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MEASURES OF CAPACITY UTILIZATION: BRAZIL, 1920/1988

Marcelo S. Portugal[1]

ABSTRACT

This paper presents and discusses four different ways of creating a measure of capacity utilization for the economy as a whole. We use Brazilian data from 1920 to 1988 to create such variables and compare the problems and merits of which one of them. We choose a variable based on moving averages as the preferred one, on the basis of the quarterly data available and economic considerations.

1. INTRODUCTION

In this paper we discuss different ways in which a measure of the level of capacity utilization in the economy can be created. We shall focus in the generation and comparison of different capacity utilization series for the Brazilian economy.

Measuring the level of capacity utilization in the economy is not only important in itself but also because this variable is expected to be relevant in explaining the behaviour of other economic aggregates. Specifically, in the case of empirical work on trade equations the use of such variable has been widespread.[2]

The paper has other three sections. In the next section we present the different ways of constructing a measure of capacity utilization and estimate it for the Brazilian economy. The third section contain a comparison of the various measures while in the final section we present some conclusions and remarks.

2. DIFFERENT MEASURES OF CAPACITY UTILIZATION

The different measures of capacity utilization available in the literature can be divided in two major groups accordingly to the way they handle the potential output. It is the potential output that is actually estimated since the capacity utilization or output gap are obtained from, respectively, the ratio or difference

1 From the Federal University of Rio Grande do Sul.

2 See, for example, Abreu (1987), Fachada (1990), Barker (1987), Braga and Markwald (1983), Kahn and Ross (1975), and Goldstein and Khan (1985).

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between actual and potential output. The potential output can be supposed to increase at a constant or time varying rate.

2.1 Measures With a Fixed Potential Output Growth Rate

A first measure of capacity utilization can be obtained by regressing the logarithm of output on a time trend. That is,

$$ly1a = \alpha + \beta \text{ trend} + \varepsilon_t$$

where ly1a is the logarithm of real GDP. In this case, the residual ε_t can be taken as a measure of the output gap in the economy.

In this context the key idea is one of normal output. There exits a kind of natural or normal path which is represented by the estimated output in the regression above. Therefore, the potential output is not the maximum output and the actual output can be below as well as above it. If the residual ε_t is positive this implies that the economy is overheated and vice versa. When the actual output is equal to potential output the residual will be zero, which means that output is at its normal or natural level.

Using Brazilian GDP data for the period 1920/1988 we estimated the regression above by least squares. The data was obtained from IBGE (1990) and Zerkowiski and Veloso (1982) . The results show the potential output growing at around 6.0% per year.

$$ly1a = 0.7471 + 0.0599 \text{ trend}$$

The residuals, named *u11a*, representing the output gap are shown in figure 1.

The variable seems to behave in accordance with expectations. It shows positive values for the 1920s while the beginning of the recession after 1929 leads to a reduction in the output gap that reaches its lowest yet negative level in 1932. The economy overheats again in 1937 and then slumps until the end of the second world war to its all time low. The post war prosperity is acknowledge by the reduction in the negative gap until the economy overheats again in 1961. With the recession of the 1960s the output gap goes down to a new trough in 1967 to then recover again until 1980 when the recession leads to its reduction.

A slightly different approach is to determine a priori the year of maximum capacity utilization, that is years where the actual and potential output are equal, and then calculate the potential output series in between these years. Suppose we know that at some specific years, say t and t+s, the capacity was at its maximum. The fixed rate of potential output growth (β) can then be calculated from the relation

