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Input Shortages in Mixed Economies: An Application to Indian Manufacturing Industries

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Abstract

Widespread shortages in key inputs are common in mixed economies of developing countries. These shortages appear to occur at the same time that relatively high rates of capacity underutilization in manufacturing industries are observed. This paper develops a simple model which explains the existence of excess capacity when there are quantitative restrictions on key inputs. This model is tested using data for manufacturing industries in India, and the results indicate that shortages in domestic rather than imported inputs imposed binding constraints on capacity utilization rates.

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Contents

I. Introduction

Shortages of key inputs in the production process are widespread in many developing countries, particularly those with mixed economic systems. Pervasive shortages have been observed in the provision of infrastructural facilities, imported inputs, and varied industrial components, among others. The emergence of such shortages may be directly traced to the planned industrial structure and the regulatory policy environment that are peculiar to mixed economies.

A mixed economy is typically characterized by the coexistence of public and private sectors within a single economic system. The public sector usually has the responsibility of controlling the "commanding heights of the economy" and, therefore, has the onus of providing the infrastructural facilities required for industrialization. The private sector's industrial investments are directed by the state via a complex regulatory system. The Soviet planning model is a precursor of such a system, which is based on the belief that the broad objectives of growth with social justice and self-reliance necessitate a centrally planned industrial strategy.

The private sector operating in this highly regulated environment frequently obtains its supply of essential inputs from the public sector either directly from state-owned enterprises, or indirectly, as in the case of imported inputs, from foreign trade organizations. For reasons which are now well established the supply of these inputs is not fully responsive to demand conditions. Administered pricing and lack of economic incentives to managers and workers, among other reasons, hinder appropriate responses of state-owned enterprises to market signals. In addition, restrictive trade policy regimes in the garb of protecting infant industry and economizing on foreign exchange, frequently involve the imposition of quantitative restrictions on imported inputs. Shortages in government regulated inputs have occurred at the same time that relatively high rates of capacity underutilization in manufacturing industries are observed.

Excess capacity in the face of capital shortages in supposedly capital-scarce developing countries is not only puzzling but also worrisome. The purpose of this paper is to explain the phenomenon of capacity under-utilization when there is some form of quantitative restriction on inputs --whether they are recurrent shortages of domestic inputs or quotas on imported inputs. 1/ It has been demonstrated, for example by Sahay (1990b), that when licenses for imported inputs are distributed on the basis of installed capacity it is likely that excess capacity will result. 2/ Firms are shown to invest in additional capacity, not because this is needed

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1/ Excess capacity and capacity underutilization will be used interchangeably in this paper.

2/ Major research projects by OECD (Little et al. (1970)) and the NBER (Bhagwati, (1978)), highlight this fact for many countries.

to produce additional output, but because it guarantees a more generous allocation of inputs.

This paper tests the implications of the model in Sahay (1990b) by generalizing it to include both imported and domestic inputs. 1/ Specifically, it tests the impact of input shortages in manufacturing industries on capacity utilization in India. India is a good example to illustrate the problem being analyzed for two important reasons. First, shortages of essential inputs have been well documented (Ahluwalia, 1985, and Bhagwati and Srinivasan, 1978) since India adopted a planned process of development in 1951. Second, available data indicates the persistence of relatively high rates of capacity underutilization in manufacturing industries. This paper intends to test the relationship between quantitative restrictions on inputs, whether domestic or imported, and the degree of capacity utilization in these industries.

The analysis presented in this paper also has policy implications for industrial and trade reforms taking place in Eastern Europe. Underutilization of capacity is believed to have been prevalent in centrally planned economies (CPEs). Managers of state enterprises in CPEs are primarily required to meet physical production targets (often gross output) where performance is evaluated according to whether plans are fulfilled or exceeded. These managers, then, have a vested interest in bargaining for the least ambitious output plan as well as overstating the resources requirements. Since input costs are irrelevant, a natural consequence is hoarding of factors of production by state enterprises, including building of excess capacity. Moreover, it is often said that the size of an enterprise (measured in terms of installed capital) is positively related to the prestige of its managers. As these economies now embark on a liberalization process, including privatization of some sectors, the transitional phase is likely to mirror a mixed economic system. Given that foreign exchange and domestic input shortages are likely to persist during the transition, the temptation to impose quantitative restrictions would be strong. As will be apparent from the analysis presented in this paper, if such a course of action is pursued firms will continue to build excess capacity.

In Section II, a theoretical model for analyzing the effects of quantitative restrictions on inputs is developed in the context of a perfectly competitive framework. The existence of excess capacity in equilibrium is shown when input quotas are binding. The industrial environment in India, particularly relating to input availability in the manufacturing sector, is discussed in Section III. In Section IV, the

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1/ The analysis presented in this paper may be related to previous research in three broad areas: capacity underutilization, imposition of quantitative restrictions, and focus on inputs in the production process. A detailed survey of the relevant theoretical literature is presented in Sahay (1990b).

model is tested using data on capacity utilization and some measures of shortages in rail services, electricity services, and imported inputs in 17 manufacturing industries. The empirical results show that even though Indian manufacturing industries may frequently have been subject to shortages in both domestic and imported inputs, it was domestic inputs rather than imported inputs that were the binding constraint and imposed the upper limit on capacity utilization rates during the period studied. Some conclusions and policy implications are contained in Section V.

