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DISEQUILIBRIUM IN THE INDIAN REGISTERED MANUFACTURING SECTOR: A SIMULATED MAXIMUM LIKELIHOOD ANALYSIS

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Abstract

How a macroeconomic policy package is designed depends critically on whether the economy in question is supply constrained or demand constrained. In simple terms, this may often be seen in terms of whether the policies should try to augment demand or to raise productive capacity. The question is relevant to objectives of growth as well as stability. In the present study, we examine this problem with regard to the registered manufacturing sector in India, within a framework of market disequilibrium for the period 1980 through 2007. The maximum simulated likelihood approach used by us indicates that the registered manufacturing sector in India has largely been demand-constrained over the entire period of analysis.

Keywords: Disequilibrium, Demand / Supply constrained, Regime-switching, Simulated-maximum likelihood.

JEL Classification: C24, D45, C15, C63.

1. Introduction

How macroeconomic policy for growth and stability or, for that matter, any other objective can be defined depends critically on how the economy functions. Broadly, two alternatives have for a long time been provided by the Keynesian theory on the one hand and its predecessor, the Classical theory on the other. Needless to say that each of these have gone through numerous modifications and extensions. Nevertheless, how markets function and what role the price system plays remains basic at the very foundation. One may recall how Friedman and Meiselman (1963) had posed this question in terms of whether one should rely on velocity, connecting income generation to money supply, both nominal, or to the multiplier, connecting autonomous expenditure to income. Ultimately, it turns out to be a question of relative stability of the two

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linkages. This question was examined by Pandit (1977, 1982) in the context of less developed economies, first by assuming that velocity as well as multiplier were fixed parameters and later by allowing these parameters to be stochastic with different variances.

In the present context, the problem is seen in a much wider and more satisfactory, though in an equally more difficult way, by posing the problem in terms of whether prices are adequately flexible to clear markets i.e., to equate quantities demanded to quantity supplied. The unavoidable related questions are short run vs. long run adjustments, and cyclical vs. secular variations. In the present exercise, we pose the problem somewhat more directly in terms of whether the level of economic activity is supply-constrained or demand-constrained. This may clearly be seen as allowing disequilibrium as a possible expost outcome. The empirical treatment of the problem, however raises the question of which factors may be considered to be relevant on either side and how adequate the database is for a proper analysis. It is for these reasons that we confine this exercise only to the registered manufacturing sector of the Indian economy for the period 1980 through 2007. Before we proceed further, it is in the fitness of things that we highlight how the problem has been treated so far.

2. Preceding Explorations

It will not be an exaggeration to state that the empirical treatment of macroeconomic issues in India and even elsewhere has generally been adhoc with regard to its theoretical basis. Perhaps this is unavoidable because much of the theoretical issues are not of much interest to either the general public or to the policy makers. It is also understandable that analysis does not adhere to a specific theoretical paradigm. Nevertheless, the question of whether it is the demand or the supply which has been the determining side of the system, has been dealt with for India in different ways as follows. In a large number of economy wide macroeconometric models for India as reviewed by Krishnamurty (2002), the view mostly taken is that agricultural sector is totally supply constrained whereas the level of economic activity in industry and services may be partly demand constrained and partly supply constrained. Generally, no clear view is taken.[4]

In some of the studies, the problem is posed in terms of saving and investment behaviour, with the former as a proxy for supply and the latter as that for demand (Lahiri and Roy, 1986). This has usually been the way economic growth has sought to be explained.[5] Again, taking output in agriculture as exogenous, Goyal (1992) argues that the non-agricultural sectors have been constrained by demand in the short run and by supply in the long run. This is in a way the standard Keynesian theory is understood; demand is a constraint only in the short run.

Some studies (Mohanty, 1997, and Basu and Maertans, 2007) attribute output growth to inadequacy of investment in infrastructure by the government, implying a supply constraint. The intersectoral linkages for growth explored by Sastry et.al (2003) are implicitly in conformity with both demand as well as supply considerations. In a similar way, we have the work of Mohan (2008), which attributes growth to sustained flow of saving and investment. An explicit exploration

4 This open ended view is also taken by Lahiri and Roy (1986).

5 While Nagaraj (2003) relates growth slowdown to inadequate investment, Bhaumik and Mukhopadhyay (1997) look at it in terms of credit crunch.

of the basic issue which poses demand constraint against the supply constraint which was taken up by Pandit (1986) is pursued in this study with a larger and more recent data base as well as a refined econometric methodology and, we believe, a better analytical model.

The foregoing literature reveals that the level of economic activity and the implied growth in the Indian economy are constrained both by demand side as well as supply side factors. Certain sectors such as agriculture have rightly been believed as being largely supply constrained. With regard to manufacturing, sector, even though there is a wide consensus that output is largely demand-constrained, it is also believed to be at times resource-constrained Growth in infrastructure is largely supply-constrained. This in turn constrains the other sectors on the supply side. Moreover, in relation to public administration, which includes defence and other public services, it is difficult to estimate the nature of constraints, since the characterisation of demand and supply in this sector is not very straightforward. The various demand and supply side elements that constrain the level of economic activity in the different sectors could in turn be attributed to real, financial, and monetary factors influencing demand as well as supply in both short as well as long run. Although the results established by the earlier studies are fairly comprehensive, the nature of constraints in the level of economic activity of the different sectors in Indian economy continues, nevertheless, to be considerably unclear.

Our focus is on the registered manufacturing sector of the Indian economy which contributes about 10% to the overall GDP in real terms, not only because of its critical importance but also because of better quality of data. We assume that demand and supply for manufacturing output respond primarily to changes in non-price variables; whereas, the market is characterized by incomplete price adjustments such that, demand and supply for manufacturing output need not be equal to each other. The model is estimated using the technique of simulated maximum likelihood. The estimated model is then solved under alternative scenarios in order to understand the major implications of the model, and also to obtain useful inputs with considerable policy relevance. The analysis is carried out for the period 1980-2007.

In section 3, we discuss the underlying framework of the study along with the model used in the study as well as the related data. The details pertaining to the methodology adopted are taken up in section 4. Finally, the empirical results are reported in section 5, leaving the summary and conclusions to be presented in the last section.

