effort. Since the labor market is missing, elasticity of working effort to the wage rate tends to be low. Therefore, wages tend to be higher than efficient level.

The allocation of capital shows the same problem. Marginal output of capital in a capitalist firm should be equal to interest rate paid for the capital, i.e.:

\[ \frac{\partial F}{\partial K} = r. \] (2.28)

And, in a two-factor production function, the marginal output of material through its effect on capital should be equal to the price of material. If K is dependent on M, the following will hold:

\[ \frac{\partial F}{\partial K} \frac{\partial K}{\partial M} = p. \] (2.29)

However, in a socialist firm, nominal capital is invariant, so is the interest paid which is like a sunk cost to the firm.
What is variable is the cost of improving the capital utilization rate, that is the material input. The total cost of material input is $pM$, the total amount of effective capital is $K_0\eta$. The manager therefore equates the marginal output of effective capital, $\Delta F/\Delta K$, to the marginal cost of effective capital, $(p\Delta M)/(K_0\Delta \eta)$, here $\Delta$ means a small change. It follows:

$$\frac{\partial F}{\partial K} = \frac{p}{K_0} \frac{\partial M}{\partial \eta}. \quad (2.30)$$

Equation (2.30) is a transformation of equation (2.9), one of the first-order conditions for optimal solution of the firm model. It can be seen by comparing (2.29) and (2.30) that generally, the equilibrium demand for effective capital in (2.30) is not necessarily the same as that given by (2.29). Precise calculation of the difference depends on specification of $\eta$ in (2.30). As long as $\eta$ is smaller than one, there will be idle capital in the firm. And, the shape of $\eta$ determines the effectiveness of using available energy and materials.

Again there are two sources of inefficiency, the divergence of effective from nominal capital, and the inefficient use of materials. Even if there is no idle capital, the firm's demand for material or energy may still be inefficient, because its demand for effective labor is not efficient.

Efficiency is not guaranteed in the interior solution, neither is it in the corner solutions.
2.5. From Comparative Statics to the Dynamic Reality

The next question of interest is which solution among the many discussed is the most probable for a typical firm in the long-run. To answer this question, the comparative statics based on the short-run firm model need to be combined with long-term factors in the real economy and with an analysis of the dynamic interaction between these factors.

Suppose prices of output, capital, and of energy and materials, and the quota of energy and materials supplied and the limits to wages all are constant. Assume population and the labor force are growing, and that the government is investing every production period. Therefore, through the central planner's allocation, nominal capital and nominal labor force in each firm will continuously increase. Comparative statics of the firm model imply that demand for energy and materials will be shifted up by labor force growth, and very probably shifted up by capital expansion. And the wage rate will shift up if the effect of the nominal capital increase is stronger than that of the labor force increase, and will shift down if vice versa.

Therefore under the assumptions given above, firms' demand for energy and materials would soon or later hit the limit set by each firm's $M_0$.\(\)
Whether or not the firm's demand for effective labor will hit one or the other wage limit is uncertain. However, more profitable firms which receive greater capital investment (and a higher capital/labor ratio) would stay at the upper-limit. For less profitable firms which get a lower investment fund from the government, wages tend to be pressed down by managers and by the wage-profit linking policy, but resisted strongly by workers. That means these firms tend to stay at the lower-limit of wages.

However, in real world, energy and material production is expanding with investment increases. Prices and the lower- and upper-limit of wages are changing too. Therefore whether or not a typical firm, in a long-run, will be in corner solutions depends on the relative growth rates of these exogenous variables in the firm model. It will be shown in the following discussion that in the Chinese context, some leading firms, with high profit-margins and so, bargaining powers under the wage-profit linking policy, will stay at the upper limit of wages. While other firms, after an initial period, will reach the corner equilibrium in which the wage level is at the lower-limit, which probably coincides with the upper-limit. And, for all firms, their demands for energy and materials will coincide with their supply-limits.
2.5.1. The wage rate

The reason for why some leading firms will stay at the upper limit of wages is obvious. With a lot of profits made, workers, managers and their supervisors are all happy to increase wages up to the upper-limit. There is simply no incentive for them to keep wages below the upper-limit.

For firms trying to keep up with the leading dogs, there are inconsistency between the interests of workers, managers and the supervisors. The result is that $W^*$ is caught up by $W_o$.

There are two major reasons explaining why $W_o$ will catch up with $W^*$ and probably further catch up with $W_1$. First, there is the "keeping up with the Joneses" effect in the determination of a firms' long-term wages. i.e., workers in firms with lower average income levels are eager to catch up with workers in firms with higher profit levels and income levels. Among many reasons for this egalitarian attitude toward income distribution, the absence of a labor market and the fact that all workers are equal in their entitlement to the State assets are the most important ones. The second reason for $W_o$ to increase faster than $W^*$ involves the slowing growth in $W^*$ as the result of the decreasing or very slowly increasing profits that firms made in the reforming period. Expecting a slower profit growth rate, managers feel less able to pay a higher wage rate.[13]
As discussed in Chapter 1, there are several ways that firms can increase workers' income levels; via wage-incomes, including bonuses, subsidies, overtime wages, piece wages, etc.; and via non-wage incomes, including in-kind payment, price-deductible coupons for consumer goods, subsidized housing and medicare, etc. There are, in the long-run, three ways to finance the increases in wage income. First, reporting a higher production cost and bargaining for a higher product price. Second, reducing unit cost of products sold at given prices. Third, reporting a larger total wage payment in the previous period and bargaining with supervisory department for a proportional increase in the wage-fund in the current period. The first and the third methods are nominal and redistributive in their effects and the second involves real gains and increased profits.

Which manner of financing a firms' wage-income increases is used depends on which way is easier. The producers of shortage goods tend to use the first method, while firms employing a large labor force so that the government is concerned about worker welfare tend to use the third method. The second way is the least found. For one, the precondition for reducing production costs, the necessary incentive for managers and technicians to improve technical efficiency, is not existent. In fact, the wage rate of employees with higher education has
long been lower than that of employees with middle or primary education.\textsuperscript{[14]} And, the gap between the average wage rate of technicians and that of less skilled workers has been shrinking during the reform.\textsuperscript{[15]}

The lack of incentive for and accomplishment of technological progress led to the noted decrease in the profit growth rate and to an increase in the energy and key material consumed per unit output. Of course, a major part of the profit drop-off was due to the rapid increases in input prices (a result of the price reform and firms' practice in using the first method to make profits and increase wages). But compared with the western firms during the oil crises (when they experienced a much higher and faster input price increase than that in China), Chinese firms certainly failed in adapting to the price shock by improving technology and efficiency.

The first method, to raise the product price, and the third method, to hide the real size of the total wage fund from the government, do not guarantee firms a "sustainable" growth rate of wages. Increasing prices will ultimately be checked by government regulations, while the amount of total wage fund cannot be too much mis-reported every year. Therefore, in the long-run, if they do not make technological progress, the growth rate of profit will be lowered, making firms' bargaining for wage-expansion increasingly harder.
However, the lower efficiency and decreasing profit growth rate of firms did not slow the growth rate of wages until recently. A recent study shows that the ratio of the increased amount of total wages to the profits and taxes handed to the central government (which was officially set at 0.7 in 1984), at the national level, was 0.73 in 1985 when the profit-wage linking policy was just implemented, and was 1.015 in 1986, 1.12 in 1987, and 1.04 in 1988 (State Planning Commission, 1990b). Zhong Jiyin (1990) reported that the correlation coefficient between profit per worker and the average wage, across 403 surveyed firms, was 0.866 in 1984, but fell to 0.600 in 1987 (notice that these statistics do not include the increase in non-wage incomes).

The numbers given above reflect also the results of wage-bargaining between firms and the government.

As operations became less profitable due to either increases in input prices, or obsolescence of technology, or shrinking demand, or lowered labor efficiency, the manager must have thought to reduce the growth rate of effective labor and of the wage rate (refer to equation (2.27)). But he could not do so because of the lower wage limit, $W_o$. Therefore, he bargained with the government for maintaining an acceptable growth rate
of wages based on $W_0$. This bargaining process may explain the deviation of average wage from profit per worker shown above.

In this catching-up process, non-wage income plays an important role too. There are three ways to finance non-wage income, as mentioned in Chapter 1, the variable proportion of retained profits used for collective welfare, the fund for labor protection and insurance, and the firm-management and workshop-operation fees. The labor protection and insurance expenditures and the firm and workshop fees all enter the production cost. It is difficult for the supervisory department to find illegal increases in these expenditures. For this or other reasons, the non-wage income of workers increased during the reform much faster than the wage income. In fact, the average annual growth rate of total wage expenditure from 1984 to 1988 was 20\% (p. 124, State Statistical Bureau, 1989), while that of total non-wage expenditure in the same period was 37\% (Zhang and Jiang, 1989). For less profitable firms, increasing the non-wage income is easier than increasing the wage income.

The rapid increase in non-wage income helped push up $W_0$ in both profitable and less profitable firms. Non-wage incomes are usually equally distributed and unrelated to work effort. The increases in non-wage income made workers richer and so increased the value of leisure and so raised the acceptable wage rate. Huang Jianquan (1989) reported that "many managers
complained about the lowered stimulating power of bonuses. A monthly 30 yuan bonus is less effective than a 5 yuan bonus three years ago."

The catch-up of \( W_0 \) may paradoxically have resulted in a serious labor redundancy in Chinese firms after the initial "Golden Period" of the effort-stimulating wage-reform policy initiated in 1983. If wages stop growing faster, the effective labor will grow at a lower rate, since labor force growth was about 6% per year during 1953-1986 period for the industry (p. 4, State Statistical Bureau, 1987). This raises the real possibility of increasing redundancy.

Du et al (1990) found that, in 1987, firms with a seriously redundant labor force had almost the same average wage level as firms without or with very little redundant labor. While the ratio of profit per worker to the wage rate in the former firms was 0.85 and in the latter firms was 1.20. Zhong Jiyin (1990) found, in 1987, the wage ratios of the former firms to the latter firms for workers, technicians, and managers were 0.97, 0.98, and 1.02 respectively. These numbers show how successful the workers were in protecting their wages from falling below others'. These numbers also support the proposition that \( W_0 \) may have caught up with \( W^* \), or \( W^* \) caught up with \( W_1 \), before 1987. Because, other things in these firms being equal, the firms with higher ratios of profit per worker
to the wage rate should also have higher wage rates according to the profit-wage linking policy, provided managers in these firms were free from the bonding of the wage-limits.

The proposition that the faster growth rate of $W_0$ than that of profit and so $W^*$ has resulted in the catch-up of $W_0$ with $W^*$ can be further supported if the increase in effective capital available to firms cannot generate a higher demand for effective labor and for a higher wage rate $W^*$, which means that firms will soon reach the corner solution described above. The rate of increase of effective capital, as shown previously, is dependent on the rate of increase in the production of energy and key materials in the economy. This is discussed below.

2.5.2. The demand for energy and materials

For all firms, in long-run, the demand for energy and materials will reach the supply limits set to firms. There are two major reasons why $M^*$ caught up with $M_0$ in Chinese firms. First, is the decreasing efficiency in the utilization of energy and materials in firms. Second, is the slower growth rate of production of energy and basic materials.

The slower growth rate of production of energy and some basic materials (usually made from minerals) than that of manufacturing products is observed not only in China but also
in other Soviet-type socialist countries. Price-distortion and so, a lower profit rate and lowered growth rate of investment, are important causes of this phenomenon. As Zhou Xiaochuan (1990) pointed out, no matter how precisely the initial prices are calculated at the Planning Center, relative prices will be seriously distorted after several decades of economic development, due to the lack of a free market system in all socialist countries. Because extraction costs are increasing as the stocks of these resources are depleted, this price distortion usually tends to bias downward the relative prices of basic energy and minerals.

However, for historical reasons, the distortion of relative prices in China is even more serious than in Soviet Union. For example, in Soviet Union, a set of synthetic coal mining system is worth about 30,000 to 90,000 tons of raw cola. While the same system is worth 400,000 tons of raw coal in China (Chen Zongfa, 1990). Tan Gang (1989) found that, in 1985, there were 50 out of 53 kinds of minerals, energies, and basic materials whose prices were lower than the "theoretical prices" (usually calculated from international market prices). For example, the price of raw coal was 53% lower than the theoretical price, that of crude oil was 66% lower, iron ore, 41%, nonferrous metals, 50%, and electricity, was 22%.
As a result of the price distortion and the low profit rate, the growth rate of production of energy has been relatively lower compared with the capacity growth in manufacturing industries during the reform period. The reform introduced profit-motivations in investment management but did not remove the price distortions penalizing the extractive sectors. In fact, the average annual growth rate of electric power generation has been 6.8%, of coal, 5.2%, and of crude oil, 2.9%, since 1980 (p. 41, State Statistical Bureau, 1990). And for the growth of production of key materials in 1980-88 period, the average annual growth rate of steel production was 5.4%, of rolled-steel, 7.4%, of cement, 11.3%, of glass plate, 12.8%, timber, 1.7%, alkaline, 5.5%, sodium, 5.1%, and of ethylene, 10.8% (pp. 41-43, State Statistical Bureau, 1990). All these rates, except that of glass plate, are lower than the growth rate of industrial investment. The latter, for all industries, was on average, 11.9% per year during 1953-1986 period (p. 4, Statistical Data of China's Industrial Economy, 1987), 12.9% in 1987 and 14.3% in 1988 (p. 8, State Statistical Bureau, 1990).