II. The Theoretical Framework

Variations in capacity utilization rates have typically been explained by variations in demand conditions. 1/ To examine the existence of excess capacity despite unchanged demand for the final output, a one-period model with many industries, each producing a final output with m intermediate inputs x^i, and capital, k, is developed. 2/ The final output of each industry is completely protected either by an outright ban on imports or by prohibitive tariffs. Thus only domestic demand and supply conditions affect the price of the final output in each industry. On the other hand, firms in each industry face quotas on the m intermediate inputs x^i. The link between intermediate input allocations and installed capital may either be explicit, as in the case of quotas on imported inputs that are based on installed capital, or implicit, as is the case when firms facing domestic input shortages receive their share of inputs in proportion to their size, the latter being measured in terms of installed capital.

The number of sellers in a typical industry, g, is fixed at a level n_g. The sellers in each industry, g, produce a standardized product, y_g. To capture capacity underutilization in a model that can be empirically verified, a simplifying assumption of no substitution possibilities among inputs is made.

The production function of each firm in each industry is

$$y_g = \min[\alpha_g^1 x_g^1, \alpha_g^2 x_g^2, \ldots, \alpha_g^m x_g^m, \beta_g k_g], \quad g = 1, 2, \ldots, G.$$

where y_g is output of a representative firm in the gth industry, x_g^i, $i = 1, 2, \ldots, m$, is the ith intermediate input of this firm in the gth industry, and k_g is the capital stock of this firm in the gth industry.

1/ This is particularly true in the literature on business cycles. For example, Lucas (1970) explicitly models capacity underutilization to explain the procyclical movement of real wages with business cycles.

2/ A perfectly elastic supply of labor is assumed. However, a labor input can be easily incorporated into the model without affecting the main conclusions.

For notational convenience the subscript g is dropped and it is assumed that a typical industry is being observed. Henceforth,

$$y = \min[\alpha^1 x^1,\ \alpha^2 x^2,\ \ldots,\ \alpha^m x^m,\ \beta k].$$

The industry's inverse demand function is given by

$$P = D(Y), \quad \text{where} \quad D'(Y) < 0, \quad \text{and} \quad Y = \Sigma_n y,$$

where n represents the number of firms in a typical industry, and inputs are assumed to be purchased at given prices: $P_x^1,\ P_x^2,\ \ldots,\ P_x^m,\ P_k.$

Before outlining the model with quotas on intermediate inputs, the benchmark case with no regulations is illustrated to contrast the results obtained in the former.

1. Benchmark Model

This is the case with no restrictions on foreign or domestic inputs. The typical firm solves the following problem: 1/

$$\max_{y,x^i,k} \pi = Py - \textstyle\sum_i^m P_x^i x^i - P_k k. \qquad (1)$$

subject to

$$y = \min[\alpha^1 x^1,\ \alpha^2 x^2, \ldots,\ \alpha^m x^m,\ \beta k]. \qquad (2)$$

When firms minimize costs subject to Leontief production functions, firms choose x^i and k such that

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1/ Capital is assumed to be a reversible decision here, in the sense that capital can be costlessly traded and firms rent it at a price, P_k. This is the least restrictive assumption that can be made in the context of explaining underutilization of capacity. The point being stressed here is that even if capital were a reversible decision, excess capacity in equilibrium still remains a possibility.

$$x^i = y/\alpha^i, \qquad i = 1, 2, \ldots, m.$$

and

$$k = y/\beta.$$

Hence the problem is reduced to

$$\max_y \ \pi = Py - \Sigma_i^m P_x^i y/\alpha^i - P_k y/\beta.$$

Competitive equilibrium implies

$$P = \Sigma_i^m P_x^i/\alpha^i + P_k/\beta,$$

or,

$$D(Y^*) = \Sigma_i^m P_x^i/\alpha^i + P_k/\beta, \qquad (3)$$

where Y* is the level of aggregate output of the industry facing no government regulations. In other words, the price of the final output is simply a linear combination of the input prices. Equation (3) is the benchmark against which comparisons of the results in the model with quantitative restrictions on inputs will be made.

2. Model with Quantitative Restrictions on Intermediate Inputs

Let quotas on each input, x^i, be based on capacity creation. Let the quota allocation rule be,

$$x^i \leq \theta^i k, \qquad i = 1, 2, \ldots, m.$$

where θ^i is an input-specific policy parameter exogenously set by the regulating authority, which determines the level of x^i supplied to a typical firm and which is based on installed capacity. 1/ The interesting case, which is analyzed in this section, is one where at least one quota is binding. 2/ The problem facing a typical firm is:

$$\max_{y, x^i, k} \pi = Py - \Sigma_i^m P_x^i x^i - P_k k \tag{4}$$

subject to

$$y = \min[\alpha^1 x^1, \alpha^2 x^2, \ldots, \alpha^m x^m, \beta k]. \tag{5}$$

and

$$x^i \leq \theta^i k, \qquad i = 1, 2, \ldots, m. \tag{6}$$

If at least one quota binds, this implies: 3/

$$k = \max_i \{x^i/\theta^i\}, \tag{7}$$

or,

1/ The model at this stage could be enriched by introducing uncertainty in the supply of domestic and imported inputs. This is often true when, for example, there are unexpected power shortages or delays in transportation services. Such an exercise, however, would needlessly complicate the simplicity of the model and is postponed for the empirical section where its introduction is warranted.

2/ Note that if this were not the case, the solution would be the same as in the benchmark model discussed above.