3. The Disequilibrium Framework

The common assumption underlying the principal that markets get cleared is that prices are flexible enough to ensure equality of demand and supply in every market. This is the fundamental element of the Walrasian economics. However, the Keynesian paradigm (Keynes,1936), gave rise to a new approach to the mechanisms of the markets under which, prices may in general be rigid, at least in the short run. In this set up, quantity adjustments play a major role in regulating and reconciling the demands and supplies in the markets. Further theoretical developments in the area by Patinkin (1951), Leijonhuvud (1968), Barro and Grossman (1971), and others, led to the strong establishment of this new framework in both theoretical as empirical literature.

Even from a theoretical perspective, markets may clear in the long term. However from the short and medium term standpoints, it is more realistic to analyze markets under a disequilibrium setup. In this exercise, we examine the relevance of disequilibrium framework for the registered manufactured sector. This implies that at any given time period, it is either the demand or the supply that is observed, but not necessarily both. However, it is possible that at some given time period the two may be equal. We also assume that –

1. Real demand for output of this sector is primarily influenced by price, overall agricultural and industrial GDP, exports, interest rate, inflation rate and, the magnitude of unrealized demand of the previous time period.
2. Supply of output of this sector is influenced by price, labor input, capital stock, as well as imports (which serves as a proxy for raw materials). As in the case of demand, supply at any given time period is also influenced by the quantity of unrealized supply of the previous time period.
3. The switch between the two-regimes is endogenously determined by the traditional 'minimum' condition. That is, the observed quantity is the minimum of the demand and the supply. If demand is observed, supply is latent, and vice versa.

Keeping in view the nature of the problem, we formulate a dynamic disequilibrium model comprising of two regimes namely, demand and supply. Disequilibrium models form one category of endogenous switching regression models. Prior to specifying the model, we present the notations used for the different variables in the model. These are given below.

Notation*	Variable
Qd_t	Demand for registered manufacturing output
Qs_t	Supply of registered manufacturing output
Q_t	Actual quantity transacted
P_t	Price of registered manufacturing output
Zag_t	Agricultural Sector GDP
Zin_t	Industrial sector GDP
Int_t	Interest Rate
$Infl_t$	Inflation Rate
Exp_t	Aggregate Exports
L_t	Labour input in the registered manufacturing sector
K_t	Capital Stock in the registered manufacturing sector
Imp_t	Aggregate Imports

* The subscript 't' for the variables denotes time period 't'.

The dynamic disequilibrium model is specified as follows –

$$Qd_t = \alpha_0 + \alpha_1 P_t + \alpha_2 Zag_t + \alpha_3 Zin_t + \alpha_4 Exp_t + \alpha_5 Int_t + \alpha_6 Infl_t + \alpha_7 (Qd_{t-1} - Q_{t-1}) + \sigma_1 \varepsilon_{1t} \quad ...(3.1)$$

$$Qs_t = \beta_0 + \beta_1 P_t + \beta_2 L_t + \beta_3 K_t + \beta_4 Imp_t + \beta_5 (Qs_{t-1} - Q_{t-1}) + \sigma_2 \varepsilon_{2t} \quad ...(3.2)$$

$$Q_t = \min(D_t S_t) \quad ...(3.3)$$

Where, ε_{1t} and ε_{2t} are error terms following standard normal distribution, that may or may not be autocorrelated. σ_1 and σ_2 indicate the standard deviations of the error terms of the demand and supply equations respectively. The above model is dynamic in nature on account of the fact that both demand and supply are influenced by unmet transactions of the previous time period. At any given time period 't', only one of the two regimes is observed, as indicated by the 'min' condition.

Let us now turn to data relating to the period 1980-2007 used in this paper. For this we rely mainly on two sources, namely, *National Accounts Statistics*, published by the Central Statistical Organization, and *The Handbook of Statistics on the Indian Economy*, 2008-09, published by the Reserve Bank of India. We also use data from the *Annual Survey of Industries*, 2008-09, published by the Central Statistical Organization. The variables considered in the model are demand and supply of registered manufacturing output, price of manufacturing output, industrial output, nominal interest rate, inflation rate, aggregate exports, labour input and real capital stock in the registered manufacturing sector, and aggregate imports.

With regard to demand and supply of manufacturing output, at any given time period, only one of the two variables is observed. The other is latent. The observed variable denotes the actual transacted quantity in the market. Actual transacted quantity is measured as real GDP in the registered manufacturing sector in 1999-00 prices. Agricultural output is measured as real GDP in the agricultural sector in 1999-00 prices. Industrial output is measured in a similar manner. All the three variables are measured in terms of 'crores of rupees'. Nominal interest rate, which is an indicator of cost of borrowing, is measured as the State Bank of India (SBI) advance rate. SBI being the largest bank in India, its advance rate would serve as a good proxy for the average lending rates in the economy. Inflation rate is measured as the rate of change in WPI (All Commodities – 1993-94=100). Interest rate and inflation rate are measured in terms of percentages. Exports are imports are measured at their aggregate real levels. To obtain the real levels of these variables, we divide their nominal values by their respective unit value indices (base year: 1999-00=100). They are measured in terms of 'crores of rupees'. The variable imports is used as a proxy for raw materials input in the registered manufacturing sector. Labour input in the registered manufacturing sector is measured as real total factor incomes in the sector. This is obtained by deflating the data on total factor incomes paid in the registered manufacturing sector by the estimated wage rate for the manufacturing sector.

We use an estimate of the wage rate across all industries, as a proxy for wage rate in the manufacturing sector. To obtain this wage rate, we divide the total emoluments paid across all industries, by the total number of employees. This gives the total emoluments paid per employee, which is used as proxy for the wage rate in the registered manufacturing sector. This is calculated in terms of 'crores of rupees'. This estimated wage rate (measured in 'crores of rupees'). is then used to deflate the data on total factor incomes paid in the registered manufacturing sector, in order to obtain real total factor income, which is used as a proxy for labour. Data on total emoluments across all industries, and total number of employees, are obtained from the *Annual Survey of Industries*, 2008-09, whereas the data on total factor incomes paid in the registered manufacturing sector is obtained from *National Accounts Statistics*. Capital is measured as real net fixed capital stock in the registered manufacturing sector, measured at 1999-00 prices. It is calculated as on 31st of March every year. It is measured in 'crores of rupees'. The data on all these variables was collected for the period 1980-2007.