The low efficiency in utilizing energy and materials could be an expected result of the fact that wages for technicians and managers were relatively decreased during the reform, as discussed above. In fact, consumption of energy and key
materials per unit output measured in real terms has been actually increasing or decreasing very slowly. One study concluded that the trend of this cost-index "has been rising in a cyclical way since 1978" (p. 3, Wang Haipe, 1990). Generally, the survey data given in Wang Haipe's (1990) book show a remarkable increase in the real-term electricity consumed per unit of real output during 1980-1987 period for almost all industries, and a moderate increase in coal consumed by each unit product in some industries, and moderate decreases in other industries. The key materials consumed per unit of real output have been decreasing very slowly (about 0.1% annually at average) in most industries.

The rapidly growing industrial capacity and the increasing consumption of energy and key materials per unit of output have greatly pushed up the aggregate demand for energy and key materials in the last several years. And, the slower growth rate of energy and material industries enlarged the gap between supply and demand for these goods.

As a result of shortages in energy and key materials, the utilization rate of productive capacity has been, as discussed in Chapter 1, lowered. For example, the utilization rate of metal cutting machines in the Machine Manufacturing Industry was 55% in 1976-80 period and 48% in 1981-88 period. The utilization rate of cement kilns in the Construction Materials
Industry was 85.3% in 1980 and gradually decreased to 78.4% in 1988. The average utilization rate of facilities in the Textile Industry was 102.4% in 1980, fell to 94.0% in 1984 and then increased slightly to 96.1% in 1988.

Thus we have reached the conclusion, that both wages and the demand for energy and materials will, after some initial progress, hit the limits set from outside of the firm. In long-run, the two corner solutions given in (2.22) and (2.23) are the most probable equilibria of a typical Chinese firm.

This conclusion is pessimistic for the success of market-oriented reforms. The purpose of such reforms, as thought by many economists, is to let state-run firms become "independent commodity-producers." This implies making choices, but corner solutions greatly constrain choices. Thus based on the firm model, it is clear that reform needs to be deepened to touch more fundamental problems such as the lack of factor markets, or the economy will be even worse than before the reform.

### 2.6. Conclusion

Three interactive factors affecting efficiency of firms and demand for inputs underlie the firm model presented in this paper. They are: the chronic shortage of key materials
and energy, the immobility of capital and labor, and the endogeny of wage rate determination to firms. These assumptions are relatively more general and realistic for the market-oriented reforming economy than the assumptions made in other models used to explain reform in centrally-planned or labor-managed socialist firms. Since the forces generating chronic shortage, immobility of factors, and endogeny of wages have been working for years and are not likely to be removed in the near future, the explanatory and predicting ability of this model is expected to be high.

The model presented has shown that resource allocation within Chinese firms is generally not efficient, and that the basic demand laws for labor and capital are distorted due to immobility of factors and endogeny of wages. Over-expansion of wages or over-demand for materials are probable. There are two sources of inefficiency within the firm, the divergence between nominal and effective employment of factors, and the inefficient payment for the effective part of factors.

The model presented has many other properties helpful in explaining Chinese economic phenomena. However, the model's extension to industrial or national level will crucially depend upon the aggregation problems. If aggregation problems can be handled, estimation of production functions and tests of hypotheses made for the firm model are possible, but difficult.
For example, in the presence of shortage and immobility, is it guaranteed that the estimated aggregate production function shows positive and decreasing marginal output? The intuitive answer is "no." For if firm A has higher labor productivity than firm B, and both firms have idle workers due to material shortage, then controlling for material input may allow us to estimate an aggregate production function, but the sign of second-order partial derivative to labor depends on the sequence in which the marginal units of labor are added. If the first additional unit of labor occurs in firm A and the second in firm B, the marginal aggregate output will be positive and decreasing. If the first additional unit occurs in firm B and the second in firm A, the result will be reversed.

The comparative statics of the firm model and their combination with a dynamic discussion of the Chinese real economy lead to the important conclusion that, with time, Chinese firms will hit the limits or the boundaries set from outside. Therefore firms would still be more or less directly regulated by the government. This conclusion calls for further and root-touching reforms, such as establishment of factor markets.

Comparative static results obtained in this chapter cannot readily be tested against empirical data. First, because most available data are aggregated, not micro level; second, because
the available aggregate data are not complete enough to control for such variables as degree of shortage, material inventory, or idle labor. And, there is no available theory of aggregation for an economy featuring shortages and factor immobility. However, these results are supported by everyday observations of authors in the field of Chinese economy.

The coexistence of a socialist structure of property rights and the serious inefficiency among firms discussed in section 2.2 cannot be regarded as a proof of the inefficiency of socialist systems. However, it is a proof that the existing socialist systems have until now failed to find institutions substituting for those of the free market system from the standpoint of efficiency.

The effectiveness of property rights in socialist countries, as in the western world, depends upon people's behavior and on the rules of behavior. Quoting from the latest book by Barzel (1989): "The rights people have over assets (including themselves and other people) are not constant; they are a function of their own direct efforts at protection, of other people's capture attempts, and of government protection." Scholars from socialist economies have been searching for better rules and institutions for protecting, say, the effective ownership of a public asset from being captured by a small group of citizens who are "closer" to that asset than others.
Therefore the efficiency problem partly is a problem in the practice of searching for better rules of behavior.

The model in this paper presents a static picture for a typical Chinese firm over a relatively long period. It helps to explain the behavior of Chinese firms during the evolution from the traditional socialist economy toward a different, more market oriented one. Without this behavioral modeling, the wage expansion after 1985 cannot be explained since it conflicts with the fact that the wage-profit linking policy was implemented in that year. Under this policy, the total wage in a firm should be proportional to the total profit of the firm, therefore the total wage of the economy should have grown at the same rate as profit growth. But this is not true. In fact, the total wage has grown much faster than and is not even positively correlated to the growth rate of total profit during the 1984-1988 period (Wang Yun-Guo, 1989; State Planning Commission, 1990). This phenomenon, however, can be better explained, in the firm model presented, as a result of the faster growth rate of the lower wage limit than that of the firm's optimal wage rate, i.e., as a result of the driving-out of firms' profit-motivation by workers' welfare motivations.

The failure of modeling the wage determination process in terms of the claimed policies and formally established regulations is another proof of the idea that economic man is not
a castle on the chess board. The effort made in this paper is simply to try modeling a man as a man.
CHAPTER 3

ESTIMATING THE COBB-DOUGLAS PRODUCTION FUNCTION

3.1. Introduction

Chapter 2 has developed a firm model, derived some of the important comparative statics results, and discussed these results in the context of the Chinese dynamic reality. For example, it has been shown that most Chinese firms would be observed in a corner equilibrium where the firm's optimal choice on wages and demand for energy and materials coincide with the externally set boundaries. In this chapter the firm theory presented in chapter 2 will be tested using the Industrial Census Data described in chapter 1.

The standard way of testing a theory, although there are some controversies, is to try to reject or, to some degree, to accept the refutable propositions that can be derived from the theory. Because in many cases it is not possible and not necessary to predict the magnitude of changes in economic variables, comparative statics guided by the theory predicts the direction of changes in endogenous variables when exogenous
variables are changing. Using some standard cut-off for significance of the signs of the relation between the endogenous and the exogenous variables (or parameters), an insignificant regression, can be taken as a counter-example to the theory. If a theory encounters too many counter-examples it cannot explain, the theory would not be regarded a "good" one.

The difficulty of directly testing the firm theory presented in chapter 2 is that the equilibrium coincides with boundaries. For example, when we regress the wage rate on nominal capital and labor or other exogenous variable, since the equilibrium wage of each sample-firm is equal to either the lower or upper wage-limit set for that firm, there will be no significant relationship found in such a regression.

Another example is the difficulty of testing the profit-motivation of Chinese firms. According to our firm model, firms are pursuing profit within a restricted domain. A basic demand law proved in chapter 2 says that firms in interior equilibrium will show a downward sloping demand curve for energy and materials (i.e., in the symbolic expression given by equation (A.24) in Appendix 2, \( \partial M^*/\partial p < 0 \)). But this law cannot be observed. Because according to the discussion in chapter 2 most firms would have been in corner equilibria, being willing to pay a price higher than \( p \), therefore showing a positive correlation between \( M \) and the price, \( p \), in a certain range.
One indirect test of the firm theory is to regress the gross output on the effective inputs, i.e., to estimate a production function. Since effective inputs are determined in the firm model, a comparison between the effective-input production function and the conventionally estimated nominal-input production function would provide a way of judging the validity of the firm theory. This is the purpose of this chapter.

Many efforts at estimating production functions have been made by students of the Chinese economy, among them most are at the aggregate level (see Chen et al., 1989, for a list of recent studies), only a few are at the firm or industrial level (Jefferson, 1988; Du et al., 1990). Estimating production functions using the 1985 Industrial Census Data has not been seen in the literature. One reason is the difficulty in making proper assumptions on firm behavior reflected in this data set. There has been no readily available theory for the Chinese firm behavior. Another reason is that the firm-level data have never been made available to outsiders.

Usually, the direct application of production function techniques to Chinese firm-level data cannot obtain production functions with normal aspects. On the other hand, estimation of production functions at the aggregate level requires very strong assumptions, which even a free-market economy like that
of U.S. has difficulty meeting (Sato, 1975). Aggregation problems for Chinese economy are harder than for the U.S., as pointed out in the concluding section of Chapter 2. And, when 20%-30% of employed labor and capital is "on-the-job" unemployed because of such facts as missing factor markets, shortage of energy, key materials, and transportation facilities, the economic meaning of parameters in a directly estimated classical Cobb-Douglas or CES production function will be ambiguous and, sometimes, misleading.

Finally, there is an inconsistency between Chinese production functions estimated with cross-section data and those estimated with time-series data (at aggregate level). For example Chen et al (1988) using national level data obtained an output elasticity of capital in Cobb-Douglas production function as high as 0.57. Jefferson (1988a) using aggregate data estimated output elasticities of capital in the state-run and the collectively-run sector, that shows the elasticity for both of the two sectors is as high as 0.996. On the other hand, Jefferson (1988b) estimated an inter-firm production function for Chinese steel and iron industry, and obtained a negative output elasticity of capital, -0.098. Equally wide variation shows up in Jefferson's estimate of the elasticity of labor, from the sectoral lows of 0.118 to a steel and iron high of 1.309. Besides these estimates, many other largely employed
guesses, ranging from 0.3 to 0.7 for labor output elasticities, and from 0.7 to 0.3 for capital output elasticities have been used by Chinese economists in their calculations of total-factor productivity (see Chen et al, 1988).

To explain the variation in elasticities estimated with aggregate data and with firm-level data, we need to keep in mind the features of Chinese economy, such as shortages of energy and materials, immobility of capital and labor and on-the-job-unemployment of labor. At the macro-level, any machinery produced for fixed capital investment will contribute to GNP since it is the output of producer firms. But in fact, this new machinery may not be utilized in user firms due to the shortage of energy and materials. This partly explains why at aggregate level the conventional production function technique tends to over-estimate the contribution of capital.

At the firm level on the other hand, it is the contribution of labor that tends to be over-estimated by conventional techniques. Because a firm's output is measured usually in value terms not in real quantity. And, the price used in calculating the value of the output is not formed on a free market, but calculated on the basis of production cost. A major part of a firm's output is sold at the planned price which is equal to unit production cost plus an average profit. This method is also used by firms to set the prices for market-sold
products. Within the production cost, wages and workers welfare expenditures count about 10% or more in 1985. When the firm is assigned more new workers, its total wage fund is expanded too. Therefore any increase in the labor force will contribute to the output by contributing to costs; even if the new laborers are not effectively employed in the firm. This partly explains why labor's output elasticity tends to be over-estimated.

It can be seen from the above analysis that the divergence between effective and nominal inputs caused the bias in estimation of production functions. To control this type of bias, one needs to introduce such variables as degree of shortage, and idle labor in the production function estimation.

In order to do this, the firm model developed in chapter 2 will be used to derive a Cobb-Douglas production function. For each of the eleven sample Chinese industries one such production function will be estimated, using the firm-level data from 1985 Industrial Census.

The results of such an application, as shown in this chapter, will be a general improvement in the result of direct estimation or as Koopmans called, "measurement without theory." Therefore they constitute an indirect test of the firm theory presented in chapter 2.
3.2. The Cobb-Douglas for a Single Firm

For three reasons we will estimate inter-firm production functions of the Cobb-Douglas type. First, the Cobb-Douglas is simpler, is log-linear, and is therefore easier for a pilot research. Second, the meaning of parameters in a Cobb-Douglas is clear and familiar to most economists. Third, effective capital and labor are complementary in the Cobb-Douglas, and therefore consistent to the assumptions made in our firm theory.