3/ Equation (7) would, of course, also hold if more than one quota were binding. In this case the capital installed would be determined by the most restrictive quota.

$$k = \max_i \{y/\alpha^i\theta^i\}, \tag{8}$$

where y is the level of output produced by the typical firm. On the other hand, if none of the quotas are binding,

$$k = y/\beta. \tag{9}$$

In the general case, the optimal level of capital that would be installed is

$$k = \max\,[\max_i \{y/\alpha^i\theta^i\},\ y/\beta] \tag{10}$$

or, the optimal level of capital per unit of output is

$$k/y = \max\,[\max_i \{1/\alpha^i\theta^i\},\ 1/\beta] \tag{11}$$

If at least one quota is binding

$$\max_i \{1/\alpha^i\theta^i\} > 1/\beta \tag{12}$$

or,

$$\beta > \min_i \{\alpha^i\theta^i\}. \tag{13}$$

The optimization problem facing the firm when at least one quota is binding is,

$$\text{Max } \pi = Py - \Sigma_i^m P_x^i y/\alpha^i - P_k.\max\{y/\alpha^i\theta^i\}.$$

In equilibrium,

$$P = \Sigma_i^m P_x^i/\alpha^i + P_k.\max_i\{1/\alpha^i\theta\}.$$

or,

$$D(Y_{(Q)}^*) = \Sigma_i^m P_x^i/\alpha^i + P_k.\max_i\{1/\alpha^i\theta^i\}. \tag{14}$$

where $Y_{(Q)}^*$ is the level of aggregate output in the industry when there are quantitative controls on inputs. The existence of excess capacity in equilibrium when at least one quota is binding is now easily established. From the production function (equation (2)), used capacity equals $Y_{(Q)}^*/\beta$ and from equation (8), installed capacity equals $Y_{(Q)}^*/\min\{\alpha^i\theta^i\}$. Therefore, capacity utilization equals used capacity/installed capacity or,

$$\text{capacity utilization} = (1/\beta)\min_i\{\alpha^i\theta^i\}. \tag{15}$$

The interesting case is one where at least one quota is binding, that is, when $\beta > \min_i\{\alpha^i\theta^i\}$ (equation (13)). Given $\alpha^i, \theta^i, \beta > 0$, there is excess capacity being created. A comparison of the level of the final output, its price, and capacity utilization in the benchmark and the input quota cases indicate that since $\beta > \min_i\{\alpha^i\theta^i\}$, $D(Y_{(Q)}^*) > D(Y^*)$, and $Y_{(Q)}^* < Y^*$. That is, the output price is less (and correspondingly the level of output is higher) in the benchmark case. Also, since K^* equals Y^*/β and $K_{(Q)}^*$ equals $Y_{(Q)}^*/\min\{\alpha^i\theta^i\}$, the relative size of the installed capacity cannot be determined. 1/ This is because $Y_{(Q)}* < Y*$ but $\beta > \min(\alpha^i\theta^i)$. What is evident however is that input quotas leads to capacity underutilization, unlike in the benchmark model.

The next step is to test the hypothesis that quotas or shortages in intermediate inputs lead to capacity underutilization. In the context of the model presented in this section, equation (15) will be estimated using data drawn from the period 1973-85 on Indian manufacturing industries. Before proceeding to the empirical analysis, the policy environment and the institutional framework in India are described.

III. Institutional Framework in India

Portraying the institutional framework at this stage serves the dual purpose of describing the policy environment that a typical private sector firm faces and justifying the choice of the independent variables used for testing the model. Specifically, the industrial and import licensing procedures are explained, shortages in the explanatory variables are discussed, and data on capacity utilization rates are presented. The evidence appears to support the hypothesis that there is a link between shortages in inputs and capacity utilization. 2/

1. Licensing System

Since 1951, India's industrialization has been promoted and regulated within a planning framework. While government controlled monopolies have been responsible for supplying the infrastructure and key heavy industry inputs, the activities of the private sector, which are concentrated in light industrial goods and consumer goods, are governed by the state through industrial and import licensing. In accordance with national priorities, the relevant regulatory authorities issue industrial licenses for installing capacity in different production units.

The import licensing system is an elaborate mechanism which directly controls the allocation of foreign exchange to different sectors in the economy. There is no official documentation of the imported input quota allocation rules used by the authorities, but it is possible to infer their nature. A typical procedure for obtaining an imported intermediate good is the following: the importer presents to the relevant government authority the industrial license for the good he produces. On the submission of this license, and depending on the category of the goods imported, the manufacturer is issued an import license. Since the industrial license stipulates the installed capacity, intermediate imports permitted ultimately get linked to installed capacity. Bhagwati and Desai, (1970, p.326) and

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1/ K^* and $K_{(Q)}*$ are the equilibrium level of capital installed in the industry in the benchmark and input quota cases, respectively.

2/ For a detailed documentation of the institutional and policy framework in India, see Sahay (1990a).

more recently, Srinivasan (1987) and Marathe (1986), have also highlighted the link between imported input quota allocations and installed capacity and suggest that such a system encouraged overbuilding of capacity.

The link between shortages in domestic inputs and installed capacity may also be derived indirectly. The private manufacturer obtains the domestic inputs supplied by state enterprises on the basis of the industrial license (which specifies the capital installed). It is reasonable to expect that in periods of shortages this firm is likely to experience a shortfall in proportion to its demand for those inputs. In fact, a firm experiencing recurrent shortages is likely to install more capacity because a higher capacity provides access to more inputs which implies more output and more profits.

2. Input Shortages

The inputs considered here include: (a) imported inputs; (b) rail services input; and (c) electricity services input. Imported inputs are included because quantitative restrictions on these have been widespread in India and it would be interesting to verify the observation (made in the OECD (1970) and the NBER (1978) studies) that quotas on imported inputs lead to capacity underutilization. Among the domestic inputs, rail and electricity services have been singled out because they are supplied by government controlled monopolies, are essential inputs in the production process, face administered pricing, and shortages of these appear to be common in India.