4. Method of Estimation

The proposed model is estimated by the method of maximum simulated likelihood recently suggested by Lee (1997). The early literature on the estimation of disequilibrium models which include Fair and Jaffee (1972), Fair and Kelejian (1974), Goldfeld and Quandt (1975), Maddala and Nelson (1974), suggested several methods broadly classified into maximum likelihood and two-stage least squares techniques. However the major limitation of these methods is that, they were largely restricted to static models. Goldfeld and Quandt (1973) developed a disequilibrium model that had a certain dynamic structure with the regime transition following a Markov process. However the underlying specifications of the demand and supply equations were not dynamic in nature. Another significant fact was that, many of the maximum likelihood methods developed in the early literature were computationally intractable. However, the development of simulation based estimation methods provided scope for the specification and estimation of more complex and dynamic disequilibrium models.

Some of the pioneering studies that have developed simulation based algorithms for the specification and maximization of complex likelihood functions are Cosslett and Lee (1985), Hamilton (1989), McFadden (1989), Pakes and Pollard (1989), Hajivassilou and McFadden (1990) among others. Lee (1997) considers the above mentioned studies and develops a maximum simulated likelihood procedure to estimate the parameters of exogenous and endogenous regime-switching models. As stated earlier, we apply the maximum simulated likelihood suggested in Lee (1997) to estimate the parameters of the dynamic-disequilibrium model specified in equations (3.1) – (3.3).

Highlights of the procedure are as follows. If we formulate a regime indicator variable I_t such that I_t = 1, if demand is observed, and I_t = 0, if supply is observed. Let q_t, I_t and z_t denote the observed variable, indicator variable, and unobserved (latent) variable during time period t. Also, let $\widetilde{q_t} = (q_1, q_2, q_3, \cdots, q_t)$ denote the vector of observed variables, $\widetilde{I_t} = (I_1, I_2, I_3, \cdots, I_t)$, the vector of indicator variables, and $\widetilde{z_t} = (z_1, z_2, z_3, \cdots, z_t)$, the vector of unobserved (latent) variables during time period t. Then the likelihood function is given by –

$$f(\widetilde{q_T}) = \sum_{I_T=0}^{1} \sum_{I_{T-1}=0}^{1} \sum_{I_{T-2}=0}^{1} \cdots \sum_{I_1=0}^{1} \int_{q_T}^{\infty} \int_{q_{T-1}}^{\infty} \int_{q_{T-2}}^{\infty} \cdots \int_{q_1}^{\infty} g\left(\widetilde{q_T}, \widetilde{I_T}, \widetilde{z_T}\right) dz_1 dz_2 dz_3 \cdots dz_T \quad \text{... (4.1)}$$

where T is the total number of time periods. $g\left(\widetilde{q_T}, \widetilde{I_T}, \widetilde{z_T}\right)$ denotes the joint density function of the observed, indicator, and latent variable vectors. The integrals are taken over all the components of the vector $\widetilde{z_T}$. In a similar manner, the summations are taken over all the components of the vector $\widetilde{I_T}$.

As can be seen, the number terms in the likelihood function resulting from the summations is 2^T. Moreover, each term involves high dimensional integrals. Dealing with extremely large summations of regime paths of the order 2^T, as well as high-dimensional integrals in the likelihood functions is enormously cumbersome. A direct estimation of the likelihood function in the present form is virtually impossible. The method suggested in Lee (1997) involves repeated simulations of the vector of indicator variables and the latent variables. Following these simulations, the simulated-likelihood function for the dynamic disequilibrium model is given by-

$$f_S(\widetilde{q_T}) = \frac{1}{S} \times \sum_{i=1}^{S} \prod_{t=2}^{T} f\left(q_t \middle| \widetilde{J_{t-1}}^{(i)}\right) \times f(q_1) \qquad \text{... (4.2)}$$

where $\widetilde{q_t} = (q_1, q_2,, \cdots, q_t)$, $\widetilde{J_{t-1}}^{(i)}$ denotes the past information pertaining to the i^{th} simulation run, and S denotes the total number of simulations. The function $f(\cdot)$ denotes the density of the observed values q_t. The simulated likelihood function given above is an unbiased estimator of the actual likelihood function $f(\widetilde{q_T})$ given in (3.4). As the number of simulations S tends to infinity, it also becomes a consistent estimator of the original likelihood function.[6]

5. Empirical Results

We obtained the specification of the simulated likelihood function after carrying out 1000 simulations of the indicator variable and latent variable vectors. We use nonlinear optimization algorithms to maximize the likelihood function. In particular, we use the downhill-simplex algorithm developed by Nelder and Mead algorithm which is a non-derivative based method and requires only functional evaluations. However, the algorithm is slow in convergence. The entire simulation procedure as well the maximization of the simulated likelihood function was carried out using the statistical programming package R. The estimated equations are as follows.

DEMAND EQUATION

$$\begin{aligned} Qd_t = & -18181.43 - 214.92P_t + 0.04Zag_t + 0.52Zin_t + 0.07Exp_t - 46.63Int_t - 34.91infl_t \\ & \quad (-8.57) \qquad (-2.14) \qquad (1.92) \qquad (4.67) \qquad (3.19) \qquad (-2.04) \qquad (-1.99) \\ & + 0.17(Qd_{t-1} - Q_{t-1}) + 2298.25\varepsilon_{1t} \\ & \quad (3.62) \qquad\qquad (4.12) \end{aligned} \qquad \text{... (5.1)}$$

SUPPLY EQUATION

$$\begin{aligned} S_t = & \, 6688.46 + 804.73P_t + 0.08K_t + 0.58L_t + 0.20Imp_t + 0.53(S_{t-1} - Q_{t-1}) + 4369.22\varepsilon_{2t} \\ & \quad (7.65) \qquad (2.43) \qquad (1.97) \qquad (5.32) \qquad (2.27) \qquad (4.03) \qquad\qquad (6.79) \end{aligned} \qquad \text{... (5.2)}$$

All the estimated coefficients in the demand and supply equations are statistically significant except the coefficient of price variable in the supply equation which is only moderately significant. The signs of the coefficients of the variables are also in consonance with the theoretical considerations. We solve the demand and supply equations dynamically for the period 1980-2007 in order to obtain the estimates of demand and supply for the registered manufacturing output. As an initial condition, we assume equilibrium at the start of the solution. That is, we assume that for the year 1980, demand is equal to supply and therefore, both are observed. Given the absence of any additional information on the nature of constraints during the period, such an assumption can be considered warranted. With this assumption in place, we go on to solve the model to obtain the estimated quantities of demand and supply for the entire sample period. These are given in table 1 and figures 1 and 2.