In this section, we specify a single firm Cobb-Douglas production function.

The two-factor Cobb-Douglas is:

\[ Q = AK^\alpha L^\beta, \]  
\[ K = \eta K_0, \]  
\[ L = \xi L_0. \]

As in chapter 2, this production function is defined in terms of effective rather than nominal inputs.

In order to specify an estimation model for the Cobb-Douglas, the functional forms of the capital utilization rate \( \eta \) as a function of nominal capital and available energy and materials and of the labor utilization rate \( \xi \) as a function of wage rate need to be specified first. It can be shown that the simplest functional form for \( \xi \) globally satisfying
conditions (2.3) (that is, taking values between 0 and 1) and (2.5) (i.e., a positive and decreasing marginal effect of wage) in chapter 2 is a logistic function (Ratkowsky, 1983).

Similarly, the simplest functional for $\eta$ to satisfy (2.3), (2.4.a) (that is, $\eta$ increases with $M$ and decreases with $K_O$) and (2.4.b) (showing diminishing returns to $M$, a positive interaction between marginal effects of $M$ and $K_O$, and a positive contribution of the increase in $K_O$ to $K$) is a multiplication of a logistic and an exponential function that is a function of the variable $S = K_O/M$. However, these functions are too complicated to be combined into a log-linear regression model. Notice that condition (2.4.b) in chapter 2 is sufficient but not necessary to guarantee the second-order equilibrium conditions of the model and the definite signs of comparative statics. So a functional form locally satisfying conditions (2.3) and (2.4.a) would be good enough for practical purposes, if the equilibrium is assumed to exist.

Probably the simplest functional forms for $\eta$ and $\xi$ locally satisfying the properties defined in equations (2.3), (2.4.a), (2.5) and not violating the log-linear form of the Cobb-Douglas, are the following:
All parameters in (3.4), (3.5), and (3.6) are assumed non-negative. By properly confining the range of parameters in (3.4) and (3.6), these functions can guarantee, in a local range, the optimality of solutions to the firm model. The locality of the effective range of (3.4) and (3.6) depends upon the magnitude of sample wages and shortage degree $S$, and upon the constraint to parameter $a$ and $b$ in (3.4) and (3.6). The basic principle for constraining $a$ and $b$ is that the utilization rates of nominal capital and labor should not exceed 100%. Therefore:

$$a \leq e^{(\min \log S)}$$  \hspace{1cm} (3.7)

$$b \leq e^{-\gamma(\max \log w)}$$  \hspace{1cm} (3.8)

Conditions (3.1), (3.2), (3.3), (2.3), (2.4.a), and (2.5), together with (2.10), the second-order condition of optimal solution to the firm model from Appendix 2, put some constraints on parameters $\alpha$, $\beta$, $\theta$, and $\gamma$. A messy but straight forward calculation leads to the following definitions of these constraints:[2]
\[ \alpha > 0, \quad (3.9) \]
\[ \beta > 0, \quad (3.10) \]
\[ 0 < \gamma < 1, \quad (3.11) \]
\[ 0 < \theta \alpha < 1, \quad (3.12) \]
\[ \alpha \theta + \gamma [\alpha \theta (\beta - 1) + 1] < 1. \quad (3.13) \]

Unlike a Cobb-Douglas production function derived from a profit-maximizing and perfectly competitive firm model (Nerlove, 1965), the constraint on parameters \( \alpha \) and \( \beta \) does not guarantee decreasing returns to scale. This implies the observed sample firms could be in a technical state of increasing returns to scale. In fact, scale economies are very significant in comparing large and small sized firms in China. However, we will see from Table 3.1 that scale economies are not very important to the sample of firms used. The latter have already been selected from the category of large or medium sized firms.

Constraint (3.11) implies a decreasing marginal effect of wage-incentive, or equivalently, decreasing marginal utility of money income.

Since \( \theta \alpha \) is the elasticity of output to \( M \) in the firm model (see equation 3.13 below), constraint (3.12) implies decreasing marginal effect of \( M \) on the output.

The economic meaning of constraint (3.13), derived from the requirement for a positive determinant of matrix \( A \) in (2.10), is not as clear as that of others. Mathematically,
(3.13) plays a similar role in the socialist firm model as $\alpha + \beta < 1$ in a capitalist Cobb-Douglas production function. Its role is to guarantee the interactive effect between $W$ and $M$ does not exceed the decreasing marginal effects of $W$ and $M$, therefore to guarantee the existence of equilibrium.

(3.9), (3.10), (3.11), (3.12) and (3.13) are indeed parameterizing the behavioral aspects of workers and managers, modeling the workers' response to a change in wage rate, the manager's effort at using the effective labor and capital, and the technical aspects of capital utilization vs shortage.

For a single firm $i$, the Cobb-Douglas is:

$$Q_i = A_i \left( K_0^a a_i S_i^{\alpha_i} \right)^{\alpha_i} \left( L_0^b b_i W_i^{\beta_i} \right)^{\beta_i}.$$  

(3.14)

$$S_i = \frac{K_0^b}{M_i}.$$  

(3.15)

Here $W_i$ and $M_i$ are the optimal choices of firm $i$. As seen in chapter 2, the supply of $M$ is fixed at $M_0$ and supply of capital and labor are fixed at $K_0$ and $L_0$ respectively in a short-term statistical analysis.

The firm is facing a "supply curve" of effective capital which is a function of shortage degree $S_i$. In this chapter, electricity consumed will be used as a measure of shortage. Electricity has been in very short supply and rationed in a very restricted way since 1985. Firms' demand for electricity
almost always exceeded their assigned quota (Zhu Chengzhang, 1989). Therefore it will be assumed that the observed data on M reflect the quota allotted to the firm, i.e., a restricted solution.

As discussed in chapter 2, the firm's equilibrium is assumed to be in the corner solution:

\[ W_i = W_0, \quad \text{or} \quad W_i = W_1, \]
\[ M_i = M_0. \]  

(3.16)  
(3.17)

3.3. Estimating The Inter-Firm Cobb-Douglas

Nerlove (1965) has clarified the concept of inter-firm production function. As he defined it, an inter-firm production function would tell us what production an "average" firm might be expected to have, taking "average firm" to mean one for which all characteristics are at the mean values for the group of firms as a whole.

The inter-firm regression of (3.14) would therefore tell an average response of firms' output in that industry to a given mean level of nominal fixed capital and labor, the historically determined lower-limit and/or the socially determined upper-limit to wages, and a mean level of energy and materials supplied.
The extended Cobb-Douglas therefore includes two more exogenous variables, the wage-limit and the energy quota. Since wage limits are individually negotiated between each firm and its supervisory department, or based on the firm's particular history of wages, there is no unified lower and upper limit. The observed wage could be continuously distributed, for 1985 it was between 800 Yuan and 1,500 Yuan per year, with a few exceptions beyond this interval.

The four parameters, $\alpha$, $\beta$, $\theta$, and $\gamma$ usually should reflect differentials in firms' technology, efficiency at using energy and materials, and the effectiveness of wage-incentives. However, there are other important differentials such as the location and policy-flexibility of firms. Those differences are assumed either connected to the four parameters listed above, or normally distributed as random variables. For the four parameters we assume:

\begin{align*}
\alpha_i &= \alpha + u^i_K, \quad (3.18) \\
\beta_i &= \beta + u^i_L, \quad (3.19) \\
\theta_i &= \theta + v^i_S, \quad (3.20) \\
\gamma_i &= \gamma + v^i_W. \quad (3.21)
\end{align*}

The random variables $u^i_K$, $u^i_L$, $v^i_S$, and $v^i_W$ in above equations are further assumed to be i.i.d. (independent and identically
distributed) randoms. Under those assumptions an inter-firm Cobb-Douglas production function in log-linear form can be written as:

\[
\log Q_j = \text{Const} + \alpha (1 - \theta) \log K_j^i + \beta \log L_j^i + \gamma \log W_j + \epsilon_i, \quad (3.22)
\]

\[
\text{Const} = \log A + \alpha \log a + \beta \log b. \quad (3.23)
\]

The random variable \( \epsilon \) in (3.22) can be shown to be a random with zero mean and a limited variance because of the i.i.d. assumption. Notice also the corner equilibrium for (3.22):

\[
W_j = W_0, \quad \text{or} \quad M_i = M_0. 
\]

Equation (3.22) and constraints (3.9), (3.10), (3.11), (3.12), and (3.13) compose the model that will be estimated using firm-level data from the Chinese 1985 National Industrial Census. However, since this model is a non-linear regression model, many good properties in a linear model no longer hold or become asymptotic (Ratkowsky, 1983).

There are mainly three approaches to assess the estimation of a nonlinear regression model. One is based on the Gauss-Newton method, and involves linearizing the model at an initial point and then directing the search using the second-order derivatives of the model. Another is based on a direct or "multidimensional search," searching always for the direction in which the criterion function, say the sum of squared errors, can be improved. The third one is based on a procedure very like the
"stock adjustment model," the difference between errors in the last and present set of searching steps is used to determine the proper direction and step length for the next set of steps.

The Gauss-Newton method is fast, but too sensitive to the initial point; a nonlinear regression usually requires a more robust estimation. The third method is not available in computer packages such as SYSTAT, SHAZAM, or SPSS. The second method is much more robust but slower than the others. For our purposes, this method is used as the major one, and the Gauss-Newton is used as a check. The direct search method is available in SYSTAT, referred to as "simplex" method.

The problems in measurement of \( Q, K_0, L_0, M_0, \) and \( W, \) have been discussed (see Chapter 1, pp. 30-34). Briefly reviewing, the only available data on seriously shortaged "materials" are those on energy and electricity consumed by the firm. As mentioned in section 3.2, since energy and electricity are rationed among firms in China, the amount of consumption usually is the amount supplied. The ratio of the net value of nominal fixed capital over electricity consumed is taken as the primary measure of the shortage degree, and the ratio of capital to energy consumed as the secondary measure. Both electricity (\( EL \)) and energy (\( EN \)) consumed in the data set are in real terms, and, since they are in fact highly correlated, they can often be represented by each other. In the estimation, \( EL \) is
used first, EN is used if it is found significant with EL in the model. Therefore $M_o$ in (3.22) and (3.25) below will be first understood as EL, then EN if necessary. The estimates of (3.22) for the eleven sample industries discussed in chapter 1 are given in Table 3.1.

As comparisons, the conventional two-factor non-restricted Cobb-Douglas, and the non-restricted four-variable ($K_o$, $L_o$, $M$, $W$) Cobb-Douglas production functions are also estimated with the same data set:

$$\log Q = \text{Const} + \alpha \log K_o + \beta \log L_o + \epsilon.$$  \hspace{1cm} (3.24)

$$\log Q = \text{Const} + \alpha \log K_o + \beta \log L_o + \theta \log M_o + \gamma \log W_o + \epsilon.$$ \hspace{1cm} (3.25)

These two models are assumed, as usual, to have all necessary properties of a well specified linear regression model. Notice that parameters may be represented by the same Greek letters in (3.22), (3.24) and (3.25), but should be regarded as different from each other.

Table 3.2 and 3.3 present estimates of (3.24) and (3.25) respectively.

In Table 3.4 we provide an indirect estimate of model (3.25) according to the following obvious relations between (3.22) and (3.25):
\[ Const_{3.25} = Const_{3.22}, \]  
\[ \alpha_{3.25} = \alpha_{3.22} (1 - \theta_{3.22}), \]  
\[ \beta_{3.25} = \beta_{3.22}, \]  
\[ \theta_{3.25} = \alpha_{3.22} \theta_{3.22}, \]  
\[ \gamma_{3.25} = \beta_{3.22} \gamma_{3.22}. \]

The subscriptions here are pointing the equations parameters belong to.

From Table 3.1 it can be seen that scale economies in most of the eleven industries have been exhausted, the sum of \( \alpha \) and \( \beta \) is smaller than one in eight industries, and is greater than one in Alkaline, TV, and Bicycles. The mean value of \( \alpha \) is 0.446, with a standardized variance at 0.168. And the mean of \( \beta \) is 0.572, with a standardized variance, 0.232. Therefore at the aggregate level (if aggregation is possible), production would show almost constant returns to scale. It is interesting that this result is not derived from the conventional assumption of constant returns to scale made by either the western or the Chinese economists on the Chinese economy.

An important result shown in Table 3.1 is the large differences in the elasticity of output to effective capital and labor among industries. In the Thermal Power industry, the output elasticity of capital is more than three times that for labor. While in Cotton Spinning, the situation is completely
reversed. For the U.S. economy, a generally accepted estimate is that the change in labor input accounts for about two thirds of changes in GNP and the change in capital only accounts for one third of changes in GNP. This is seen in Table 3.7, which is based on findings of Hildebrand and Liu (1965) in their estimation of U.S. inter-firm Cobb-Douglas production functions. The mean of the output elasticity of labor in the Cobb-Douglas is 0.677 with a standardized variance only at 0.128, much smaller than that of China's (see Table 3.1 and 3.7).