Import licensing has been an invariant feature of the Indian economy. However, there is no a priori reason to believe that license requirements for imported inputs necessarily imply shortages. The relevant question to ask is whether the quotas implied by the licensing mechanism were binding or not. The possibility of shortfalls in imported inputs is merely inferred by noting that India has faced perpetual foreign exchange shortages (and therefore it is likely that demand for imported intermediate inputs has exceeded their supply), and that the presence of black markets in import licenses have been a continuing cause for concern among policymakers. It is also worth mentioning that the elaborate administrative machinery involved in distributing the imports evolved into an excessively time consuming allocating entity. Hence, even if firms were allocated quotas sufficient to utilize existing capacity fully, the long delays between the submission of the request and the issue of the import license were equivalent to additional quotas on imported inputs.

Documentation of shortages in rail and electricity services is available in various government publications and Ahluwalia (1985), among others. Ahluwalia's study extensively documents the long-term trends in industrial performance, including the trends in rail and electricity services for the period 1956-57 to 1981-82. High industrial growth was observed during 1955-65 reflecting ambitious public investment programs in heavy industries and the impetus given to import substitution. Ahluwalia (1985) provides evidence for slow growth of light industries throughout the period studied and a definite decline in the pace of growth of heavy industries since the mid-sixties. In fact, it is argued in that study that the brunt of the slowdown in the latter period was borne by the infrastructure sectors, that is the railways and electricity.

The decrease in the priority given to railways in the Five Year Plans over time are verified by observing that the share of railways in planned public investment which accounted for 23 percent in the Second Five Year Plan (1956-61) declined to five percent in the Sixth Five Year Plan (1980-85). Between 1973-74 and 1979-80 the growth in railway freight traffic was on average slower than the GDP growth rate. In particular, in 1973-74 and 1978-79, the growth of railway services declined while total GDP as well the industrial sector's growth rates increased. It could possibly be argued that there may have been a substitution away from railway services into some other mode of transportation. However, the record of outstanding registrations for goods and services for the Indian Railways shows a substantial backlog, and Ahluwalia (1985, page 93) concludes that a deceleration of railway freight traffic was more a reflection of supply constraints than a slackening of demand for railway services.

Power shortages were recurrent and substantial during the 1970's and the early 1980's. The supply shortages in power are well documented in various annual issues of the Economic Survey, Government of India. According to official sources, the estimated deficit in the power availability as a percentage of demand averaged 10.6 percent during 1973-1985.

3. Evidence on Capacity Underutilization in India

Besides the problem of data availability, a major hinderance in documenting capacity utilization rates in India is the absence of a meaningful measure of these rates. In this sub-section some of these issues are addressed, and the U.S and Indian data are compared to highlight the persistence of capacity underutilization in India.

The Center for Monitoring the Indian Economy (CMIE, 1986) provides some estimates which show that between 1972 and 1985 the capacity utilization rates for manufacturing industries in India have varied between 71.1 percent and 79.2 percent (Table 1). The corresponding figures for the United States are 70.3 percent and 84.6 percent. These figures would indicate that there is only a marginal difference between the Indian and the U.S. capacity utilization rates. However, a direct comparison between the two rates cannot be made since the methodology used in computing the rates in the two countries is not the same. The most significant difference is that in India the rates can exceed 100 percent, while in the United States the rates, by definition, cannot. The Indian government in fact allows the private sector to produce up to 125 percent of installed capacity. There-

Table 1. Capacity Utilization Rates--India & USA
Index of Capacity Utilization in Manufacturing Industries

	(1)	(2)	(3)	(4)	(5)
Year	U.S.	India-1	Col(2) minus Col(1)	India-2	Col(4) minus Col(1)
1972	82.8	79.2	-3.6	63.4	-19.4
1973	87.0	76.8	-10.2	61.4	-25.6
1974	82.6	72.0	-10.6	57.6	-25.0
1975	72.3	73.1	0.8	58.5	-13.8
1976	77.4	72.5	-4.9	58.0	-19.4
1977	81.4	71.1	-10.3	56.9	-24.5
1978	84.2	75.1	-9.1	60.1	-24.1
1979	84.6	75.4	-9.2	60.3	-24.3
1980	79.3	73.3	-6.0	58.6	-20.7
1981	78.2	75.5	-2.7	60.4	-17.8
1982	70.3	74.2	3.9	59.4	-10.9
1983	73.9	73.0	-0.9	58.4	-15.5
1984	80.5	75.2	-5.3	60.2	-20.3
1985	80.1	76.6	-3.5	61.3	-18.8
Average	79.6	74.5	-5.1	59.6	-20.0

Source: 1. "Capacity Utilization in India, 1970-1986," Center for Monitoring Indian Economy, Bombay.
2. "Capacity Utilization - Manufacturing, Mining, Utilities, and Industrial Materials," Federal Reserve Statistical Release, October 19, 1987.

Note: India-1: These figures on capacity utilization are reproduced from published documents.
India-2: This column equals India-1 divided by 1.25.

fore, to make a more meaningful comparison between the Indian and the U.S. rates the Indian capacity utilization rates are deflated by 1.25 in Table 1.

Firm level data reveals that many firms have operated beyond the 125 percent limit (CMIE, 1985), which means that this level is clearly feasible. As is evident, there is no appropriate measure of capacity utilization rates in India that can compared to the U.S. rates. What is obvious is that "India-1" (the data reproduced from published documents in India) is overestimated if the upper bound on capacity utilization is defined as 100 percent. A more realistic measure, India-2, indicates that the Indian rate was 20 percent less than the U.S. rate on average for the period 1972-1985.

As will be confirmed by the empirical results, the main causes for capacity underutilization during the period studied appear to be supply limitations rather than demand factors. Also, these limitations were imposed by domestic rather than imported inputs. In the literature on business cycles, which basically focuses on demand, underutilization of capacity occurs during recessions but firms operate close to full capacity during the upswings. In India, however, capacity underutilization appears to be a persistent phenomenon over time. It is unlikely, then, that if demand were the limiting factor, firms would continue to build excess capacity. Data on fluctuations in capacity utilization rates relative to real GDP growth rates indicate that the Indian capacity utilization rates have, on average, been lower and relatively more stable than the U.S. capacity utilization rates (see Charts 1 and 2).