$$yp_{t+s} = yp_t\,(1 + \beta)^s.$$

FIGURE 1
u11a

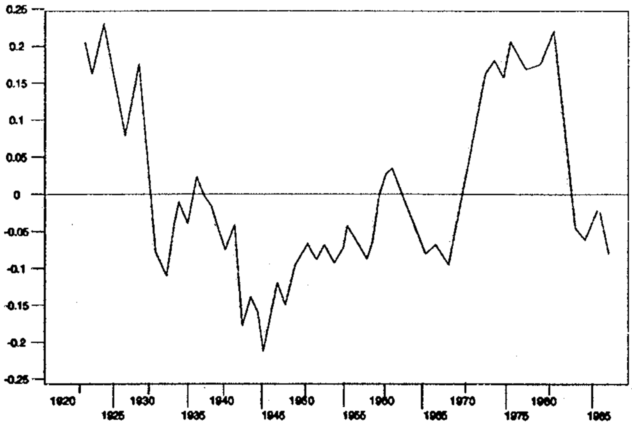
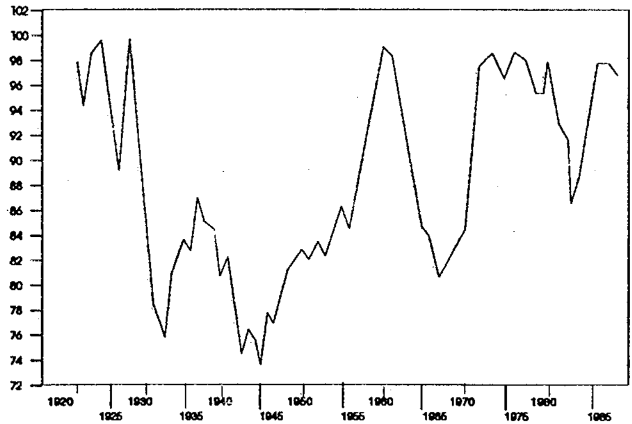


FIGURA 2
u14a



Once the potential output yp is obtained the level of capacity utilization can be calculated as the ratio y/yp. As before the potential output is supposed to grow at a constant rate β but in this case we have a more intuitive measure of capacity utilization bounded at 100%.

As we had various years of probable maximum capacity utilization between 1920 and 1988 we decided to do the potential output estimation in steps. The years designated as maximum capacity ones were 1928, 1961, 1974, 1980 and 1986. We have then four different growth rates for the potential output. Therefore, although the potential output grows at a constant rate within in each period, it changes from one period to another.

TABLE 1

RATE OF GROWTH OF β (%)

1920/1961	5.63
1961/1974	7.55
1974/1980	6.88
1980/1986	2.16

The capacity utilization index calculated in this fashion, named *u14a*, is shown in figure 2. The behaviour of *u14a* is again quite reasonable, meeting what is intuitively known about the level of capacity utilization of the economy.

2.2 Measures With a Varying Potential Output Growth Rate

Some time varying methods of estimating the potential product have been put forward by Moreira (1985) and Pereira (1986). They use a moving average process and a structural time series model respectively.

The structural time series methodology tries to decompose a series into its different unobserved components.[3] In this case we use the trend plus cycle model where the actual GDP is decomposed in a trend, cycle and irregular components.

$$ly1a = \mu_t + \varphi_t + \varepsilon_t$$

The cycle component is obtained as a combination of sine and cosine waves. Given the frequency λ_c and a damping factor ρ the cycle component can be written as

$$\begin{bmatrix} \varphi_t \\ \varphi_t^* \end{bmatrix} = \rho \begin{bmatrix} \cos\lambda_c & \sin\lambda_c \\ -\sin\lambda_c & \cos\lambda_c \end{bmatrix} \begin{bmatrix} \varphi_{t-1} \\ \varphi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \kappa_t \\ \kappa_t^* \end{bmatrix}$$

3 For details on the this approach see Harvey (1989).

where k_t and k_t^* are white noise errors with a common constant variance σ_k^2. The complete model is

$$
\begin{aligned}
ly1a_t &= \mu_t + \varphi_t + \varepsilon_t \\
\mu_t &= \mu_{t-1} + \beta_{t-1} + \eta_t \\
\beta_t &= \beta_{t-1} + \zeta_t \\
\varphi_t &= \frac{(1-\rho\cos\lambda_c L)k_t + (\rho\sin\lambda_c L)k_t^*}{1 - 2\rho\cos\lambda_c L + \rho^2 L^2}
\end{aligned}
$$

where η and ζ are also white noise variances σ^2_η and σ^2_ζ.