The unevenness of the output elasticity distribution among industries as measured by the large variance of $\alpha$ and $\beta$ implies a potential for improvement in the efficiency of production. However, any further analysis would have to be conditioned on the availability of data on shadow prices of major industrial products. The same difficulty is encountered in applications of the estimated $\theta$ and $\gamma$.

Turning to the other tables, it is clear that the estimate in Table 3.3 is an improvement to that in Table 3.2. Capital input is insignificant in six of the eleven industries in the conventional estimation. The failure to obtain a significant coefficient for capital input results from the failure to distinguish nominal from effective inputs in the conventional model. The inclusion of $W$, EL and EN in Table 3.3 implicitly
assumes a relationship between effective and nominal inputs as defined, say by equations (2.2), (2.3) in chapter 2 and (3.4), (3.5) in section 3.2. This modification makes capital significant in all industries.

However, there are three industries in Table 3.3 with negative coefficients for nominal capital. This requires further explanation. From (3.27) it can be seen that the coefficient of nominal capital in Table 3.3, according to our firm model, has two components, the elasticity of output with respect to effective capital and the elasticity of output with respect to shortage of electricity or energy. Whenever the shortage effect dominates we would observe a negative elasticity of output to nominal capital. This is illustrated by deriving Table 3.4 from Table 3.1. Obviously, the estimate in Table 3.4 is an improvement to that in Table 3.3.

3.4. An Application to Labor Redundancy Estimation

The estimated value of \( \theta \) and \( \gamma \) have broad application. As an illustration we use them to calculate the upper bound of the labor utilization rate in Chinese industries.

The labor utilization rate has been defined as \( \xi \) in our firm model. A locally effective functional form of \( \xi \) is given
in equations (3.4) and (3.6). The difference between 100% and the labor utilization rate is the labor redundancy rate, which more frequently appears in the Chinese economic literature.

As mentioned in chapter 2, many Chinese authors have noticed the serious "on-the-job-unemployment" phenomena in Chinese industrial sectors. But there has been no model or method to estimate the unemployment rate of labor employed in firms. On the other hand, the estimate of labor redundancy in firms is extremely important to the governmental policies on rural-urban labor transferring, employment structure adjustment, investment directions, wage-system reforms, social security reforms, and everything about improving labor productivity in firms.

The much improved estimates of production functions obtained in the previous section opens a new approach to assessing the labor redundancy estimation. This is the purpose of this short section.

Calculating labor redundancy is equivalent to calculating labor utilization rate which is

\[ \xi(W_i) = b W_i^\gamma \]

in our model for firm i. The mean or parameter \( \gamma \) has been estimated and presented in Table 3.1. If the parameter \( b \) can be determined, it will be possible to estimate the labor
utilization rate in each sample firm and to estimate an average utilization rate in each industry.

However, constants $A$, $a$, and $b$ in equation (3.23) are unidentifiable. The approach used here is to estimate the upper bound for parameter $b$ using the conditions given in equation (3.8):

$$b < e^{-v \max_{i,j} \left( \log W_i, j \right)} = \bar{b}. \tag{3.31}$$

The right hand side, $\bar{b}$ is called an upper bound of $b$. If wage rates are highly concentrated about the mean value in an industry, this upper bound can be expected to be very close to the true value of $b$.

Table 3.5 provides wage rate differentials and labor productivity differentials among the eleven industries. ASPD or Average Squared Percentage Deviation, the ratio of the variance to the mean, is the index used to measure the differential. If each firm has a wage rate deviating from the mean wage rate by exactly twenty per cent, the ASPD for this industry will be 0.04. An ASPD of 4.00 would imply an average of 200% deviation from the mean. Table 3.5 shows that ASPD in wage rates is relatively very low compared with the ASPD in labor productivity.

Two implications can be derived from Table 3.5. First, the relatively small wage differential among firms may be one
outcome of the dynamic procedure of the "keeping up with the Joneses" movement during the reform period. To keep the peace within the firm, managers must keep wage differentials from becoming too large, which they can do without much concern for the effect on profits, given their "soft" budget constraint. This weakens the linkages between profit and wages. The big difference between the ASPDs of wages and those of nominal labor productivity points out the difference between a profit directed competitive economy, which would tend to bring about small intra-industry differences in both wages and productivity, and China's "other-directed" economy.

As is discussed in chapter 2, the effect of wage-equalizing dynamics has been modeled by the increasing lower-limit of wage rate, \( W_0 \), in catching up with the leading firms' wages which usually stay at the upper-limits of wage rates in the leading firms. In the beginning of each period, firms are facing a \( W_0 \) which is based on wages reached in the last period, or even higher than that because of the "catching up" movement. After some periods, firms unable to match productivities with the increasing lower-limits of wages will be at corner equilibria, bonded by their lower wage-limits. This, together with the differentials in firms' technologies, can explain why there are such great differences in productivity compared to wage rates between firms within an industry, despite the significance
of wages in explaining the differentials in labor productivities as found in Chapter 1. The whole story is: the wage-profit linking policy stimulated work effort and labor productivity, but to a limited degree due to the absence of factor markets. Beyond that limit, the "catching up" effect will dominate the "wage-profit linkage" effect.

The second implication of the relatively high concentration of wage rates on the mean value is that the approximation of $\tilde{b}$ to $b$ would be expected to be very close. Based on (3.31) and (3.6), Table 3.6 presents upper bounds of $b$ in eleven industries, and the upper bounds of labor utilization rates correspondingly, which represent the highest utilization rate of labor force among firms within the same industry, given the data and the assumptions made on the model. All calculations are at the mean value of wages in each industry, for the mean is a good proxy to the actual wages. It can be seen that the upper bounds of utilization rates are close to intuitive estimates of Chinese economists, about 70% to 80% of total employment.

The labor utilization rate in the plastics industry seems too low. According to Census Data at the industrial level, plastics production in 1985 was seriously constrained by a shortage of basic organic materials such as ethylene and polyvinyl chloride. This may explain part of the low labor utilization rate.
Generally speaking, the on-the-job-unemployment rate is very high in Chinese industries, from about 15% to about 30%. If this is the general case, China would have, plus a 5% explicit unemployment rate, a 20-35% unemployment rate. And this is exactly what the Chinese economists believe (Tu Ping, 1989).

3.5. Concluding Remarks

In order to test the theory of the Chinese firm presented in chapter 2, a Cobb-Douglas production function is derived from the firm model. This production function is estimated for eleven Chinese industries.

Unlike previous studies, parameters in the Cobb-Douglas production function are non-linearly constrained by a set of conditions derived from the firm model. The economic meaning of parameters therefore becomes much clearer than in previous studies. The clarified concept of elasticities in the Cobb-Douglas and the improved estimates allow applications of the results to policy-making. An illustration of such an application is the calculation of labor utilization rates in different industrial sectors. The result is very close to economists' intuition.
There are other possible applications of production functions in Chinese economic policy analysis and economic theory. For example, the production function theory developed here could be used to derive a method of estimating the supply curve of products. In fact, if constant returns to scale is a correct hypothesis, then the Euler theorem for a function of first-degree homogeneity will hold for Chinese industry, at least for large and medium sized firms. Therefore, the percent change in output can be expressed by a weighted sum of percent changes in inputs, with the weights the "income shares" of effective inputs. If costs of factors are known, the supply curve of output can be estimated by this formula.

Another application of the production function theory developed here is to estimate firms' demand for effective labor and capital. Unlike a capitalist firm, the Chinese firms modeled in chapter 2 cannot change their nominal labor and capital; they can only chose the utilization rates of the fixed quantities of capital and labor they are allotted under the plan. The firms' demand for effective factors can be estimated based on the estimated utilization rates. At the aggregate level, the total demand for effective labor or/and capital could be obtained as could the true unemployment rate. If an explicit unemployment rate of labor and capital is not acceptable to a socialist system, the government at least can improve
efficiency by allocating more nominal labor or capital to firms where utilization rates of nominal factors are higher. The aggregate demand thus obtained could be used to estimate the potential for rural-urban labor force transfer.

A third application of the production theory developed would be to estimate efficient growth rates of wages in each industry. In the firm model, increasing demand for effective labor implies increasing wage rates. The magnitude of the wage increase depends on the elasticity of the labor utilization rate with respect to wages and on the elasticity of output with respect to effective labor. Since elasticities vary greatly among industries, the efficiency criterion would require different rates of wage growth. In this respect, the firms' tendency to set wages on the basis of the wages earned elsewhere in the industry may not be consistent with the efficiency requirement and the central planner is called on to improve efficiency. The central planner has to press down firms' wage-requests in some industries, leaving the inequality problem to the social income-distribution system.

As the reader can see, this list could go on and on. Many other applications are possible, including the very important one of the analysis of technological progress.

The work done in this chapter supports the validity of firm theory developed in chapter 2. The conformation of that
theory in empirical studies encourages an extension of the theory toward a microeconomic and macroeconomic theory of reforms. Chapter 4 will be devoted to this extension.
CHAPTER 4

TOWARD AN ECONOMIC THEORY OF REFORMS

4.1. Introduction

It is possible based on previous chapters to establish an economic theory for a socialist economy in the transitional period from a system characterized by factor immobility, centrally planned prices, and chronic shortage, to a market-oriented economy. This economic system therefore has some properties endowed by the old system, and some from the new one. Namely, there are the continued shortage, the still far from complete mobility of capital and labor, the growing profit-motivation and the decentralization of decision-making in some fields. All these features have been observed to different degrees, in such socialist reforming economies as the Soviet Union, Hungary, Yugoslavia, Poland, and recently in Vietnam. An economic theory for socialist reforms is both theoretically and practically demanded. In this chapter, a framework potentially leading to such a theory is outlined to direct future studies.
As discussed in the preface of this thesis, a microeconomic theory needs to tell stories about consumers, about the firm, and about the interaction between consumers and firms, taking account of the role of government. In previous chapters, but mainly in chapter 2, a foundation is laid for further thinking about the microeconomic theory of a traditional socialist economy in transition to becoming a post-reform economy.

Most socialist economies of the Soviet-type began their reforms under the pressure of low economic efficiency and designed those reforms to be market-oriented. However, all such reforms failed. In order to succeed, some fundamental problems must be handled successfully even though the people begin to want a purely capitalist system.

First, there is the problem of how to turn the state enterprises, which count for over 70% of fixed assets in most Soviet-type economies, into market-oriented operations. (This topic includes who will be owners, the handling of the often redundant labor and over age capital, etc.) Managers and workers in state enterprises are not rooks on a chessboard; without a properly designed institutional and constitutional system they may behave unpredictably in a market-oriented reforming economy. It is not known that simply making an all-at-one-time move to a free-market system can succeed. Chinese and Soviet
economists are watching the great revolution in Eastern Europe and how the arduous task of reforming public ownership will be done there.

Second, what is the rate of change the society could bear? This is really the art of reform-politics; no answer could be given by theory but only by practice and experience. However, economics can provide some tools for managing performance of the in-reform economy. For example, economics should be able to explain, during the reform period, the formation and the movement of prices, the utilization rate of resources, the efficiency of allocation, redistribution of welfare among social groups, etc.

Third, where to start the reform so it can more likely succeed? China started with agriculture, Yugoslavia and USSR (the current reform) started by reforming the communist party itself, Poland began outside of the Party. The selection of the driver and supporter of reform is, posed in Mao's words, "the number one problem of revolution."

The above problems show part of the complexity of socialist reforms. It will be very difficult to solve problems like these without the guidelines provided to understanding by an economic theory.

This concluding part will give a brief list of elements of the sort of economic theory that would help in handling the
problems inherent in reforms of China and probably also in other socialist countries. It should be noticed that two important elements in an economic theory are left out, the investment problem and the monetary topics. These subjects need to be treated in another thesis.

4.2. Aggregating the Economy

As is mentioned in the concluding section of chapter 2, aggregation might be the first serious problem in establishing a Chinese macroeconomic theory.

In dealing with a competitive market-economy one could aggregate all products into a composite commodity. As Hicks has shown in his "Value and Capital," under not very restrictive assumptions, demand for this composite commodity still obeys basic demand laws. This allows a macroeconomic theory to be set up on a microeconomic foundation.

However, in a socialist economy, goods and services cannot be aggregated into a single commodity while keeping basic economic features unchanged. If all goods are composited into a single one, the so-called chronic shortage will disappear from the picture, for the firm will use its outputs as inputs to remove the shortage bottle-neck. It would be better to aggregate all goods into two, consumer goods and producer
goods, and assume the producer good is the shortage good. This does not mean the consumer good is not in short supply; it means the shortage of producer goods is much more decisive than that of consumer goods. This is so because it is at the early stages of production that the Soviet-type ownership structure stands at the center and most lowers the efficiency, causing chronic shortage. As reforms alleviate the shortages by improving efficiency, the separation between the two goods will be less important.