IV. An Empirical Application

1. Specification for Estimation

Data on capacity utilization for 17 manufacturing industries in India for the three years 1973-74, 1978-79, and 1984-85 that were available from the Center for Monitoring the Indian Economy have been pooled. As has already been noted in Section III, the Indian Government does not reveal data on the quota allocation rules used for imported inputs or the extent of shortages in domestic inputs experienced in each industry. In view of this difficulty, equation (15) is transformed so as to use the data on values of input-output coefficients which are available from the Input-Output tables constructed by the Planning Commission of the Government of India. The result is an equation where capacity utilization rates are a function of the values of imported input coefficient (the Input-Output table publishes an aggregate measure for imported inputs), rail services coefficient, and electricity services coefficient. The choice of the three years were dictated by the availability of a consistent set of data on capacity utilization rates and the input coefficients for the 17 industries.

Define I^i as the input coefficient of the ith input. Then, I^i = share of input x^i in total value of output y, or,

$$I^i = \frac{P_x^i x^i}{\Sigma_j^m P_x^j x^j} \qquad j = 1,2,\ldots,i,\ldots,m.$$

But in equilibrium,

$$x^j = y/\alpha^j \qquad j = 1,2,\ldots,m.$$

Hence,

$$I^i = \frac{P_x^i/\alpha^i}{\Sigma_1^m P_x^j/\alpha^j} \quad . \tag{16}$$

As only three input coefficients I^i, of electricity, rail services, and an aggregate measure of imported input are used, equation (16) may be rewritten as

$$I^i = \frac{P_x^i/\alpha^i}{\Sigma_1^3 P_x^j/\alpha^j + A} \tag{17}$$

where $A = \Sigma_4^m P_x^j/\alpha^j$ and is henceforth treated as constant. For simplicity the subscript x is dropped in P_x^j. Thus, $P_x^j = P^j$ in what follows.

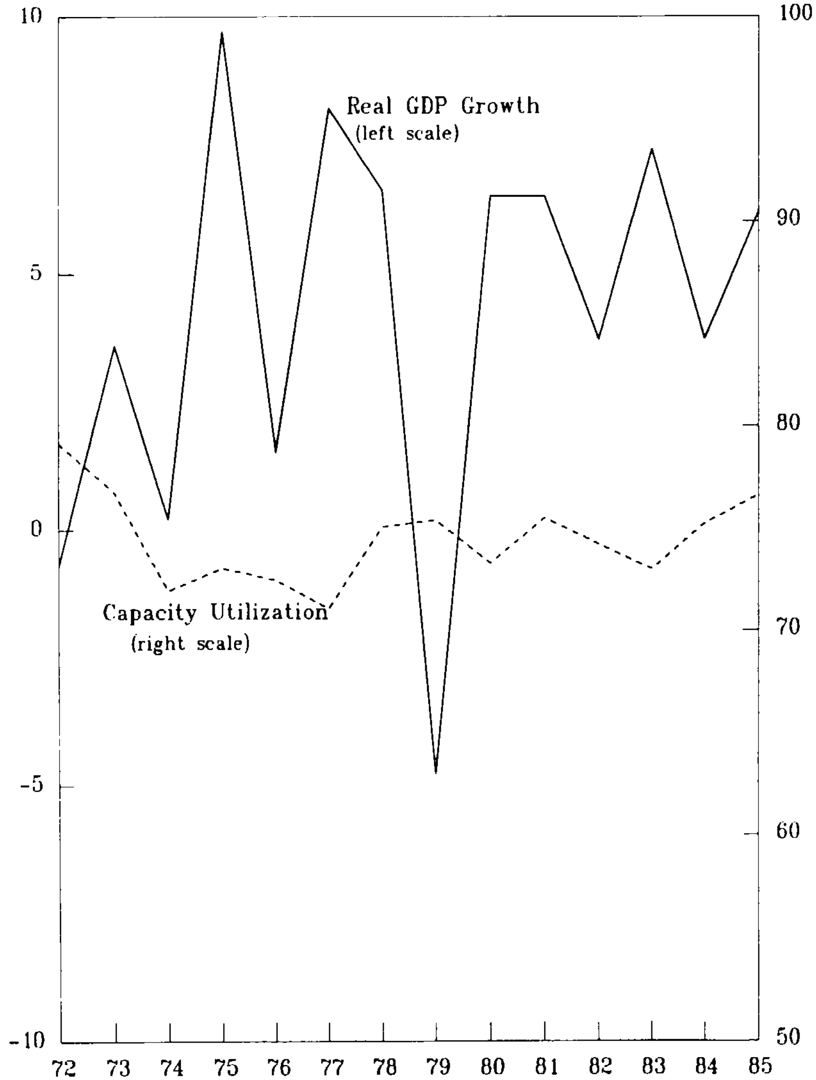
Since there are three input coefficients, I^1, I^2, and I^3 corresponding to electricity, rail services, and imported inputs, the three equations in (17) may be rewritten separately. Totally differentiating the three equations, the solution for $d\alpha^i/dI^i$ and $d\alpha^i/dI^j$ on the assumption that dA and dP^j equal zero is: 1/

$$d\alpha^i/dI^i < 0 \tag{18a}$$

1/ See Appendix I for the derivation.