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6 The detailed steps of the simulation procedure carried out are provided in the appendix.

Table 1. Estimates of Demand and Supply (Crores of Rupees)

Year	*Demand*	*Supply*	*Supply – Demand Gap*
1980	45773	45773	0
1981	52982.47	62563.66	9581.19
1982	55881.78	70228.41	14346.63
1983	62446.35	77766.75	15320.4
1984	65656.51	80046.21	14389.7
1985	67915.05	84713.58	16798.53
1986	73150.91	90736.33	17585.42
1987	77493.21	94992.14	17498.93
1988	87688.09	100482.5	12794.4
1989	96083.86	103662.7	7578.88
1990	102224.1	107320.2	5096.1
1991	100487.8	113412.9	12925.1
1992	104088.7	128774.4	24685.73
1993	113431.9	144113.4	30681.52
1994	126458.7	161900.2	35441.5
1995	145670.6	179674.5	34003.95
1996	159956.9	186156.1	26199.12
1997	161623.9	194054.4	32430.45
1998	168296.6	213743	45446.35
1999	176350.3	233122.7	56772.4
2000	189565.7	250055.5	60489.86
2001	195227.5	259624.8	64397.3
2002	209671.6	269364.7	59693.08
2003	224516.7	282178.9	57662.22
2004	244035.7	303241.4	59205.61
2005	267116.9	329006.2	61889.34
2006	297161.2	359315.6	62154.44
2007	320746.8	397305.8	76559.03

The foregoing results indicate that for the period under consideration, output in the registered manufacturing sector has been entirely demand constrained for the sample period. This result of a demand-constrained regime for the manufacturing output is nearly in line with the conclusions of the studies discussed earlier as well as other studies analyzing the nature of constraints facing the manufacturing sector. From a policy perspective, the various strategies adopted to increase the level of economic activity and overall growth in the Indian registered manufacturing sector must primarily aim at raising the level of demand for output in this sector.