In order to get an aggregate production function showing decreasing returns to inputs, a particular hypothetical method, which I call the "selection axiom," is used. Suppose there exists an ordering of efficiency of firms in capital use and labor use respectively, given the capital and labor inputs in those firms. The selection axiom will put the first additional or marginal unit of total capital into the most efficient capital-use firm, and the second additional unit into the next most efficient capital-use firm, which may be the same firm that received the first unit, and so on. A similar procedure is followed for labor. When the resource is to be withdrawn from firms, the selection axiom is to pull out the first marginal unit from the least efficient firm, and so on.

Efficiency here is defined by the marginal productivity of factors. In this way, we can guarantee that the aggregate
production function has decreasingly positive marginal-output in the neighborhood of the initial level of total capital and total labor of the economy. It should be noticed this is automatically done in a perfectly competitive market economy where resources flow to the most efficient use. This is why I call it an "axiom." As a socialist reforming economy improves its efficiency, the selection will be more and more automatic rather than hypothetical.

Other aggregation problems such as adding up heterogeneous capital goods, or human capitals are also serious problems as in a market economy. To solve for these adding-up problems it would be justifiable to aggregate factors by their observed prices, which are distorted, to obtain the aggregate of "nominal factors" and to aggregate factors by their hypothetically existing general equilibrium prices to obtain the aggregate of "effective factors." As resource waste becomes less and less with market-oriented reforms, the deviation of effective from nominal factors will vanish.

Before one can successfully go into the deep water of modeling an economy, the above things must all be discussed and the necessary assumptions made.
4.3. Dualistic Prices in the Reforming Economy

In discussing the price mechanism, it is assumed (a) production can be aggregated and represented by two producers, one producing consumer goods and the other producer goods (the shortage goods), (b) both producers are monopolists in their sector.

In a reforming economy there are many pricing mechanisms. One is the traditional central-planning. Another is based on free-market equilibrium between demand and supply. The third type is called the "floating pricing" by Chinese economists, or "norm control" by Hungarian economists, and is a price free to change in a fixed range around a planned price.

The basis of a centrally planned price is production cost theory, accordingly, price is set equal to unit costs plus an average profit margin in each industry. There is an incentive for firms to report a higher cost in bargaining with the planner for a higher price.

The basis of a market price is in the equality between demand and supply. If the equilibrium price of a good is too high to be accepted, which would occur when demand is inefficiently high or supply is monopolized, the government will step in to regulate the price.

In an intermediate situation between central control and prices free to change, is the floating price. There are many
forms of floating pricing. One is that firms, after selling planned products to the State at planned prices can sell out-plan products at floating market prices. In the aggregate model, it is best to assume different combinations for different stages of reform. For China in 1985-1988 period, the combination was a floating price for the shortage good and a free-market price for the consumer good. Before 1985, it is proper to assume a centrally planned price for the producer good and floating prices for the consumer good.

The floating-price system is also called "dualistic pricing," since there exist more than one price for one commodity simultaneously. This is a central feature of a socialist reforming economy. Recently many economists in China asked for removal of the dualistic pricing system. However this is not realistic unless the transition from a pre-reform to a post-reform economy can take place in a very short period. The total abolition of dualistic pricing in China at this time implies a complete restoration of central planning, which is neither necessary nor possible.

The nature of dualistic prices is the diversification of the power of control over the shortage good. In a reforming socialist economy, if the power remains concentrated in the central planner, or is completely decentralized among firms, there will only be a single price for each good. Usually, then,
the centrally planned price will be too low and the completely decentralized price too high. The dualistic-price plays the role of generating profit-incentives to firms to increase their efficiency in production and consumption of the shortage good, while smoothing out strong shocks due to change in the pricing-mechanism.

4.4. Price Formation in the Dual-System

There are three prices in the aggregate model without investment, one for the consumer good, another for the shortage good, and the third one for labor services.

A consumer-choice model is needed to complete the price formation discussion. It should be noticed that a consumer theory is not as important as a producer theory in classical socialist economics. The consumer is not the sovereign unless market power is on the buyer's side.

Consumers are aggregated into one, with a total income equal to the wage rate multiplied by the available nominal labor time. Some of the consumer's labor is idled, but still paid at the same wage rate. The wage rate is exogenous to the consumer; determined by firms' demands for effective labor. The consumer makes decisions on demand for consumer goods and for leisure (or how much to work at each wage). Since a labor
market is missing, wage rates may be different in the two aggregate firms. And, the government allocates the consumer's labor time between the two firms, so movement to equalize wages is impossible. With reform more and more, movement between sectors becomes possible and the government's allocation role becomes less important. This picture may look strange to a Western economist but it seems realistic in socialist economies. It can be assumed or shown that the consumer's demand for the consumer good is downward sloping and supply of effective labor is upward sloping in this model.

Selecting one of the pricing-mechanisms listed in the previous section, the two firms and the consumer then inter-play to form three prices. The equilibrium prices are functions of degree of central planning in the shortage good allocation and in the nominal labor time allocation, since a part of the shortage good is transferred by the central planner from the shortage-good producer to the consumer-good producer at a planned price.

As reform goes deeper, the planned part of production shrinks and equilibrium prices change with it. Also changing are the utilization rates of labor and capital. The direction of price change is not determinate. Given the nominal labor time allocation, it depends mainly on two forces. First, as an increasing part of the output of the shortage-good producer
is sold at the market price, the incentives for the producer of the shortage good to utilize more efficiently its nominal labor and capital stock are stronger. This will help to increase the volume of the shortage good available in the economy. On the demand side, the producer of the consumer good, facing a higher price of producer good, will reduce the excess demand for the shortage good and enhance the efficiency in using the shortage good. Therefore, the price of the shortage good may go up and remain at a high level, if the price-stimulated efficiency in both producers cannot shift down the demand and the supply curve sufficiently. However, the price of the shortage good may go up first, then go down, if the improved efficiency finally balances out the price increases due to the liberation of prices. Similarly, the price of the consumer good may go up and stay there, if the price of producer good increases and the efficiency effect in the consumer-good production is not strong enough. And, the consumer-good price may go up, then go down, if efficiency improvement in using the shortage good can balance out its price increase. When the consumer-good price goes up, the consumer's real income will go down if the wage rate cannot catch up. This generates a need for consumer subsidies, resulting in an increasingly heavy burden to the government budget. If the wage rate catches up
with the consumer price increase, without improving productivity at the same pace, the costs of production will go up, adding more pressure on price increases.

In the Chinese reform process, the gap between the market price and the planned price of agricultural products shrunk with the introduction of economic reform policies during the 1978-84 period, a signal showing the desired interaction between the price liberation and efficiency improvement. However, the prices of industrial products during the 1984-88 reform period show an accelerating increase, a symptom of poor efficiency performance in this sector.

Among the many possible important macroeconomic issues for a socialist reforming economy, three have priority. First, the underutilization of resources is a prime target of socialist reforms, but is often not improved significantly during the reform. Second, the inflation rate during reform receives at least the same attention as in a market economy. Third, the increasing inequality of income distribution that often accompanies reforms is the killer of socialist reforms.

The intuitive analysis given above provides a useful way to approach the first two of these three macroeconomic topics in the economics of socialist reforms. It helps socialist economists to cope with the institutional problems in improving efficiency
at the firm level, while reforming the planning system at the macro-level.

4.5. Concluding Remarks

It seems through out the thesis that I have been trying to analyze a non-market economy using neoclassical tools which readers may think may not be suitable. But, what I am doing in fact is applying the fundamental principles of economics to a non-market economy. These principles must hold in any economy for the economy to be efficient, efficient in the sense that total output if aggregated as a single good is maximized with given inputs. This is the state where the marginal rates of substitution in terms of consumer's utility are equal in every sector for every pair of resources given to the economy. It has been shown that this state can be realized asymptotically in a free-market system, but it has not been shown whether it can or cannot be realized in any other system.

I respect the effort made in socialist countries to search for ways of improving all people's welfare equally. As Hayek acknowledged, pursuit for equality might be the only attractive reason for socialism. To me this reason is not the only one, the historical reason is also obvious, though too complicated to discuss. The existence of a socialist ownership structure,
especially of a Soviet-type one makes a transition to capitalism highly costly and not certain to have a net benefit, at least given the usual time horizon of societies. I take this as a more important reason for socialist countries to keep searching for reforms of the socialist type. It may be the case that the better way is to improve the system rather than destroy it. It is toward the improvement of efficiency in reforming socialist economies that I devoted this study.
In Chapter 3 Cobb-Douglas production functions were developed and estimated, partly as an application of the firm theory developed in chapter 1 and 2 and partly as an indirect test of this firm theory, based on analysis of the effect of long- and medium-term institutional arrangements. Within this framework, some special features of the Chinese economy were expected to influence production relations.

One such feature is the unemployment of fixed capital held and of labor, nominally employed by firms due to factor immobility, energy and material shortages and a large ineffective part of wages. The divergence of observed inputs from effectively used inputs has seriously biased previous estimations of Chinese production functions. With the conventional Cobb-Douglas estimation method, capital output elasticity tends to be over-estimated at the aggregate level and under-estimated at the firm level.
By introducing capital- and labor-utilization rates, and by recognizing that these rates are functions of the degree of shortage and of the wage rate respectively, the firm theory presented makes it possible to control for the unobservable internally unemployed capital and labor in production function estimations. This technique remarkably improved our estimates. With this change, the estimated Cobb-Douglas production functions show a normal value for capital and labor output elasticity.

Another feature that the theory presented suggests Chinese firms would show is the boundary condition of wage rates and energy-supplies. There is a dynamic process pushing the wage rate to the boundary. Since neither can move, workers' welfare requests put considerable pressure on managers' and influence their decisions about wages and bonuses. Workers in firms with lower wage rates press their managers to speed up the wage rate increase, despite often great differentials in productivity due to the immobility of capital and labor. This dynamic tends to push wages toward the upper limit, since there is little motivation to constrain them below that level.

The upper wage limits are usually set by the government, based on the social average wage level and the one-to-one firm-government wage bargaining procedure under the profit-wage linking policy. These upper limits are slow to change because
of the bargaining costs. As lower wage rates are raised, there is pressure to push the upper wage limit up to a higher level. With workers' welfare motivation modeled in Chapter 2 as the lower wage limit, the above dynamic explains why the lower wage limit tends to catch up to the upper wage limit and the upper wage limit tends to slowly increase as the lower limit catches up. When the two limits coincide, there will be very little room for the managers to pursue profits.

Further, there is a force driving the demand for and the supply of energy, materials, and transportation services toward a similar corner equilibrium. Both labor and capital growth will increase firms' demand for energy and materials. On the other hand, the supply of energy and basic materials tends to grow more slowly as the price distortions biased against these sectors remain. Thus, more investment funds, under the market-oriented reform policy, are attracted to the highly profitable manufacturing industries relative to the extractive, transportation and energy industries.

The corner equilibria of wages and energy supplies in firms implies that the observed wage and energy consumption are determined outside of firms, though they are modeled as endogenous variables. This implication further justifies the use of the observed wage rate and energy consumed in the
production function estimation, and itself is justified by the fact that there is no significant relation between the observed wage rate and other exogenous variables.

That wages are bonded in a narrow band by their limits is also supported by the small variance of average wages among firms in comparison with that of labor productivity as shown in Table 3.5.

During the reform, wages are no longer centrally planned, but have not yet become market regulated. This is a matter of fact, not a matter of hypothesis. Before the reform, analysis shows no meaningful connection between the growth rate of labor productivity and that of wages. While during the reform, it shows a definitely positive connection between the two, but with wages growing much faster than productivity. To reject the hypothesis of a market-regulated wage rate, we just need to look at Table 3.5. It is difficult to imagine such great differences in labor productivity in a market economy, or that, if in an adjustment period such differences still exist, they could be accompanied by such a small difference in wage rates. On the other hand, it is much easier to imagine this situation in a limited profit-oriented wage-determination system such as the one described in this thesis.

One contribution of this thesis is to model wage determination during the reform as a "big sandwich." At the bottom,
is workers' interest to push wages up. On the top is the government's interest to press wages down. The managers' decision concerns are then split into three pieces, the one at the bottom representing workers' interests, the one on the top for the government, and whatever is left in the middle for the pursuit of profit. A successful market-oriented reform should be able to make the middle piece larger and larger.

These two features, internal unemployment of capital and labor and the corner equilibria for wages and energy then further clarify the two statistical associations found in chapter 1.

The first association is that between capital productivity and the shortage of energy, which established the importance of energy shortages in determining the capital utilization rate. With the firm theory it can be predicted that the shortage of energy would lead to a long-term, corner equilibrium. Therefore capital productivity depends on the capital utilization rate with the latter depending on the degree of shortage in energy and materials. In this way the association is better understood than before.

The second association is that between labor productivity and the wage rate. The significance of the wage rate in the labor productivity regression suggested the important hypothesis that the labor utilization rate is a function of
the wage rate. The great variance in labor productivity corresponding to a relatively small variance in the wage rate then led to a further study on the process of wage determination in Chapter 2.