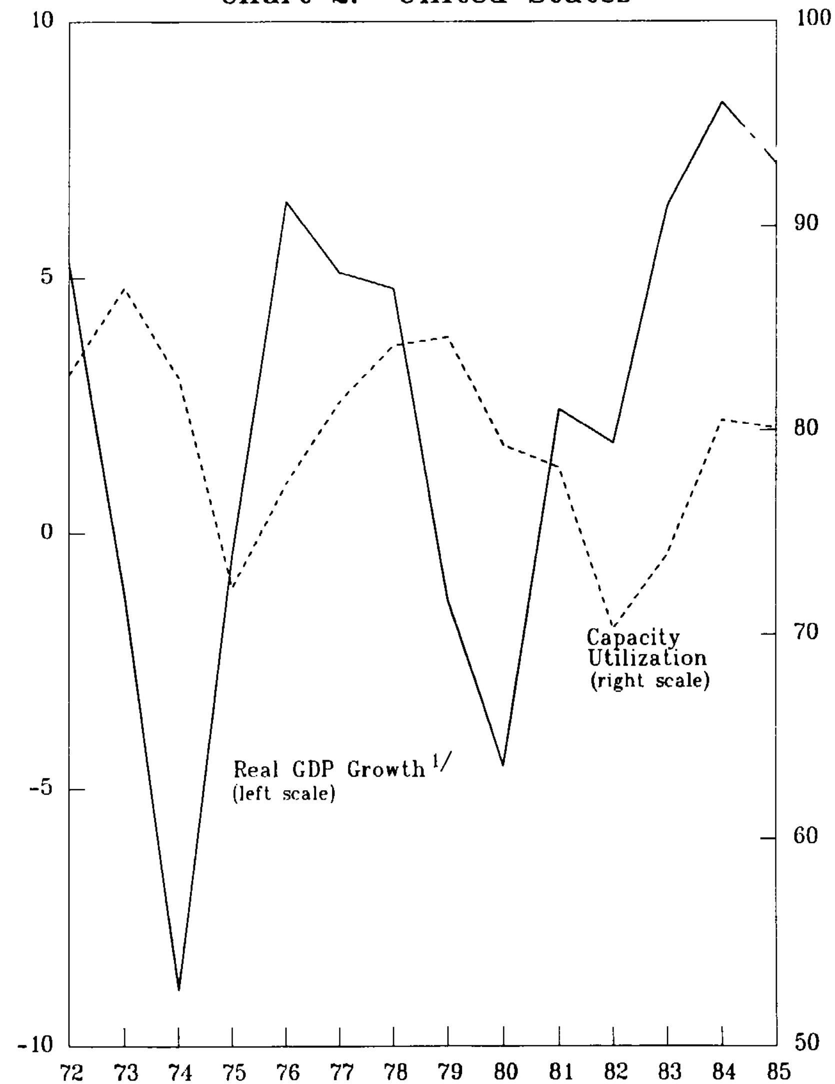
Real GDP Growth and Capacity Utilization Rates, 1972-1985

Chart 1: India



Source: International Financial Statistics and Center for Monitoring the Indian Economy

Chart 2: United States



Source: International Financial Statistics and Federal Reserve Statistical Release, various issues.

1/ Nominal GDP has been deflated by the Producer Price indices.

and,

$$d\alpha^i/dI^j < 0 \tag{18b}$$

From equations (18a) and (18b) it is clear that the α^i's are a function of I^i and the I^j's. Now equation (15), the equation that will be tested, may be rewritten in general notation as

$$CU = 1/\beta \min_j \{ \phi_j(I^1,I^2,I^3)\theta^j \} \tag{19}$$

where $\phi_j(I^1,I^2,I^3) = \alpha^j$.

In the absence of information on the most restrictive quota, that is, if $\min_j \{ \phi_j(I^1,I^2,I^3)\theta^j \}$ is not known with certainty, then (19) may be

expressed as

$$E[CU] = 1/\beta \ \underset{\theta}{E}[\min_j \{ \phi_j(I^1,I^2,I^3)\theta^j \}] \tag{20}$$

where $\theta = (\theta^1 \ \theta^2 \ \theta^3)$ is the vector of input-specific policy parameter exogenously determined by the government.

Taking a Taylor's expansion around the industry means, $\bar{I}^1$, $\bar{I}^2$, $\bar{I}^3$; and letting i = industry index, we obtain, 1/

$$E[CU_i] = B + 1/\beta \ . \ \sum_{s=1}^{3} \text{Prob } \{\theta_i^s = \min_\ell \theta_i^\ell\} . \ \frac{\partial \phi_s(\bar{I}^1,\bar{I}^2,\bar{I}^3)}{\partial I_i^1} . \quad I_i^1$$

1/ A detailed derivation is presented in Appendix I.

$$+ 1/\beta \ . \ \sum_{s=1}^{3} \text{Prob} \ \{\theta_i^s = \min_{\ell} \theta_i^{\ell}\} . \ \frac{\partial \phi_s(\bar{I}^1, \bar{I}^2, \bar{I}^3)}{\partial I_i^2} . \quad I_i^2$$

$$+ 1/\beta \ . \ \sum_{s=1}^{3} \text{Prob} \ \{\theta_i^s = \min_{\ell} \theta_i^{\ell}\} . \ \frac{\partial \phi_s(\bar{I}^1, \bar{I}^2, \bar{I}^3)}{\partial I_i^3} . \quad I_i^3 \qquad (21)$$

where B is a constant.

or,

$$CU_i = B + b_1 I_i^1 + b_2 I_i^2 + b_3 I_i^3 + u_i \qquad (22)$$

where CU_i = capacity utilization in industry i

I_i^1 = imported input coefficient in industry i

I_i^2 = electricity input coefficients in industry i

I_i^3 = rail service input coefficient in industry i

and the b_j's, j = 1,2,3, are the coefficients of the I_i^j's in equation (21).