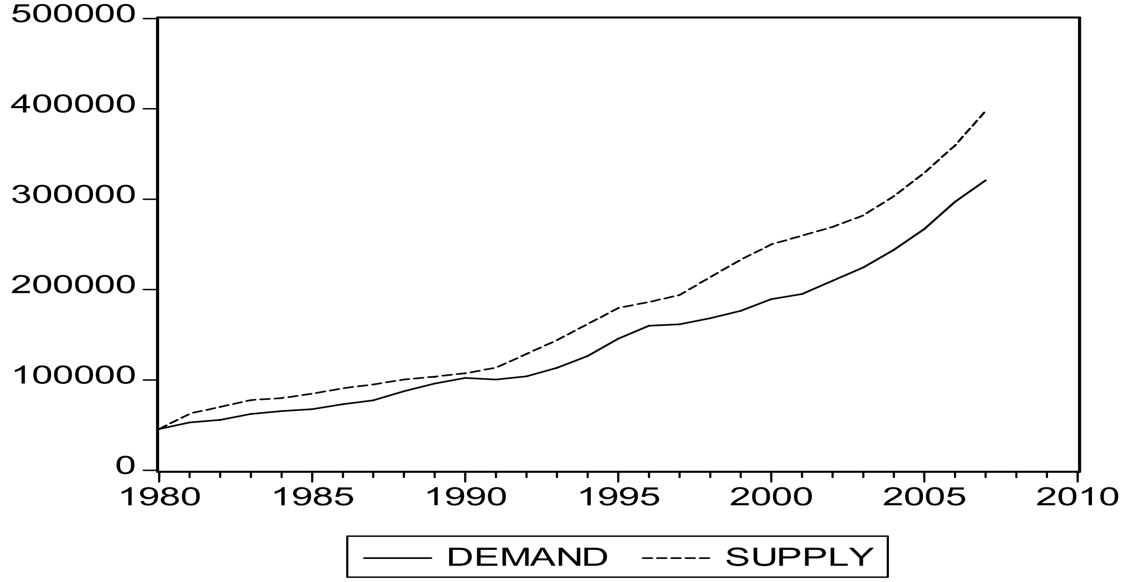

Figure 1. Estimated Demand and Supply

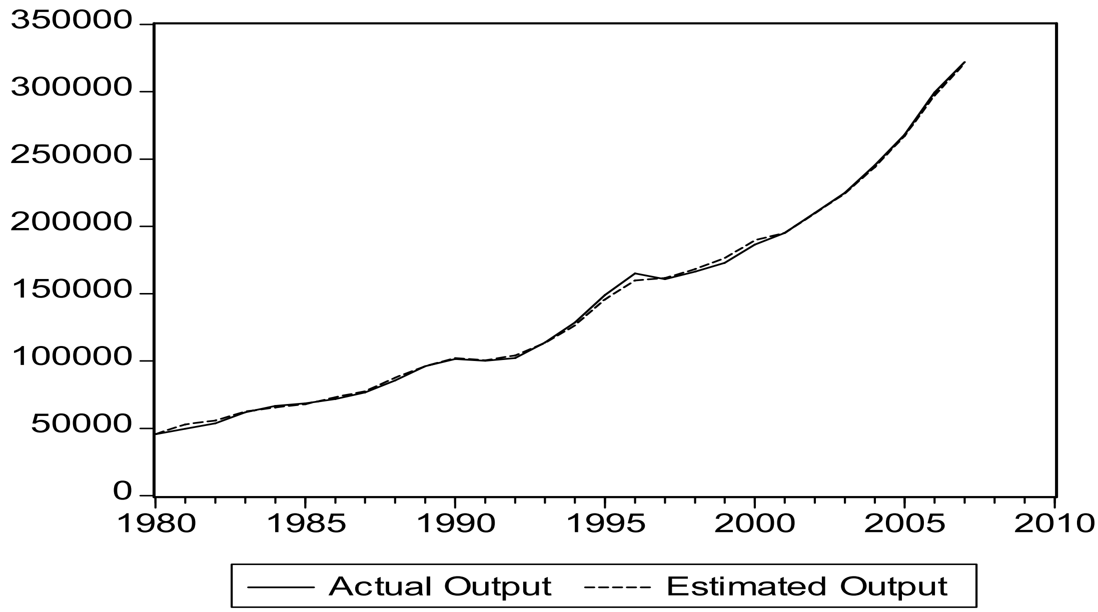

Figure 2. Actual and Estimated Output

6. Accuracy and Implications of the Model

We first examine the accuracy of the estimated model using the *Root Mean Square Percentage Error (RMSPE)* and *Theil-Inequality coefficient*. However, we cannot directly apply these measures to the estimated equations since we do not have the actual values of demand and supply. We only have the estimated values for these variables. Therefore, in order to validate the estimate demand and supply equations, we compare the actual and estimated values of output. The resulting *RMSPE* and *Theil-Inequality Coefficient* values are 1.91 and 0.005 respectively. The values indicate that the overall fit of the model is very good. This can also be verified from figure 2. The model captures the turning points very well. Thus, on the whole, the model is well suited to be subject to policy analysis. An exercise to examine the implications of the estimated model is carried out through several counter-factual simulation exercises under alternative policy scenarios. All of these pertain to raising the level of demand for output in the registered manufacturing sector. As indicated earlier, the registered manufacturing sector is demand constrained for the entire period of analysis. Therefore, the policy analysis is focused on identifying practically feasible measures to raise the level of demand. In turn, we examine whether the resulting increase in demand is sufficient to change the nature of constraint in the sector from demand-constrained to supply-constrained. In particular, we consider policy adjustments to three target variables namely, exports, interest rate, and inflation rate, in order to raise the level of demand in the sector. With regard to exports, we consider two alternative scenarios, namely, raising the level of exports throughout the sample period by 25% and 50 % respectively. With regard to interest rate and inflation rate, we consider a 1% and 2% reduction in their levels throughout the sample period. To begin with, we consider these changes individually, and then examine their combined effect. Keeping the solution of the original model as a baseline, we compare with it the model solutions under the alternative scenarios. The results are indicated in tables 2, 3, and 4 respectively.

The results indicated in tables clearly reveal the impact of the various policy instruments used to increase the demand for output in the registered manufacturing sector. The following points can be inferred from the results. In all the three cases, we find an increase in demand through the entire sample period. A larger magnitude of policy adjustment results in a greater increase in the demand. Moreover, the quantity supplied also changes due its dynamic relationship with output. We find the level of economic activity in the sector, indicated by the actual output, also increasing under all the three policy adjustments. In spite of an increase in the demand, we however find that regime continues to entirely demand-constrained. Thus, even while the demand increases, the magnitude of increase is not adequate to alter the nature of constraints in the sector.

Table 2. Impact of Higher Exports

Year	*25 % Increase in Exports*				*50 % Increase in Exports*			
	Change in Demand (Percent)	*Change in Supply (Percent)*	*Change in Output (Percent)*	*Reduction in Supply Demand Gap (Percent)*	*Change in Demand (Percent)*	*Change in Supply (Percent)*	*Change in Output (Percent)*	*Reduction in Supply Demand Gap (Percent)*
1980	0	0	0	0	0	0	0	0
1981	1.37	0	1.37	7.57	2.74	0	2.74	15.13
1982	1.38	-0.55	1.38	8.05	2.75	-1.10	2.75	16.11
1983	1.19	-0.79	1.19	8.89	2.39	-1.58	2.39	17.78
1984	1.21	-0.91	1.21	10.59	2.43	-1.81	2.43	21.17
1985	1.08	-0.96	1.08	9.21	2.17	-1.92	2.17	18.42
1986	1.09	-0.91	1.09	9.24	2.19	-1.82	2.19	18.48
1987	1.19	-0.91	1.19	10.24	2.39	-1.82	2.39	20.47
1988	1.15	-0.95	1.15	15.31	2.29	-1.90	2.29	30.63
1989	1.20	-1.01	1.20	28.99	2.40	-2.02	2.40	57.99
1990	1.26	-1.09	1.26	48.17	2.51	-2.18	2.51	96.34
1991	1.37	-1.15	1.37	20.76	2.73	-2.31	2.73	41.51
1992	1.41	-1.11	1.41	11.74	2.82	-2.22	2.82	23.49
1993	1.50	-1.07	1.50	10.57	2.99	-2.15	2.99	21.13
1994	1.52	-1.07	1.52	10.31	3.05	-2.14	3.05	20.63
1995	1.74	-1.08	1.74	13.18	3.48	-2.17	3.48	26.35
1996	1.70	-1.28	1.70	19.48	3.39	-2.57	3.39	38.95
1997	1.57	-1.40	1.57	16.24	3.15	-2.80	3.15	32.47
1998	1.56	-1.31	1.56	11.97	3.13	-2.63	3.13	23.94
1999	1.73	-1.24	1.73	10.47	3.45	-2.49	3.45	20.95
2000	2.01	-1.27	2.01	11.54	4.02	-2.54	4.02	23.08
2001	1.98	-1.43	1.98	11.79	3.97	-2.87	3.97	23.59
2002	2.19	-1.50	2.19	14.48	4.38	-3.01	4.38	28.96
2003	2.19	-1.63	2.19	16.51	4.37	-3.27	4.37	33.02
2004	2.24	-1.67	2.24	17.81	4.48	-3.35	4.48	35.62
2005	2.35	-1.71	2.35	19.21	4.69	-3.42	4.69	38.42
2006	2.32	-1.76	2.32	21.31	4.65	-3.53	4.65	42.62
2007	2.35	-1.78	2.35	19.07	4.70	-3.56	4.70	38.15