The estimation of this model is then performed using the kalman filter. The state space representation of the model can be written as

$$ly1a_t = [1\ 0\ 1\ 0]\ \alpha_t + \varepsilon_t$$

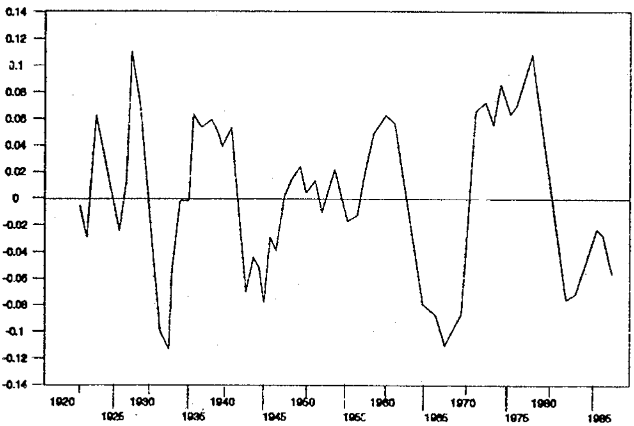
$$\alpha_t = \begin{bmatrix} \mu_t \\ \beta_t \\ \varphi_t \\ \varphi_t^* \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \rho\cos\lambda c & \rho\sin\lambda c \\ 0 & 0 & -\rho\sin\lambda c & \rho\cos\lambda c \end{bmatrix} \begin{bmatrix} \mu_{t-1} \\ \beta_{t-1} \\ \varphi_{t-1} \\ \varphi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \eta_t \\ \zeta_t \\ \kappa_t \\ \kappa_t^* \end{bmatrix}$$

In this case we again calculate the output gap by taking the difference between the actual and potential output but now the potential output, represented by the trend μ_t, does not have a constant rate of growth.

The estimated hyperparameters $\sigma_\eta^2, \sigma_\zeta^2, \sigma_\kappa^2$ and σ_ε^2 the state vector at the end of the sample α_{1988} and the frequency and damping factor are shown below.

FIGURE 3

u10a



Time Domain Estimation
Dependent variable is LOG(Y1A)
Sample period 1920 to 1988 69 Observations

Estimate	Parameter	Standard Error	t-ratio
.0000013	σ(Level)	.0028546	.0004649
.0000288	σ(Trend)	.0000315	.9125
.0011365	σ(Cycle)	.0021098	.5387
.8648	Damping Factor	.0966	8.9557
.3487	Frequency	.1662	2.0985
18.0165	Period		
.0000000	σ(Irregular)	.0002704	.0000000

Estimate	State	RMSE	t-ratio
4.8505	Level	.0539	89.9692
.0393	Trend	.0131	2.9897
-.0583	Cycle	.0539	-.0809
-.0004129	Cycle	.0551	-1.0074982
			-.0074982

Skewness χ^2 (1) = 2.4231 Kurtosis χ^2 (1) = .1935
Normality χ^2 (2) = 2.6166

Q(1) = .3271 Q(3) = 1.643 Q(5) = 8.364 Q(10) = 11.47
Heteroscedasticity test F(22, 22) = .5613
Log-likelihood kernel 176.2228 Sum of squares .1309
Prediction error variance .001862

R^2 = .9987 RD^2= .0230

The output gap calculated using the structural time series model, named ***u10a***, is shown in figure 3 and, as in previous examples, it also looks like what would be intuitively expected. The output gap is calculated in this case as the difference between the actual output and the trend component. The average potential output rate of growth in this case is 5.8%. It reaches a maximum of 7.7% in the 1970s and falls back to a average of only 4.4% during the 1980s.

An alternative way of allowing for a time varying potential output growth rate was proposed by Moreira (1985). The idea is to construct the potential product using a two period moving average of the actual output.