Transforming equation (15) into equation (22) allows the latter to be expressed in terms of observable variables. The hypothesis is that the b_j's, associated with the I_i^j's are negative (from equations (18a) and (18b)) and significant for those inputs which have a high probability of being the binding constraint on capacity utilization.

2. Estimation Results

Estimation of equation (22) by Ordinary Least Squares estimation procedure is inappropriate since capacity utilization rates have a limited range and the residual error terms exhibit heteroscedasticity. A weighted least squares model was therefore used to correct for the existence of heteroscedasticity. The procedure followed was to weight the dependent and the independent variables by w, where

$$w = (y_f(1-y_f))^{-1/2} \qquad (23)$$

and y_f is the forecasted value of the dependent variable from OLS estimation.

While experimenting with various model specifications, dummy variables were also introduced in each of the three years to capture demand shocks that may be specific to that year but common to all industries. This specification did not yield significant coefficients for the dummies implying that variations in demand were not among the important variables affecting capacity utilization rates.

The following results in Table 2 were obtained from the Weighted Least Squares estimation. 1/

Table 2. Weighted Least Squares Estimates 2/

	Imports	Electricity	Rail Service
Coefficients (b)	0.201	-0.870	-3.726
S.E.	0.143	0.405	1.533
T-Statistic	1.405	-2.150	-2.430
Constant			0.710
SEE			0.029
R^2			0.407

1/ The sources of the data and the definitions of the variables used is given in Appendix II.

2/ The S.E. is the standard error of the estimated coefficient, SEE is the standard error of the estimated equation, and R^2 is the coefficient of determination.

The signs of the coefficients for electricity and rail services are negative while it is positive for imports. Secondly, the t-statistics associated with electricity and rail services input coefficients are significant while that of imports is not at the 5 percent level.

The empirical results show that shortages in electricity and rail services were important in limiting capacity utilization in the 17 manufacturing industries. The insignificance of the results for imported inputs may be explained by the fact that India is a relatively closed economy and imported inputs are not among the critical variables affecting capacity utilization. Another possible explanation is that the import tariffs on intermediate inputs may already have been so high as to have rendered the quotas ineffective.

The lack of significance of imported input shortages in affecting capacity utilization in India contrasts sharply with the NBER (1978) and the OECD (1970) studies which hypothesize that the existence of capacity underutilization in the case of India, among other countries, is directly linked to the quota allocation rules used in distributing imported inputs. The NBER and the OECD conclusions cannot, of course, be ruled out for other countries where quotas on imported inputs rather than domestic inputs are binding.

V. Conclusions and Policy Implications

The main purpose of this paper has been to provide an analytical framework and test the impact of quantitative restrictions on intermediate inputs on capacity utilization rates for a country characterized by a mixed economic system. When quotas are allocated on the basis of installed capacity or when there are shortages of domestic inputs (rationed on the basis of installed capacity), it was shown how capacity underutilization could be a natural outcome in equilibrium.

The model presented in Section II was applied to test the effect of quantitative restrictions on capacity utilization in Indian manufacturing industries. It was found that shortages of key domestic inputs, such as electricity and rail services, are important determinants of capacity utilization rates. The main reason why domestic, rather than foreign inputs, affect capacity underutilization in Indian manufacturing industries is that India is a relatively closed economy and depends much less on foreign inputs.

Some interesting policy implications follow from the analysis presented in this paper. In mixed economies, the state-owned enterprises are frequently responsible for producing essential inputs. More often than not, the supply of these inputs does not respond to market signals, which results in pervasive shortages. It is essential then that the government either provides the incentives to state enterprises to be more responsive to demand or, better still, allow private enterprises to produce these essential inputs at market-determined prices.

Another lesson that may be drawn which is relevant for economic transformations in CPEs is that unless the intermediate and final goods industries are privatized simultaneously, inefficiencies in the form of underutilization of capacity will remain. Newly privatized producers would have the incentive to build excess capacity as long as they are dependent on the state enterprises for critical inputs which remain price insensitive, and therefore continue to be rationed on the basis of the size of the firm demanding them.

The methodology used in the empirical section shows one way of determining those input shortages that impose relatively greater constraints on capacity utilization rates. This has implications for sequencing issues in a country's economic liberalization process. A controlled economy often faces, at the initial stage, the problem of choosing between domestic deregulation or trade reforms. The estimation results indicate that domestic inputs were more important determinants of capacity utilization rates in India. Therefore, if this country aims at increasing the productivity of its stock of pre-existing capital then, as a first step, deregulation of the domestic economy should precede trade reforms. If imported inputs were binding the reverse would hold. A word of caution should be added at this point; since this study has been conducted in a partial equilibrium framework no statement about efficiency gains of any reform can be made (with the possible exception of a simultaneous elimination of all restrictions.)

A theoretical extension of this paper would be to study sequencing issues in privatization in planned economies. That is, if governments are constrained in their ability to undertake simultaneous privatization of all sectors, a relevant question to ask is whether firms producing inputs or those producing outputs should be privatized first. A useful extension to the empirical analysis of this paper would involve testing the model on a cross-section of mixed economic systems with a variety of input constraints.

Derivation of Equations

This appendix provides a detailed derivation of the results obtained in Section IV.