Table 3. Impact of Lower Rate of Inflation

Year	*1% Reduction in Inflation rate*				*2% Reduction in Inflation rate*			
	Change in Demand (Percent)	*Change in Supply (Percent)*	*Change in Output (Percent)*	*Reduction in Supply Demand Gap (Percent)*	*Change in Demand (Percent)*	*Change in Supply (Percent)*	*Change in Output (Percent)*	*Reduction in Supply Demand Gap (Percent)*
1980	0	0	0	0	0	0	0	0
1981	0.07	0	0.07	0.36	0.13	0	0.13	0.73
1982	0.06	-0.03	0.06	0.37	0.12	-0.05	0.12	0.75
1983	0.06	-0.04	0.06	0.41	0.11	-0.07	0.11	0.83
1984	0.05	-0.04	0.05	0.48	0.11	-0.08	0.11	0.96
1985	0.05	-0.04	0.05	0.43	0.10	-0.09	0.10	0.85
1986	0.05	-0.04	0.05	0.42	0.10	-0.08	0.10	0.83
1987	0.05	-0.04	0.05	0.42	0.09	-0.08	0.09	0.84
1988	0.04	-0.04	0.04	0.58	0.08	-0.08	0.08	1.16
1989	0.04	-0.04	0.04	0.98	0.07	-0.08	0.07	1.97
1990	0.03	-0.04	0.03	1.46	0.07	-0.07	0.07	2.93
1991	0.03	-0.04	0.03	0.58	0.07	-0.07	0.07	1.16
1992	0.03	-0.03	0.03	0.30	0.07	-0.06	0.07	0.61
1993	0.03	-0.03	0.03	0.24	0.06	-0.06	0.06	0.49
1994	0.03	-0.02	0.03	0.21	0.06	-0.05	0.06	0.42
1995	0.02	-0.02	0.02	0.22	0.05	-0.04	0.05	0.44
1996	0.02	-0.02	0.02	0.29	0.04	-0.04	0.04	0.57
1997	0.02	-0.02	0.02	0.23	0.04	-0.04	0.04	0.46
1998	0.02	-0.02	0.02	0.16	0.04	-0.04	0.04	0.33
1999	0.02	-0.02	0.02	0.13	0.04	-0.03	0.04	0.26
2000	0.02	-0.02	0.02	0.12	0.04	-0.03	0.04	0.25
2001	0.02	-0.02	0.02	0.12	0.04	-0.03	0.04	0.23
2002	0.02	-0.01	0.02	0.13	0.03	-0.03	0.03	0.25
2003	0.02	-0.01	0.02	0.13	0.03	-0.03	0.03	0.26
2004	0.01	-0.01	0.01	0.13	0.03	-0.03	0.03	0.25
2005	0.01	-0.01	0.01	0.12	0.03	-0.02	0.03	0.24
2006	0.01	-0.01	0.01	0.12	0.02	-0.02	0.02	0.24
2007	0.01	-0.01	0.01	0.10	0.02	-0.02	0.02	0.20

Table 4 . Impact of Lower Interest Rate

Year	*1% Reduction in Interest Rate*				*2% Reduction in Interest Rate*			
	Change in Demand (Percent)	*Change in Supply (Percent)*	*Change in Output (Percent)*	*Reduction in Supply Demand Gap (Percent)*	*Change in Demand (Percent)*	*Change in Supply (Percent)*	*Change in Output (Percent)*	*Reduction in Supply Demand Gap (Percent)*
1980	0	0	0	0	0	0	0	0
1981	0.09	0	0.09	0.49	0.18	0	0.18	0.97
1982	0.08	-0.04	0.08	0.50	0.17	-0.07	0.17	1.00
1983	0.07	-0.05	0.07	0.55	0.15	-0.10	0.15	1.11
1984	0.07	-0.06	0.07	0.64	0.14	-0.11	0.14	1.28
1985	0.07	-0.06	0.07	0.57	0.14	-0.12	0.14	1.14
1986	0.06	-0.06	0.06	0.56	0.13	-0.11	0.13	1.11
1987	0.06	-0.05	0.06	0.56	0.12	-0.11	0.12	1.13
1988	0.05	-0.05	0.05	0.78	0.11	-0.10	0.11	1.55
1989	0.05	-0.05	0.05	1.31	0.10	-0.10	0.10	2.63
1990	0.05	-0.05	0.05	1.96	0.09	-0.10	0.09	3.91
1991	0.05	-0.05	0.05	0.77	0.09	-0.09	0.09	1.54
1992	0.04	-0.04	0.04	0.40	0.09	-0.08	0.09	0.81
1993	0.04	-0.04	0.04	0.33	0.08	-0.07	0.08	0.65
1994	0.04	-0.03	0.04	0.28	0.07	-0.07	0.07	0.56
1995	0.03	-0.03	0.03	0.29	0.06	-0.06	0.06	0.59
1996	0.03	-0.03	0.03	0.38	0.06	-0.06	0.06	0.76
1997	0.03	-0.03	0.03	0.31	0.06	-0.05	0.06	0.62
1998	0.03	-0.02	0.03	0.22	0.06	-0.05	0.06	0.44
1999	0.03	-0.02	0.03	0.18	0.05	-0.05	0.05	0.35
2000	0.02	-0.02	0.02	0.17	0.05	-0.04	0.05	0.33
2001	0.02	-0.02	0.02	0.16	0.05	-0.04	0.05	0.31
2002	0.02	-0.02	0.02	0.17	0.04	-0.04	0.04	0.33
2003	0.02	-0.02	0.02	0.17	0.04	-0.04	0.04	0.35
2004	0.02	-0.02	0.02	0.17	0.04	-0.04	0.04	0.34
2005	0.02	-0.02	0.02	0.16	0.03	-0.03	0.03	0.32
2006	0.02	-0.01	0.02	0.16	0.03	-0.03	0.03	0.32
2007	0.01	-0.01	0.01	0.13	0.03	-0.03	0.03	0.26

We now combine the three policy adjustments together and examine their joint effect on demand. More specifically, we simultaneously raise exports by 50%, and reduce interest rate and inflation rate by 2% each. The results of this exercise are indicated in table 5. Here also, we see an increase in demand through the entire sample period. However, the increase is not sufficient to change the overall nature of constraints in the sector. A shift in the nature of constraint occurs only during one year namely 1990, where the regime switches to one of supply-constrained. For the rest of the years, the regime continues to be one of demand-constrained. Therefore, we can conclude that although we may be in a position to raise the demand, and thereby, the level of economic activity in Indian registered manufacturing sector using feasible policy instruments, it is not possible to change the nature of constraints facing this sector. The sector continues to remain a largely demand-constrained sector. Therefore, any policy initiative targeted at raising the level of economic activity in this sector must take on the Keynesian approach of raising the level of quantity demanded in order to increase the overall output.