Suppose that the actual output expected rate of growth in each period, say g^*, is formed as an average of the rates of growth in the last two periods and that

FIGURE 4
u12a

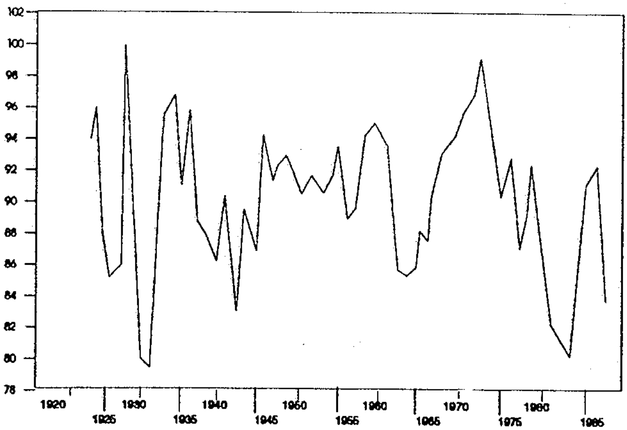
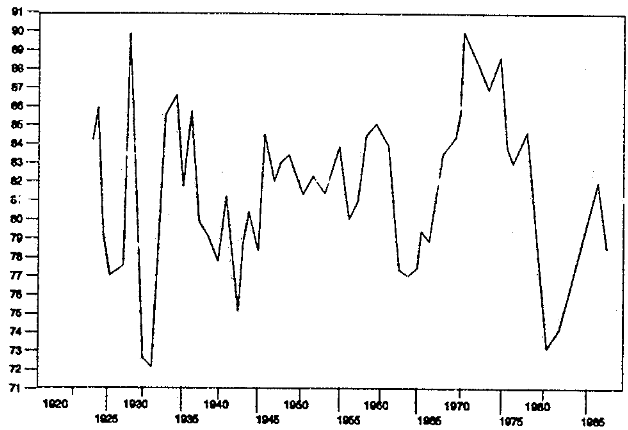


FIGURE 5
u13a



investment is done accordingly to this expectations trying to keep constant the level of capacity utilization. Formally,

$$g^*_t = \frac{g_{t-1} + g_{t-2}}{2}$$

$$u^*_t = u_{t-1} \quad \text{or} \quad = \frac{yp_t}{yp_{t-1}} = \frac{y_t}{y_{t-1}} ,$$

as $1 + g_t = \dfrac{y_t}{y_{t-1}}$ we then have

$$\frac{yp_t}{yp_{t-1}} = 1 + g_t .$$

As g_t is not known its expected value g_t^* is used instead. Therefore,

$$\frac{yp_t}{yp_{t-1}} = 1 + \frac{g_{t-1} + g_{t-2}}{2}$$

$$\frac{yp_t - yp_{t-1}}{yp_{t-1}} = \frac{y_{t-1}/y_{t-2} + y_{t-2}/y_{t-3}}{2} = \theta_t$$

The potential output is the calculated from the recursion $yp_t = \theta_t \, yp_{t-1}$ and $yp_0 = y_0$.

We chose the year of 1928 to start the recursions since, as we said before, the level of capacity utilization in this year is probably near the maximum. The result variable is presented in figure 4 under the name of *u12a*. Experiments where θ_t is a two period geometric mean lead to very similar results. The average potential output rate of growth obtained in this case, 6.0%, is close to the figure from the structural time series model. It shows though a more erratic behaviour. As before, this variable also seems to provide a reasonable approximation of what is intuitively known about the level of capacity utilization.

The final measure of capacity utilization we calculate, named *u13a*, combines the information available in quarterly data for the period post 1970 with the variable *u12a*.[4] Therefore, for the period post 1970 we use the annual average

4 See Conjuntura Economica, several issues.

whereas for the period before 1970 the series is calculated using the rate of change in *u12a*.

There exist a further method of generating the capacity utilization series by using the stock of capital and the capital/output ratio. If a series of average capital stock is available and the capital/output ratio is known for a year of maximum capacity utilization, the potential output series can be created by multiplying the capital stock in each year by this capital/output ratio. No prior information is actually needed about the year of maximum capacity utilization since it should correspond to the lowest capital output ratio.[5] This method is not used here since it is impossible to obtain reliable data on the average stock of capital for the period under consideration.

3. COMPARING THE DIFFERENT MEASURES

The main thing to notice about these different measures of capacity utilization is that variables that allow for a time varying rate of growth for the potential output (*u10a* and *u12a*) have a smaller standard deviation when compared with the those which have a fixed potential output growth rate (*u11a* and *u14a*). It can be seen from figures 6 and 7 that *u11a* and *u14a* are normally below *u10a* and *u12a* during the recession years and above it during the years of boom.