The firm theory developed in Chapter 2 and indirectly tested in Chapter 3 then was taken in Chapter 4 as the basis of establishing a micro- and, furthermore, a macro-economic theory for socialist market-oriented reforming economies. The main concerns in Chapter 4 include: (a) the aggregation problem, (b) the price formation procedure, and (c) the dynamic of resource utilization rates and price-movement during the reform period. The success of the reform requires the design of a proper policy-package to promote efficiency at the firm level while liberating prices from central control.

It can be seen that in the firm theory presented and the micro-macro theory outlined, the existence of shortages in energy, key materials, and transportation services played an important role. In fact, the firm theory developed here could be called a microeconomic theory of the shortages in a reforming economy. It is an attempt to be partially complementary to Kornai's microeconomic theory of the shortage which is basically for the unreformed economy. [1]
Appendix 1. Tables

Table 1.1. Dual Prices of Some Producer Goods in 1985

<table>
<thead>
<tr>
<th>Name</th>
<th>Unit</th>
<th>Planned Price (RMB)</th>
<th>Negotiated Price (RMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Iron</td>
<td>ton</td>
<td>265</td>
<td>500</td>
</tr>
<tr>
<td>Rolled Steel (small, round)</td>
<td>ton</td>
<td>600</td>
<td>1,300</td>
</tr>
<tr>
<td>Raw Coal</td>
<td>ton</td>
<td>32</td>
<td>80</td>
</tr>
<tr>
<td>Coke</td>
<td>ton</td>
<td>90</td>
<td>250-300</td>
</tr>
<tr>
<td>Cement (#425)</td>
<td>ton</td>
<td>90</td>
<td>140-150</td>
</tr>
<tr>
<td>Fertilizer (ammonia)</td>
<td>ton</td>
<td>410</td>
<td>700-800</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>ton</td>
<td>170</td>
<td>250</td>
</tr>
<tr>
<td>Alkaline</td>
<td>ton</td>
<td>390</td>
<td>650-750</td>
</tr>
<tr>
<td>Copper</td>
<td>ton</td>
<td>5,500</td>
<td>6,800</td>
</tr>
<tr>
<td>Aluminium</td>
<td>ton</td>
<td>2,700</td>
<td>5,300</td>
</tr>
</tbody>
</table>

Source: Personal data exchange.
Table 1.2.
Proportion of Out-of-the-Plan Sales in 11 Industries, 1985

<table>
<thead>
<tr>
<th>Name</th>
<th>in Value (%)</th>
<th>in Quantity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal power</td>
<td>2.61</td>
<td>2.13</td>
</tr>
<tr>
<td>Cotton spinning</td>
<td>23.49</td>
<td>23.39</td>
</tr>
<tr>
<td>Coal mining</td>
<td>24.90</td>
<td>23.33</td>
</tr>
<tr>
<td>Metal cutting machine</td>
<td>60.45</td>
<td>62.11</td>
</tr>
<tr>
<td>Sugar</td>
<td>32.43</td>
<td>32.44</td>
</tr>
<tr>
<td>Alkaline</td>
<td>27.92</td>
<td>26.38</td>
</tr>
<tr>
<td>T.V.</td>
<td>25.60</td>
<td>24.98</td>
</tr>
<tr>
<td>Paper</td>
<td>32.81</td>
<td>32.20</td>
</tr>
<tr>
<td>Bicycles</td>
<td>32.54</td>
<td>29.56</td>
</tr>
<tr>
<td>Steel rolling</td>
<td>23.30</td>
<td>18.21</td>
</tr>
<tr>
<td>Plastics</td>
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<td>47.51</td>
</tr>
</tbody>
</table>

Table 1.3.

<table>
<thead>
<tr>
<th></th>
<th>Cnst</th>
<th>logS1</th>
<th>logS2</th>
<th>logW</th>
<th>logQ</th>
<th>R²</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>-4.39</td>
<td>-1.03</td>
<td>0.90</td>
<td>0.17</td>
<td>0.86</td>
<td>0.86</td>
<td>98</td>
</tr>
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<td></td>
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<td>(-22.86)</td>
<td>(2.14)</td>
<td>(2.94)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS</td>
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<td>-0.54</td>
<td>-0.14</td>
<td>1.07</td>
<td>0.15</td>
<td>0.71</td>
<td>76</td>
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<tr>
<td></td>
<td>(-2.04)</td>
<td>(-8.06)</td>
<td>(-2.29)</td>
<td>(3.98)</td>
<td>(1.86)</td>
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<tr>
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<td>2.15</td>
<td>0.26</td>
<td>0.58</td>
<td>0.26</td>
<td>63</td>
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<td>(-4.33)</td>
<td>(3.15)</td>
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<td></td>
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</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>SG</td>
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<td></td>
<td>-0.09</td>
<td>0.43</td>
<td>0.43</td>
<td>45</td>
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<td>(-6.05)</td>
<td></td>
<td>(-9.39)</td>
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<tr>
<td>AK</td>
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<td>0.52</td>
<td>44</td>
</tr>
<tr>
<td></td>
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<td>(-3.13)</td>
<td>(-4.46)</td>
<td>(2.26)</td>
<td>(3.23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV</td>
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<td></td>
<td>1.29</td>
<td>0.13</td>
<td>0.55</td>
<td>0.55</td>
<td>38</td>
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<tr>
<td></td>
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<td></td>
<td>(1.84)</td>
<td>(3.91)</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td>0.35</td>
<td>0.35</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>(-6.31)</td>
<td>(-4.30)</td>
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<td>0.73</td>
<td>0.73</td>
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<td>(2.07)</td>
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<tr>
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<td>0.85</td>
<td>22</td>
</tr>
<tr>
<td></td>
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<td>(-2.01)</td>
<td>(-3.28)</td>
<td>(2.83)</td>
<td>(3.41)</td>
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Note: Dependent variable is log(Y/K₀), Y is net output, K₀ for nominal capital. Parentheses represent t-ratios. Cnst is constant term; S1 for degree of shortage of electricity; S2, degree of shortage of energy; W, wage; Q, gross output. N is sample size. TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
### Table 1.4.

**Estimation of Labor Productivity**

<table>
<thead>
<tr>
<th>Name</th>
<th>Cnst</th>
<th>logS1</th>
<th>logS2</th>
<th>logW</th>
<th>logQ</th>
<th>R²</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td>TP</td>
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<td>1.45</td>
<td>0.21</td>
<td></td>
<td>0.11</td>
<td>98</td>
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<tr>
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<td>(10.46)</td>
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<td></td>
<td></td>
<td>0.57</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>(-4.41)</td>
<td>(5.24)</td>
<td>(6.61)</td>
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</tr>
<tr>
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<tr>
<td></td>
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<td>(-1.60)</td>
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<td>(7.21)</td>
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<tr>
<td>TV</td>
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<td>(20.83)</td>
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<td>(1.92)</td>
<td>(5.00)</td>
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<td>(2.99)</td>
<td>(4.55)</td>
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</table>

Note: Dependent variable is log(Y/L₀), Y is net output, L₀ for nominal labor. Parentheses represent t-ratios. Cnst is constant term; S1 for degree of shortage of electricity; S2, degree of shortage of energy; W, wage; Q, gross output. N is sample size. TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
Table 3.1.

Estimation of the Non-Linear Cobb-Douglas

<table>
<thead>
<tr>
<th></th>
<th>Cnst</th>
<th>α</th>
<th>β</th>
<th>θ</th>
<th>γ</th>
<th>Loss</th>
<th>N</th>
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<tbody>
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<td>0.109</td>
<td>0.599</td>
<td>7.341</td>
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</tr>
<tr>
<td>CS</td>
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<td>0.253</td>
<td>0.738</td>
<td>0.695</td>
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<td>2.978</td>
<td>76</td>
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<tr>
<td>CM</td>
<td>0.698</td>
<td>0.503</td>
<td>0.468</td>
<td>0.322</td>
<td>0.917</td>
<td>5.026</td>
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<tr>
<td>MC</td>
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<td>0.308</td>
<td>0.560</td>
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<tr>
<td>SG</td>
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<td>0.232</td>
<td>0.751</td>
<td>1.333</td>
<td>0.568</td>
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<td>AK</td>
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<tr>
<td>TV</td>
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<td>0.348</td>
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<td>0.728</td>
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<td>0.566</td>
<td>0.163</td>
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Note: All coefficients are significant, with asymptotic t-ratios higher than 2.0. Dependent variable is logQ, Q is gross output. Cnst is for constant term; α, capital output elasticity; β, labor output elasticity; θ, output elasticity of degree of shortage of electricity; γ, wage output elasticity; Loss, sum of errors squared; N, sample size. TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
Table 3.2.

Estimation of Conventional Cobb-Douglas

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Note: Parentheses represent t- ratios. Dependent variable is logQ, Q is gross output. Constant is for constant term; K_o, nominal capital; L_o, nominal labor; N, sample size. TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
### Table 3.3.

**Estimation of Modified Linear Cobb-Douglas**

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<th>logEN</th>
<th>logW</th>
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<th>N</th>
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Note: Parentheses represent t-ratios. Dependent variable is log\(Q\), \(Q\) is gross output. Const is for constant term; \(K_o\), nominal capital; \(L_o\), nominal labor; EL, electricity used; EN, energy; W, wage; N, sample size. TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
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Note: Parentheses represent t-ratios. Dependent variable is logQ, Q is gross output. Const is for constant term; K₀, nominal capital; L₀, nominal labor; EL, electricity used; EN, energy; W, wage; N, sample size. TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
Table 3.5.

Basic Statistics of Nominal Labor Productivity and Wages

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Note: TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
Table 3.6.

Estimation of Labor Utilization Rate

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<th>Upper Bound of Labor Utilization Rate</th>
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<tr>
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Note: TP is for Thermal Power; CS for Cotton Spinning; CM, Coal Mining; MC, Metal Cutting Machine; SG, Sugar; AK, Alkaline; TV, Television; PP, Paper; BY, Bicycle; SR, Steel Rolling; PL, Plastics.
## Table 3.7.

### Inter-Firm Cobb-Douglas of U.S. Manufacturing, 1957

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<tbody>
<tr>
<td>Food and Kindred</td>
<td>0.618</td>
<td>0.536</td>
<td>0.90</td>
</tr>
<tr>
<td>Apparel and Related</td>
<td>0.289</td>
<td>0.501</td>
<td>0.93</td>
</tr>
<tr>
<td>Lumber and Wood</td>
<td>0.462</td>
<td>0.443</td>
<td>0.89</td>
</tr>
<tr>
<td>Paper and Pulp</td>
<td>0.345</td>
<td>0.669</td>
<td>0.99</td>
</tr>
<tr>
<td>Chemicals</td>
<td>0.209</td>
<td>0.801</td>
<td>0.89</td>
</tr>
<tr>
<td>Petroleum and Coal</td>
<td>0.291</td>
<td>0.673</td>
<td>0.94</td>
</tr>
<tr>
<td>Rubber and Plastic</td>
<td>0.358</td>
<td>0.716</td>
<td>0.98</td>
</tr>
<tr>
<td>Leather and Products</td>
<td>0.118</td>
<td>0.824</td>
<td>0.89</td>
</tr>
<tr>
<td>Primary Metals</td>
<td>0.303</td>
<td>0.764</td>
<td>0.90</td>
</tr>
<tr>
<td>Fabricated Metals</td>
<td>0.276</td>
<td>0.649</td>
<td>0.95</td>
</tr>
<tr>
<td>Machinery</td>
<td>0.269</td>
<td>0.763</td>
<td>0.98</td>
</tr>
<tr>
<td>Electrical Machinery</td>
<td>0.337</td>
<td>0.584</td>
<td>0.96</td>
</tr>
<tr>
<td>Transportation Equipment</td>
<td>0.252</td>
<td>0.887</td>
<td>0.96</td>
</tr>
<tr>
<td>Instruments</td>
<td>0.362</td>
<td>0.666</td>
<td>0.96</td>
</tr>
<tr>
<td>Mean</td>
<td>0.321</td>
<td>0.677</td>
<td></td>
</tr>
<tr>
<td>Stand. Var.</td>
<td>0.117</td>
<td>0.128</td>
<td></td>
</tr>
</tbody>
</table>

Source: From Hildebrand and Liu (1965). All coefficients are significant.
Appendix 2. Mathematical Appendix to Chapter 2

The model is:

\[
\max \{ J = Q - rK_0 - WL_0 - pM \}, \tag{A.1}
\]

s.t. \( Q = F(K, L), \quad \frac{\partial F}{\partial (\cdot)} > 0, \quad \frac{\partial^2 F}{\partial (\cdot)^2} \leq 0, \tag{A.2.a} \)

\[
\frac{\partial^2 F}{\partial K \partial L} \geq 0, \tag{A.2.b}
\]

\[
\left( \frac{\partial^2 F}{\partial K \partial L} \right)^2 \leq \frac{\partial^2 F}{\partial K^2} \frac{\partial^2 F}{\partial L^2}, \tag{A.2.c}
\]

\( K = K_0 \eta, \quad L = L_0 \xi, \quad 0 \leq \eta \leq 1, \quad 0 \leq \xi \leq 1, \tag{A.3} \)