Table 5. Combined Policy Adjustment Impact

Year	Change in Demand (Percent)	Change in Supply (Percent)	Change in Output (Percent)	Reduction in Supply Demand Gap (Percent)
1980	0	0	0	0
1981	3.04	0	3.04	16.84
1982	3.04	-1.22	3.04	17.85
1983	2.65	-1.76	2.65	19.71
1984	2.68	-2.01	2.68	23.41
1985	2.41	-2.12	2.41	20.42
1986	2.41	-2.02	2.41	20.43
1987	2.60	-2.02	2.60	22.44
1988	2.48	-2.08	2.48	33.34
1989	2.57	-2.19	2.57	62.58
1990	2.67	-2.36	2.51	103.18
1991	2.92	-2.40	2.92	43.76
1992	2.98	-2.34	2.98	24.77
1993	3.13	-2.26	3.13	22.21
1994	3.18	-2.24	3.18	21.59
1995	3.59	-2.27	3.59	27.37
1996	3.49	-2.67	3.49	40.28
1997	3.25	-2.90	3.25	33.54
1998	3.23	-2.71	3.23	24.71
1999	3.55	-2.57	3.55	21.56
2000	4.10	-2.61	4.10	23.65
2001	4.05	-2.94	4.05	24.13
2002	4.46	-3.08	4.46	29.54
2003	4.45	-3.33	4.45	33.62
2004	4.55	-3.41	4.55	36.21
2005	4.75	-3.47	4.75	38.98
2006	4.70	-3.58	4.70	43.18
2007	4.75	-3.60	4.75	38.60

7. Conclusions

The main objective of the present study has been to examine and identify the nature of constraints facing the level of economic activity in the registered manufacturing sector of the Indian economy. In other words the purpose is to examine the various demand side and supply side factors that influence the level of economic activity in this sector, and in turn identify whether the level of economic activity is constrained by demand or by supply. The analysis if carried out within a framework of market disequilibrium. The model comprises of a demand equation, a supply equation, and the traditional 'min' condition which states that the observed quantity is the minimum of demand and supply. A significant feature of the model used in the study, unlike the conventional formulations of single-market disequilibrium models is that, it incorporates intertemporal spillover effects of unrealized past transactions on both demand as well supply. The likelihood function for the model is extremely complex involving high dimensional integrals and multiple summations over all possible regime paths, thereby making direct estimation of the parameters though the maximization of the likelihood function virtually intractable. Therefore, we use the simulated-maximum likelihood approach to estimate the parameters of the model. More specifically, the procedure involves simulation of the regime paths and in turn, the observed and latent variables. The resulting simulated likelihood function is an unbiased estimator of the original likelihood function. Moreover, as the number of simulations tends to infinity, it also becomes a consistent estimator of the original likelihood function. Following the estimation of the parameters of the model, we solve the resulting demand and supply equations dynamically over the entire period of analysis in order to obtain the estimates of demand and supply. The estimated values of demand and supply reveal that the registered manufacturing sector in India has been demand-constrained over the entire period of analysis namely, 1980-2007. The policy implication of this result is that, any initiative to increase the level of economic activity and the overall growth in the Indian registered manufacturing sector must principally aim at augmenting the demand for output in this sector rather than supply. We also carry out certain counterfactual simulation exercises where we attempt to identify certain policy instruments using which we would be in a position to raise the level of demand in the sector and in turn, alter the nature of constraints. The results however reveal that using feasible policy instruments, we are in a position to raise the demand and thereby, the level of economic activity in the sector. However, the resulting increase in demand is not sufficient to bridge the supply- demand gap, which remains largely positive. Thus, the sector continues to be demand-constrained albeit changes in the level of economic activity.

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Appendix

Simulation Procedure for Dynamic Disequilibrium Model

1. To begin with, specify the initial estimates of the different parameters of the model. These include the coefficients of the various variables in the model as well as the values of demand and supply at the initial time period (i.e. time period 0).

2. Let $\phi(.)$ and $\Phi(.)$ denote the probability density function and cumulative distribution function of a standard normal random variable. For time period 1, we estimate the following variables–

$$M_{11} = \left(\frac{1}{\sigma_1}\right) * \varphi\left(\frac{(Q_1 - \alpha_0 - (\alpha_1 P_1) - (\alpha_2 Zin_1) - (\alpha_3 Exp_1) - (\alpha_4 Int_1) - (\alpha_5 Infl_1))}{\sigma_1}\right) * \Phi\left(\frac{-(Q_1 - \beta_0 - (\beta_1 P_1) - (\beta_2 K_1) - (\beta_3 L_1) - (\beta_4 Imp_1))}{\sigma_2}\right) \quad \text{... (A.1)}$$

$$M_{21} = \left(\frac{1}{\sigma_2}\right) * \varphi\left(\frac{(Q_1 - \beta_0 - (\beta_1 P_1) - (\beta_2 K_1) - (\beta_3 L_1) - (\beta_4 Imp_1))}{\sigma_2}\right) * \Phi\left(\frac{-(Q_1 - \alpha_0 - (\alpha_1 P_1) - (\alpha_2 Zin_1) - (\alpha_3 Exp_1) - (\alpha_4 Int_1) - (\alpha_5 Infl_1))}{\sigma_1}\right) \quad \text{... (A.2)}$$

We define $Pr_1 = \frac{M_{11}}{(M_{11} + M_{21})}$ and $R_1 = M_{11} + M_{21}$

3. We simulate a uniform random variable v_1 on the interval [0, 1]. Thereafter we simulate the regime indicator for time period 1, namely I_1 such that $I_1 = 1$ if $v_1 < Pr_1$ else $I_1 = 0$. Here $I_1 = 1$ indicates that demand is observed (and hence, supply is latent). Similarly, $I_1 = 0$ means that supply is observed and (and hence, demand is latent). We also simulate a uniform random variable u_1 on the interval [0, 1].