This behaviour is in line with what would be expected since in the fixed potential output growth rate case, investment decisions are not influenced by short rum movements in GDP. When the potential output rate of growth is allowed to vary it seems that during recession periods it falls below the constant rate and vice versa.

TABLE 2
STATISTICAL MEASURES

	u10a	u11a	u12a	u13a	u14a
Mean	.0009	.0000	90.2105	81.6612	89.0488
Std.Devn.	.0588	.1234	4.7452	4.3140	7.9186
Skewness	-.0928	.4285	-.4110	-.3416	-.0777
Exc. Kurtosis	-.7194	-1.0490	-.2457	-.3739	-1.1787
Minimum	-.1225	-.2091	79.1901	71.2996	73.3718
Maximum	.1243	.2294	100.0000	90.0360	100.0000

5 See Bonelli and Malan (1976) for an aplication of this method.

FIGURE 6
u10a and u11a

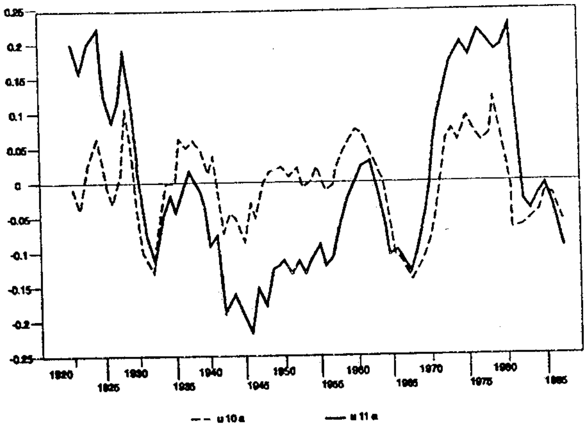
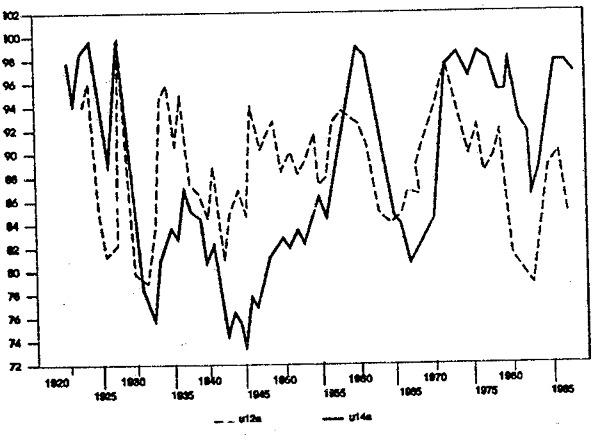


FIGURE 7
u12a and u14a



Although the hypothesis of a time varying potential output growth rate is much more appealing, the structural time series model presented in the previous section does not allow us to accept it. The t ratio test on σ_{ζ}^2 cannot reject the hypothesis of a fixed rate of growth.

The estimation of a structural time series model with a fixed potential output growth rate, that is using β instead of β_t, leads to a constant growth rate of 5.3%. The comparison of these two models using the AIC and the BIC also favours the fixed growth rate model. Therefore, although it makes more economic sense to think in terms of a varying rate of growth, at least in the structural time series framework, there seems to be no statistical confirmation of it.

TABLE 3
CORRELATION MATRIX 1970/1988

	u10a	u11a	u12a	u13a	u14a
u10a	1.0000				
u11a	.9593	1.0000			
u12a	.4018	.3887	1.0000		
u13a	.6405	.6143	.8803	1.0000	
u14a	.7003	.4876	.2770	.4755	1.0000

As a way of testing the different measures of capacity utilization provided here we tried to compare them with the available quarterly data on industrial capacity utilization for the period post 1970, denoted by *u13a*. Obviously the level of capacity utilization for the economy as a whole does not have to follow exactly the same path of the capacity utilization in the industrial sector. Nevertheless, especially for the recent period when the industrial sector has became more and more important, a high correlation is expected.

The evidence in the correlation matrix shown above is strongly in favour *u12a* which has a correlation coefficient of 0.8803. The second higher correlation coefficient, 0.6405, was obtained by *u10a*. Therefore, this test seems to give backing to the idea that measures allowing a time varying rate of growth for the potential output are closer to the reality.