\( \eta = \eta(M, K_0), \quad \frac{\partial \eta}{\partial M} > 0, \quad \frac{\partial \eta}{\partial K_0} < 0, \tag{A.4.a} \)

\[
\frac{\partial^2 \eta}{\partial M^2} \leq 0, \quad \frac{\partial^2 \eta}{\partial M \partial K_0} \geq 0, \quad \eta + K_0 \frac{\partial \eta}{\partial K_0} > 0, \tag{A.4.b}
\]

\( \xi = \xi(W), \quad \frac{d \xi}{d W} > 0, \quad \frac{d^2 \xi}{d W^2} \leq 0, \tag{A.5} \)

\( W_0 \leq W \leq W_1, \quad M \leq M_0. \tag{A.6} \)

The Lagrangian is:

\[
L = F(K_0 \eta(M, K_0), L_0 \xi(W)) - rK_0 - WL_0 - pM + \lambda_0 (W - W_0) + \lambda_1 (W_1 - W) + \mu (M_0 - M). \tag{A.7}
\]

Kuhn-Tucker conditions are:
\[
\frac{\delta L}{\delta W} = L_0 \frac{\delta F}{\delta L} \frac{dW}{dW} - L_0 + \lambda_0 - \lambda_1 \leq 0, \quad \lambda_0 \geq 0, \quad \lambda_1 \geq 0, \quad (A.8)
\]

for \( \frac{\delta L}{\delta W} < 0: \ W^* = W_0, \text{ if } \lambda_0 - \lambda_1 > 0, \quad (A.9) \)

or \( W^* = W_1, \text{ if } \lambda_0 - \lambda_1 < 0, \quad (A.10) \)

\[
\frac{\delta L}{\delta M} = K_0 \frac{\delta F}{\delta K} \frac{d\eta}{dM} - p - \mu \geq 0, \quad \mu \geq 0, \quad (A.11)
\]

if \( \frac{\delta L}{\delta M} > 0, \quad M^* = M_0, \quad (A.12) \)

\( W - W_0 \geq 0, \text{ if } > 0, \quad \lambda_0 = 0, \quad (A.13) \)

\( W - W_1 \leq 0, \text{ if } < 0, \quad \lambda_1 = 0, \quad (A.14) \)

\( M - M_0 \leq 0, \text{ if } < 0, \quad \mu = 0. \quad (A.15) \)

1) Interior Solution

For interior solution: \( W_0 < W^* < W_1, \) and \( M < M_0, \) the first-order conditions are:

\[
L_0 \frac{\delta F}{\delta L} \frac{dW}{dW} - L_0 = 0, \quad (A.16)
\]

\[
K_0 \frac{\delta F}{\delta K} \frac{d\eta}{dM} - p = 0. \quad (A.17)
\]

Solving for \( \vec{\alpha} = (W^*, M^*) \) as function of \( \vec{\alpha} = (K_0, L_0, M_0, p, W_0, W_1). \)

The second-order condition is:

\[
A = (\alpha_{ij})_{2x2} = D_{xx}^2 L < 0, \quad (A.18)
\]
\[ D^2_{xx}L = \begin{bmatrix} L_0 \partial^2 F \left( \frac{d\xi}{d\omega} \right)^2 + L_0 \frac{\partial F}{\partial L} \frac{d^2\xi}{d\omega^2}, & L_0 K_0 \frac{\partial^2 F}{\partial K \partial L} \frac{d\eta}{dM}, & L_0 K_0 \frac{\partial^2 F}{\partial K^2} \frac{d\xi}{dM} \\ L_0 K_0 \frac{\partial^2 F}{\partial K \partial L} \frac{d\eta}{dM}, & K_0 \frac{\partial^2 F}{\partial K^2} \left( \frac{d\eta}{dM} \right)^2 + K_0 \frac{\partial F}{\partial K} \frac{\partial^2 \eta}{dM^2} \end{bmatrix}. \]

Condition (18) requires:

\[ a_{11} < 0, \ a_{22} < 0, \ a_{11}a_{22} - a_{12}^2 = \Delta > 0. \]

Denote the matrix of derivatives of \( \bar{x}^* \) with respect to \( \bar{\alpha} \) by \( D_{\bar{\alpha}}\bar{x}^* \), comparative static analysis gives the following matrix equation:

\[ A \times D_{\bar{\alpha}}\bar{x}^* = B, \quad (A.19) \]

\[ B = (b_{ij})_{2 \times 5} = -D^2_{xx}L, \quad (A.20) \]

\[ -D^2_{xx}L = \begin{bmatrix} L_0 \frac{\partial^2 F}{\partial L \partial K} \frac{d\eta}{dM} (\eta + K_0 \frac{\partial \eta}{\partial K_0}), & L_0 \frac{\partial^2 F}{\partial L^2} \frac{d\xi}{d\omega}, & 0, & 0, & 0 \\ K_0 \frac{\partial^2 F}{\partial K \partial M} (\eta + K_0 \frac{\partial \eta}{\partial K_0}) + K_0 \frac{\partial F}{\partial K} \frac{\partial^2 \eta}{dM^2} + \frac{\partial F}{\partial \eta} \frac{\partial \eta}{\partial M}, & K_0 \frac{\partial^2 F}{\partial K^2} \frac{d\xi}{dM}, & 0, & -1, & 0, & 0 \end{bmatrix}. \]

By Cramer's rule, \( D_{\bar{\alpha}}\bar{x}^* \) is solved:

\[ \frac{\partial \bar{x}^*}{\partial M_0} = 0, \quad \frac{\partial \bar{x}^*}{\partial W_0} = 0, \quad \frac{\partial \bar{x}^*}{\partial W_1} = 0, \quad (A.21) \]

\[ \frac{\partial \bar{M}^*}{\partial M_0} = 0, \quad \frac{\partial \bar{M}^*}{\partial W_0} = 0, \quad \frac{\partial \bar{M}^*}{\partial W_1} = 0. \quad (A.22) \]

Equations (A.21) and (A.22) compose the comparative statics results of category 1 in chapter 2.
\[ \frac{\partial \omega_1^*}{\partial p} = \frac{-a_{12}}{\Delta} < 0, \quad (A.23) \]

\[ \frac{\partial M^*}{\partial p} = \frac{a_{11}}{\Delta} < 0, \quad (A.24) \]

\[ \frac{\partial \omega_1^*}{\partial K_\theta} = \frac{1}{\Delta} \left[ -b_{11} a_{22} + b_{21} a_{12} \right] \]

\[ = \frac{1}{\Delta} \left( K_\theta^2 L_0 \frac{\partial^2 F}{\partial K \partial L} \frac{\partial^2 \eta}{\partial K \partial M} \frac{\partial \eta}{\partial M} d\xi \right) \]

\[ + K_\theta L_0 \frac{\partial^2 F}{\partial K^2 \partial M} d\xi \left[ \left( \frac{\partial \eta}{\partial M} \right)^2 - \frac{\partial^2 \eta}{\partial M^2} \left( \eta + K_\theta \frac{\partial \eta}{\partial K_\theta} \right) \right] > 0, \quad (A.25) \]

\[ \frac{\partial \omega_2^*}{\partial L_0} = \frac{1}{\Delta} \left[ -b_{12} a_{21} + b_{22} a_{12} \right] \]

\[ = \frac{1}{\Delta} \left\{ K_\theta^2 L_0 \frac{\partial^2 F}{\partial K \partial L} \frac{\partial^2 \eta}{\partial K^2 \partial M} \frac{\partial \eta}{\partial M} d\xi \right\} + \]

\[ K_\theta^2 L_0 \left( \frac{\partial \eta}{\partial M} \right)^2 \frac{d\xi}{d\omega} \left[ \left( \frac{\partial^2 F}{\partial K^2 \partial \omega} \right)^2 - \frac{\partial^2 F}{\partial L \partial K^2} \right] < 0, \quad (A.26) \]

\[ \frac{\partial M^*}{\partial L_0} = \frac{1}{\Delta} \left[ b_{12} a_{12} - b_{22} a_{11} \right] \]

\[ = \frac{1}{\Delta} \left\{ -K_\theta^2 L_0 \frac{\partial^2 F}{\partial K \partial L} \frac{\partial \eta}{\partial L} \frac{d^2 \xi}{d\omega} \right\} > 0. \quad (A.27) \]

These equations compose category 2 of the comparative statics results presented in chapter 2.
\[ \frac{\partial M^*}{\partial K_0} = \frac{1}{\Delta} [b_{11} a_{12} - b_{21} a_{11}] \]

\[ = \frac{1}{\Delta} \left( K_0 L_0^2 \frac{\partial \eta}{\partial M} \frac{d \xi}{d \omega} \right)^2 \left( \eta + K_0 \frac{\partial \eta}{\partial K_0} \right) \left[ \left( \frac{\partial^2 F}{\partial \eta^2} \right)^2 - \frac{\partial^2 F}{\partial K^2} \frac{\partial^2 \eta}{\partial L^2} \right] \]

\[ - K_0 L_0 \frac{\partial^2 F}{\partial K^2} \frac{\partial \eta}{\partial L} \frac{d \eta}{d \omega} \left( \eta + K_0 \frac{\partial \eta}{\partial K_0} \right) \frac{d^2 \xi}{d \omega^2} \]

\[ - \frac{1}{\Delta} \left( L_0^2 \frac{\partial^2 F}{\partial L^2} \frac{d \xi}{d \omega} \right)^2 \left[ \frac{\partial \eta}{\partial M} + K_0 \frac{\partial^2 \eta}{\partial M \partial K_0} \right] \]

\[ + L_0 \frac{\partial F}{\partial K} \frac{d \xi}{d \omega} \left[ \frac{\partial \eta}{\partial M} + K_0 \frac{\partial^2 \eta}{\partial M \partial K_0} \right] \}

(A.28)

Both braces in (A.28) show a negative sign. The sum is indeterminate in sign. However by intuition, when nominal fixed capital rises the firm usually needs more energy and materials to run, therefore showing a positive correlation between nominal capital and demanded energy and materials. This composes category 3 in chapter 2.

2). Minimization of Inefficiency in Chinese Firms

Proving that an economy is efficient can be considered equivalent to showing that the total inefficiency is minimized in the economy. On the other hand, by showing that Chinese firms usually do not satisfy the conditions of inefficiency-minimization we can show that the firms are not efficient.

There are efficiency losses in the firm modeled in section 2.3, because, first, prices are distorted in the whole economy,
second, factor immobility and shortage cause underutilization of nominal capital and labor, third, the endogeny of wage rates to the firm generates inefficiency. If government is omniscient, it should be able to minimize the total efficiency loss by reassigning parameters to firms.

Any measurement of inefficiency must be related to some standard of efficiency. General equilibrium in a perfectly functioning market economy is efficient since it generates the outcome that marginal rates of substitution between any two factors are the same in every sector. The price system in the perfectly competitive market system is a mechanism to reveal the general equilibrium allocation which guarantees this law.

Given structures of resource endowment, technology, and tastes of people, there should exist a general equilibrium allocation, explicitly or implicitly in any economy. This idea will be taken as an axiom underlying the analysis that follows.

Suppose there are two factors, K and L, and a single output, Q, in a shortage-economy (short of M). Let the general equilibrium prices be r** for capital, w** for labor, 1 for the output (normalized in the general equilibrium system), and p** for energy and key materials.