4. If we denote the unobserved (latent) variable during time period 1 by Q_1^* then we have the following simulations. If $I_1 = 1$, we simulate –

$$Q_1^* = \beta_0 + \beta_1 P_1 + \beta_2 K_1 + \beta_3 L_1 + \beta_4 Imp_1 - \sigma_2 \Phi^{-1}\left[u_1 \Phi\left(\frac{-(Q_1 - \beta_0 - (\beta_1 P_1) - (\beta_2 K_1) - (\beta_3 L_1) - (\beta_4 Imp_1))}{\sigma_2}\right)\right] \quad \text{... (A.3)}$$

Else if, $I_1 = 0$, we simulate –

$$Q_1^* = \alpha_0 + \alpha_1 P_1 + \alpha_2 Zin_1 + \alpha_3 Exp_1 + \alpha_4 Int_1 + \alpha_5 Infl_1 - \sigma_1 \Phi^{-1}\left[u_1 \Phi\left(\frac{-(Q_1 - \alpha_0 - (\alpha_1 P_1) - (\alpha_2 Zin_1) - (\alpha_3 Exp_1) - (\alpha_4 Int_1) - (\alpha_5 Infl_1))}{\sigma_1}\right)\right] \quad \text{... (A.4)}$$

5. For any time period t > 1, we carry out the following procedure –

(a) We define $Q^{P}_{1,t-1} = \begin{Bmatrix} Q_{t-1} \text{ if } I_{t-1} = 1 \\ Q^{*}_{t-1} \text{ if } I_{t-1} = 0 \end{Bmatrix}$ ... (A.5)

And $Q^{P}_{2,t-1} = \begin{Bmatrix} Q^{*}_{t-1} \text{ if } I_{t-1} = 1 \\ Q_{t-1} \text{ if } I_{t-1} = 0 \end{Bmatrix}$

(b) We estimate the following variables –

$$M_{1t} = \left(\frac{1}{\sigma_1}\right) * \left(\varphi\left(\frac{(Q_t - \alpha_0 - (\alpha_1 P_t) - (\alpha_2 Zin_t) - (\alpha_3 Exp_t) - (\alpha_4 Int_t) - (\alpha_5 Infl_t) - (\alpha_6 (Q^{P}_{1,t-1} - Q_{t-1}))}{\sigma_1}\right)\right) *$$
$$\left(\Phi\left(\frac{-(Q_t - \beta_0 - (\beta_1 P_t) - (\beta_2 K_t) - (\beta_3 L_t) - (\beta_4 Imp_t) - (\beta_5 (Q^{P}_{2,t-1} - Q_{t-1})))}{\sigma_2}\right)\right) \quad \text{... (A.6)}$$

$$M_{2t} = \left(\frac{1}{\sigma_2}\right) * \left(\varphi\left(\frac{(Q_t - \beta_0 - (\beta_1 P_t) - (\beta_2 K_t) - (\beta_3 L_t) - (\beta_4 Imp_t) - (\beta_5 (Q^{P}_{2,t-1} - Q_{t-1}))}{\sigma_2}\right)\right) *$$
$$\left(\Phi\left(\frac{-(Q_t - \alpha_0 - (\alpha_1 P_t) - (\alpha_2 Zin_t) - (\alpha_3 Exp_t) - (\alpha_4 Int_t) - (\alpha_5 Infl_t) - (\alpha_6 (Q^{P}_{1,t-1} - Q_{t-1})))}{\sigma_1}\right)\right) \quad \text{... (A.7)}$$

We define $Pr_t = \frac{M_{1t}}{(M_{1t} + M_{2t})}$ and $R_t = (M_{1t} + M_{2t}) * R_{t-1}$

(c) We simulate a uniform random variable v_t on the interval [0, 1]. We then simulate the regime indicator I_t for time period t, such that $I_t = 1$ if $v_t < Pr_t$; else $I_t = 0$. We also simulate a uniform random variable u_t on the interval [0, 1].

(d) Finally, we simulate the latent variable Q^{*}_{t} for time period t. in the following manner. If $I_t = 1$, we simulate -

$$Q^{*}_{t} = \beta_0 + \beta_1 P_t + \beta_2 K_t + \beta_3 L_t + \beta_4 Imp_t + \beta_5 (Q^{P}_{2,t-1} - Q_{t-1}) -$$
$$\sigma_2 \Phi^{-1}\left[u_1 \Phi\left(\frac{-(Q_1 - \beta_0 - (\beta_1 P_t) - (\beta_2 K_t) - (\beta_3 L_t) - (\beta_4 Imp_t) - (\beta_5 (Q^{P}_{2,t-1} - Q_{t-1}))}{\sigma_2}\right)\right] \quad \text{... (A.8)}$$

Else, if $I_t = 0$ we simulate –

$$Q^{*}_{1} = \alpha_0 + \alpha_1 P_t + \alpha_2 Zin_t + \alpha_3 Exp_t + \alpha_4 Int_t + \alpha_5 Infl_t + \alpha_6 (Q^{P}_{1,t-1} - Q_{t-1}) -$$
$$\sigma_1 \Phi^{-1}\left[u_1 \Phi\left(\frac{-(Q_t - \alpha_0 - (\alpha_1 P_t) - (\alpha_2 Zin_t) - (\alpha_3 Exp_t) - (\alpha_4 Int_t) - (\alpha_5 Infl_t) - \alpha_6 (Q^{P}_{1,t-1} - Q_{t-1}))}{\sigma_1}\right)\right] \quad \text{... (A.9)}$$

6) We carry out the above simulation procedure for all time periods t = 1,2, ..., T under consideration. This constitutes one simulation run. Given that we carry out S such simulation runs, the simulated log-likelihood function is given by –

$$L_S = \ln\left(\frac{1}{S}\sum_{j=1}^{S} R_{T,j}\right) \quad \text{... (A.9)}$$

where $R_{T,j}$ denotes the value of R_T in the j^{th} simulation run.

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