Equations (18a) and (18b) are derived from equation (17) as follows: Let $1/\alpha^i = \delta^i$. Then,

$$I^i = \frac{P_x^i \delta^i}{\Sigma_1^3 P_x^j \delta^j + A} \tag{24}$$

where $A = \Sigma_4^m P_x^j \delta^j$ and is assumed to be a constant. Define $P_x^j = P^j$ and

rewrite the three input coefficients equations in (24) as,

$$P^1\delta^1 I^1 + P^2\delta^2 I^1 + P^3\delta^3 I^1 + AI^1 - P^1\delta^1 = 0 \tag{24a}$$

$$P^1\delta^1 I^2 + P^2\delta^2 I^2 + P^3\delta^3 I^2 + AI^2 - P^2\delta^2 = 0 \tag{24b}$$

$$P^1\delta^1 I^3 + P^2\delta^2 I^3 + P^3\delta^3 I^3 + AI^3 - P^3\delta^3 = 0 \tag{24c}$$

Totally differentiating (24a) - (24c), and assuming $dA = dP^j = 0$ for all j, the following system of equations may be expressed in matrix form.

$$\begin{bmatrix} +P^1(1-I^1) & -P^2I^1 & -P^3I^1 \\ -P^1I^2 & +P^2(1-I^2) & -P^3I^2 \\ -P^1I^3 & -P^2I^3 & +P^3(1-I^3) \end{bmatrix} \begin{bmatrix} d\delta^1 \\ d\delta^2 \\ d\delta^3 \end{bmatrix} = (\Sigma_1^3 P^j\delta^j + A) \begin{bmatrix} dI^1 \\ dI^2 \\ dI^3 \end{bmatrix}$$

Solving for $d\delta^i/dI^i$ and $d\delta^i/dI^j$,

$$\frac{d\delta^i}{dI^i} = \frac{(\Sigma_1^3 P^j \delta^j + A)(1 - \Sigma_{j\neq i} I^j)}{P_i(1 - \Sigma_1^3 I^j)} > 0 \qquad (25a)$$

and,

$$\frac{d\delta^i}{dI^j} = \frac{(\Sigma_1^3 P^j \delta^j + A) I^i}{P_i(1 - \Sigma_1^3 I^j)} > 0 \qquad (25b)$$

since δ^i is defined as $1/\alpha^i$, equations (18a) and (18b) follow.

Finally, the intermediate steps between equations (20) and (21) are:

A Taylor's expansion around the industry means, $\bar{I}^1$, $\bar{I}^2$, $\bar{I}^3$, yields

$$E[CU_i] = 1/\beta \; \underset{\theta}{E}[\min_j \{\phi_j(\bar{I}^1, \bar{I}^2, \bar{I}^3)\theta_i^j\}]$$

$$+ 1/\beta \sum_{j=1}^3 \frac{\partial}{\partial I_i^j} \left\{ \underset{\theta_i}{E} [\min_\ell \{\phi_\ell(\bar{I}^1, \bar{I}^2, \bar{I}^3)\theta_i^\ell\}] \right\} . \; (I_i^j - \bar{I}^j)$$

$$+ R,$$

where i = industry index and R = higher order terms which are ignored. But,

$$\frac{\partial}{\partial I_i^j} \left\{ \underset{\theta_i}{E} [\min_\ell \{\phi_j(\bar{I}^1, \bar{I}^2, \bar{I}^3)\theta_i^\ell\}] \right\}$$

$$= \sum_{s=1}^3 \text{Prob}\{\theta_i^s = \min_\ell \theta_i^\ell\} . \; \frac{\partial \phi_s(\bar{I}^1, \bar{I}^2, \bar{I}^3)}{\partial I_i^j}$$

or,

$$E[CU_i] = B + 1/\beta \left\{ \sum_{j=1}^{3} \sum_{s=1}^{3} \text{Prob}(\theta_i^s = \min_\ell \theta_i^\ell) . \frac{\partial \phi_s(\bar{I}^1, \bar{I}^2, \bar{I}^3)}{\partial I_i^j} \right\} I_i^j ,$$

where $B = 1/\beta \; \underset{\theta}{E}[\min_j(\phi_j(\bar{I}^1, \bar{I}^2, \bar{I}^3)\theta_i^j)]$

$$- 1/\beta \sum_{j=1}^{3} \frac{\partial}{\partial I_i^j} \left\{ \underset{\theta}{E}[\min_\ell(\phi_\ell(\bar{I}^1, \bar{I}^2, \bar{I}^3)\theta_i^\ell)] \right\} . (\bar{I}^j)$$

Since B does not depend on i, equation (21) follows.

Data Sources and Definitions

This Appendix presents a description of the construction of, and the data sources for, the variables used in estimations.

1. Capacity Utilization

The capacity utilization rates were obtained from Center for Monitoring Indian Economy, a research organization in Bombay, which publishes economic data periodically. The capacity utilization rate in a particular year is defined as:

$$\text{capacity utilization} = \frac{\text{total production}}{\text{installed capacity}}$$

Annual data on installed capacity and production are collected by the Center for Monitoring Indian Economy (CMIE) from publications by government organizations, that is, those issued by the Central Statistical Organization, Directorate General of Technical Development, and Annual Reports issued by various departments of the Indian Ministries.

A manufacturing unit in India records installed capacity on a one-shift basis (eight working hours). When more than one shift is operated, the production is said to exceed the potential installed capacity. The government officially permits a unit to produce up to 25 percent in excess of installed capacity.

2. Input Coefficients

The values of the imported input coefficients, the electricity and railway services input coefficients were taken from "A Technical Note" on the Fifth, Sixth, and Seventh Plan of India, respectively. They are published by the Planning Commission, Government of India. Each of the inputs are computed, respectively, as:

$$\text{imported input coefficient} = \frac{\text{sum of values of all imported inputs used in the industry}}{\text{value of total output in the industry}}$$

$$\text{electricity input coefficient} = \frac{\text{value of electricity services used in the industry}}{\text{value of total output in the industry}}$$

$$\text{rail input coefficient} = \frac{\text{value of rail transportation services used in the industry}}{\text{value of total output in the industry}}$$

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