For a firm described by the model in section 2.3, we can define efficient allocation of factors (K**, L**) by:
\[
\frac{\delta F}{\delta K} = r^{**}.
\]  
\[
\frac{\delta F}{\delta L} = w^{**}.
\]

From (A.29) and (A.30), we can solve \( K^{**} \) and \( L^{**} \), then solve for the efficient amount of the two behavioral variables, \( W^{**} \) and \( M^{**} \) as they are determined by:

\[
L^{**} = L_0 \xi (W^{**}).
\]  
\[
K^{**} = K_0 \eta (M^{**}, K_0).
\]

The first part of the efficiency loss in the firm is the value of idle factors (suppose there is no material and energy unemployment):

\[
T_1 = r^{**}(K_0 - K^{**}) + W^{**}(L_0 - L^{**}).
\]

The second part of the efficiency loss is the integration of difference between marginal social benefit and marginal social cost along the path from the actual state to the efficient state of the firm. This part of efficiency loss is:

\[
T_2 = \int_{(K, L)^{**}}^{(K^{**}, L^{**})} (MB - MC)(dK, dL).
\]

MB in (A.34) is marginal social benefit of a change in factor allocation, and MC marginal social cost of the change. Since we have assumed an implicit general equilibrium price system, MB can be expressed in terms of marginal output, i.e.:
\[ MB(dK,dL) = \frac{\partial F}{\partial K} dK + \frac{\partial F}{\partial L} dL, \]  
\[ (A.35) \]

and MC can be expressed as:
\[ MC(dK,dL) = r^{**}dK + W^{**}dL + p^{**}dM. \]  
\[ (A.36) \]

Assuming path-independence in the integration in (A.34), we choose the path as:
\[(K,L) \rightarrow (K^{**},L) \rightarrow (K^{**},L^{**}).\]

The total efficiency loss therefore is:
\[ T = T_1 + T_2 \]
\[ = [r^{**}(K_0 - K^{**}) + W^{**}(L_0 - L^{**}) + p^{**}(M - M^{**}) + F(K^{**},L^{**}) - F(K,L)]. \]  
\[ (A.37) \]

The explanation of (A.37) is straightforward. The value of the first bracket represents the waste of employed resources which would not have occurred if the firm is efficient. The second bracket represents the foregone value of the output that would have been produced if the firm is efficient.

\[ T \] is a function of parameters \( K_0, L_0, M_0, p, W_0, W_1 \) as defined in chapter 2. The government can control all but \( W_0 \) of these parameters to minimize total efficiency loss:
\[ \min_{\{K_0, L_0, M_0, p, W_1\}} T. \]  
\[ (A.38) \]

The first-order conditions are:
\[ \frac{\partial T}{\partial K_0} = 0 : r^{**} + p^{**} \delta_{K_0} M = \frac{\partial F}{\partial K} \delta_{K_0} K + \frac{\partial F}{\partial L} \delta_{K_0} L, \]  
\[ (A.39) \]
\[ \frac{\partial T}{\partial L_0} = 0 : \quad \psi' + p' \delta_{L_0} M = \frac{\partial F}{\partial K} \delta_{L_0} K + \frac{\partial F}{\partial L} \delta_{L_0} L, \quad (A.40) \]

\[ \frac{\partial T}{\partial M_0} = 0 : \quad p'' \delta_{M_0} M = \frac{\partial F}{\partial K} \delta_{M_0} K + \frac{\partial F}{\partial L} \delta_{M_0} L, \quad (A.41) \]

\[ \frac{\partial T}{\partial p} = 0 : \quad r'' + p' \delta_{p} M = \frac{\partial F}{\partial K} \delta_{p} K + \frac{\partial F}{\partial L} \delta_{p} L, \quad (A.42) \]

\[ \frac{\partial T}{\partial \nu_1} = 0 : \quad p'' \delta_{\nu_1} M = \frac{\partial F}{\partial K} \delta_{\nu_1} K + \frac{\partial F}{\partial L} \delta_{\nu_1} L. \quad (A.43) \]

The notation \( \delta_{i,j} \) here stands for the change in variable \( j \) corresponding to a small change in variable \( i \), which can be easily derived from the comparative static results obtained in Appendix 2. Meanings of the above conditions are clear, for each equation, the left hand side represents the marginal cost of changes in the parameter described by that equation and the right hand side is the marginal benefit due to that change.

The second-order condition for optimal solution to (A.38) is expressed by:

\[ D_{\delta T}^2 > 0, \quad (A.44) \]

which is a 5x5 matrix and strictly positive definite. \( \beta \) is the vector that equals \( \alpha \) but without parameter \( W_0 \). The economic meaning of (A.44) is not easy to be explained precisely because some elements of the matrix consist of third-order derivatives of functions \( F, \eta, \) and \( \xi \) with respect to their variables. But generally, equation (A.44) specifies some of the relations.
between decreasing marginal benefits resulting from changes in $\bar{a}$ and the interactive effects among changes in different parameters.

From the first-order conditions, it is easy to see that firms are efficient if:

$$\delta_{K_0} K = 1, \quad \delta_{L_0} L = 1,$$

and all other $\delta_i/s$ become zero. In this way (A.29) and (A.30) can be held.

Generally, firms do not satisfy these first-order conditions and therefore are not necessarily efficient from the viewpoint of society.
ENDNOTES

Endnotes to Chapter 1

1. The word "firm" will be used in this paper instead of "enterprise." However, Chinese firms are not true firms, they are executive units, to some degree, of the central planning commission. See the comparison in Ryntero Omiya, 1989.

2. Chen Kuan et. al. (1988) did point out the important effect of shortages on firms' working capital.

3. For a list of quantity and quality of outputs and inputs, see Bela Gold, 1955.

4. Articles on this topic are mainly from the western literature, A. Alchian, (1965); Alchian and Demsetz (1972); Jensen and Meckling (1976); Leibenstein (1982). From the Chinese literature, see Zhu Ron-Ji (1985); and Hao Xu-Guang (1988).

5. Economists from China and the Eastern European countries have largely contributed to this topic. See Dong Furen (1979), and 1985; Chen and Du (1988); Wen and Yu (1988); Cai (1988); Zhang (1989); and the reviews by Jiang Si-Dong (1989), and Liu Ji-Peng (1989).

7. The supply curve is derived from the seller's limited profit-maximization model. Corresponding to each upper-bound of regulated price there is an optimal quantity for the seller to produce. It is assumed here that sellers' monopolist power cannot influence the regulated price. Rigorous derivation of the demand and supply curve requires a whole economic theory of the firm during the reform period.

8. The same kind of firms in the U.S. would certainly make a loss if run at this rate.

9. The data are kindly provided by Mr. Wang Zhen-Zhi, head of Department of Costs and Prices, Institute of Financial Economics, Chinese Academy of Social Sciences.

10. For the proof of this point, see Layard and Walters, 1978; Hal R. Varian, 1984; and E. Silberberg, 1978.

11. There are other measures of fixed capital in the Census Data. One is called "installed industrial equipment" (IIE), and is based on the original value of the equipment directly used in the industrial production of the firm. The capital used in non-industrial activities is excluded from IIE. Another measure is the original value of machinery and equipment in productive fixed capital (MPFC), which excludes the value of non-productive fixed
assets (e.g., houses, roads, etc.) or other non-machinery facilities from the productive fixed capital. IIE includes rent-in assets and excludes lease-out assets. However IIE does not include the assets used in services. MPFC covers all productive equipment including any used in productive services. However, IIE and MPFC (and productive fixed capital, PFC) are measures of gross values. For most industries under consideration, the three measures are highly correlated. In this paper the net value of fixed capital ($K_0$) will be used instead of the others. By its nature, capital productivity in terms of net output per unit of net fixed capital will convey more information about the firm efficiency than if the gross value measure of IIE or MPFC are used.

12. If the proportions of redundant workers and non-productive capital are similar across firms, they will not affect the relative productivity.

13. Table 1.2 is based on a broad classification of which large and medium firms comprised only a very small percentage. Since the State controls most of the large and medium firms, a much higher proportion of sales in those firms than shown in Table 1.2 is under the control of the State.
14. In socialist countries, encouraging intensive expansion rather than extensive expansion is considered the best medicine for reform-linked inflation, since it enhances supply while depresses the over-demand.


16. Proportion of purchased fuel and power in total production cost is over 7.0% in categories III and IV, and between 0.10% and 4.30% in I and II. The criterion of market conditions or demand vs supply situation of those industries is based on the author's reading of Chinese economic literature. It is supported by the Census Data too. For example, the utilization rate of T.V. and Cotton Spinning industries was below 75% in 1985, while the utilization rate of Coal Mining and Alkaline industries was over 100%.

17. Notice that energy is extremely lowly priced in China; this energy expenditure would represent a 30% production cost without price distortion.
Endnotes to Chapter 2

1. This is a terminology used by Kornai (1980). Managers of firms, leaders of superior departments, officials of ministries have strong interests in expansion of the domain under their control. Expansion could be in terms of fixed assets, financial power, or total employment, depending upon the concrete situation.

2. The deprivation of the depriver, or the removal of private owners of productive means, is thought by Maxists a pre-condition of direct combination of laborers and productive means. The latter is thought an assurance for socialist equality among people.

3. The freedom of a seller-firm to raise price and the soft-budget constraint to a buyer-firm to accept the price would make any shortage impossible. This logic makes Goldfeld and Quandt (1988) believe that the hypothesis of soft-budget constraint cannot explain the existence of shortage. This shows the importance of a more precise definition and deeper understanding of the concept of shortage to a student of socialist economy.

4. This is the hottest topic in economic discussions in China recently. Many plans, including establishment of stock market, allowance of equity issuing, private and collective investors, etc., have been suggested and
experimented, there is hope in this kind of practice. Recently, the revolution in Eastern Europe brings us another opportunity to see how this ownership problem will be solved.

5. The transferability is still possible. In order to utilize those idle equipments, the central planning authority calls a meeting where various departments report the amounts and types of assets in their inventories and trade for the ones they need. Since effect of this meeting is not very significant and the interval between two meetings is too long, usually more than one year, it is safe for a short-term model to assume that assets cannot be transferred.

6. In many cases, the limited fund for investment has to be split among many powerful departments, duplicating many under-economic-scale therefore old-technology-embodied plants. This phenomenon is called by economists from the Chinese Economic System Reform Research Institute (CESRRI) the "small and old tree" projects.

7. A great Chinese scholar, Lin Yu-Tang, did a clear analysis on this topic fifty years ago (Lin, 1939).

8. As profits are partly retained in firms, the central planning has to pass part of investment power down to
either local governments or firms. This was one of the most important step in enlarging firms' autonomy in China.

9. The cooperation and benefit-dividing between central and local governments are traditional in China. Since the country is large, a principle of federalism has been implicitly working against the centralization efforts made in the long Chinese history.

10. For a thorough review of the responsibility systems and their effects on firm behavior, see Liu, 1989.

11. Hua, Zhang, and Luo (1988) have noticed this effort-minimization of managers as a feature of Chinese economy.

12. Notice here that price of capital $r$ has no effect on any of the firm's decisions because the cost of nominal fixed capital is sunk to the firm, due to the immobility of capital.

13. Fang and Wu (1989) reported that the growth rate of loss made by industrial firms was -8.9% in 1984, 18.3% in 1985, 78.7% in 1986, and 16.9% in 1987. And, the proportion of the firms making loss in total industrial firms was 10.7% in 1984, 10.8% in 1985, 13.1% in 1986, and 14.4% in 1987.
14. Wang Yunguo (1989) reported that at the national level this wage difference was from 19.7 yuan to 2.8 yuan per month, depending on job-tenures.

15. Zhong Jiyin (1990) reported that the ratio of the former to the latter was 1.21 in 1980 and 1.13 in 1987. And, this ratio was further decreased to 1.09 in 1988 (State Statistical Bureau, 1989c). Du et al (1990) also found that the wage rates of managers and technicians have been lowered relatively to that of workers.

16. For example, does there exist an aggregate production function with positive and non-increasing marginal product of factors? How would wage rates be aggregated into a single variable? What is the meaning of aggregate demand and supply? To the author's reading, answers to these questions have not yet been worked out.

17. The deprivation of the depriver, or the removal of private owners of productive means, is thought by Maxists a pre-condition of direct combination of laborers and productive means. The latter is thought an assurance for socialist equality among people.

18. The freedom of a seller-firm to raise price would make any shortage impossible. This logic makes Goldfeld and Quandt (1988) believe that the hypothesis of soft-budget constraint cannot explain the existence of shortage.
This shows the importance of a more precise definition and deeper understanding of the concept of shortage to a student of socialist economy.

19. This is the hottest topic in economic discussions in China recently. Many plans, including establishment of stock market, allowance of equity issuing, private and collective investors, etc., have been suggested and experimented. Recently, the revolution in Eastern Europe brings another opportunity to see how this ownership problem can be solved.
Endnotes to Chapter 3

1. A logistic function is like:

\[ y = \frac{a}{1 + be^{-cx}} \]

and the functional form for \( \eta \) is like:

\[ y = \frac{\alpha \theta}{1 - ce^{dx}} \]

2. In fact, substituting (3.1), (3.2), (3.3) into the mathematical expression of (2.10) in Appendix, we get:

\[ \gamma < \frac{L_0}{L_0 + \beta - 1} \]

\[ 1 - \alpha \theta > 0, \]

\[ \gamma[\alpha \theta(\beta - 1) + 1] < \frac{L_0(1 - \alpha \theta) - \beta \gamma}{L_0 - 1} \]

Usually, \( L_0 \) is much larger than the parameters, therefore a good enough approximation to these conditions can be obtained by dividing \( L_0 \) in the numerator and denominator of above equations, and we get (3.11), (3.12), and (3.13).

3. In fact, we have:

\[ \epsilon_i = u^i_k + (1 - \theta)(1 - \theta) \log K^i_0 + \theta \log M_i \]

\[ + u^i_k[ \log b_i + \beta \log L_0 - \gamma \log W_i ] + v^i_s[ \alpha \log M_i - \alpha \log K^i_0 ] \]

\[ + v^i_w \beta \log W_i + u^i_k v^i_s[ \log M_i - \log K^i_0 ] + u^i_k v^i_w \log W_i. \]
It can be seen that the error term in (3.22) has a zero mean and a limited variance.

4. There are ten volumes of aggregate data published recently, and more than twenty volumes of industrial-level data available to scholars in China. There is also a nine-volume version of firm-level data only available to "insiders." The data set used in this work is from Vol. 1 and 2 of the insider-version.
Endnotes to Chapter 5

1. Brabant (1990) concluded that: "Kornai's shortage theory (1980) is essentially a microeconomic theory." He also criticized that Kornai "essentially takes the institutional and policy framework of the unreformed centrally planned economy for granted and derives implications for economic performance, relying chiefly on the peculiar behavior of the firm in such an economy."
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