4. CONCLUSION AND REMARKS

In this article we have presented different ways in which a series of capacity utilization or output gap can be created. The main question is how to model the potential output. This can be done by either applying a fixed rate of growth or by allowing it to be time varying.

Five different series were generated using annual data for the period 1920/1988. Although the statistical evidence cannot confirm the time varying growth rate hypothesis, this alternative still seems more appropriate not only in economic terms but also on the grounds of the information available for the industrial sector.

From the evidence in the correlation matrix it seems that u12a is the most appropriate measures to use. Moreover, since u12a is bounded between zero and one, it is also a more intuitive measure.

REFERENCES

ABREU, M. de P. *Equações de Demanda de Importações Revisitadas: Brasil, 1960-1985*. Rio de Janeiro: Departamento de Economia da PUC, 1986 (Texto para Discussão, n.148).

BARKER, T. S. Exports and Imports. In: BARKER, T. S. and PETERSON, W. (eds.). *The Cambridge Multisectorial Dynamic Model of the British Economy*. Cambridge: Cambridge University Press, 1987.

BRAGA, H. C. e MARKWALD, R. A. Funções de Oferta e de Demanda das Exportações de Manufaturados no Brasil: Estimação de um Modelo Simultâneo, *Pesquisa e Planejamento Econômico*, v.13, p.707-743, 1983.

BONELLI, R. e MALAN, P. S. Os Limites do Possível: Notas Sobre Balanço de Pagamentos e Indústria nos anos 70, *Pesquisa e Planejamento Econômico*, v.6, p.353-406, 1976.

FACHADA, J. P. *Um Estudo Econométrico da Balança Comercial Brasileira: 1975-1988*. Rio de Janeiro: PUC, 1990. Dissert. (mestr., econ.), PUC-RJ.

GOLDSTEIN, M. and KHAN, M. S. Income and Price Effects in Foreign Trade. In: JONES, R. W. and KENEN, P. B. (eds.). *Handbook of International Economics*, v. 2, Amsterdam: North-Holland, 1985.

HARVEY, A. C. *Forecasting Structural Time Series and the Kalman Filter*. Cambridge: University Press, 1989. IBGE. *Estatísticas Históricas do Brasil*, v.3, Rio de Janeiro: IBGE, 1990.

KHAN, M. S. and ROSS, K. Z. Cyclical and Secular Income Elasticities of the Demand for Imports, Review of *Economics and Statistics*, v.57, p.357-361, 1975.

MOREIRA, A. B. *Balanço de Pagamentos: Um Modelo de Simulação*, Rio de Janeiro: INPES/IPEA, 1985 (Texto para Discussão Interna, n.74).

PEREIRA, P. L. V. Estimação do Hiato do Produto Via Componentes Não Observados, *Revista de* Econometria, v.6, p.47-68, 1986.

ZERKOWISKI, R. M. e VELOSO, M. A. V. Seis Décadas de Economia Brasileira Através do PIB, Revista Brasileira *de Economia*, v.36, p.331-338, 1982.

SINOPSE
MEDIDAS DE UTILIZAÇÃO DA CAPACIDADE: BRASIL, 1920/1988

Este artigo apresenta e discute quatro variáveis diferentes para mensurar o grau de utilização da capacidade produtiva de uma economia. Utilizou-se dados da economia brasileira relativos ao período de 1920/1988, para criar tais variáveis, a fim de comparar os problemas e vantagens de cada uma delas. Escolheu-se uma das variáveis como sendo a mais indicada, com base em dados trimestrais existentes, para o período recente, e em considerações econômicas.

APPENDIX I
CAPACITY UTILIZATION
(Part A)

	u10	u11a	u12a	u13a	u14a
1920	-0.0090	0.205350	-	-	97.59435
1	-0.0362	0.161707	-	-	93.91061
2	0.0233	0.205477	93.86680	84.51390	98.62058
3	0.0634	0.229473	96.04857	86.47827	100.00000
4	0.0239	0.172853	87.73340	78.99163	96.44656
5	-0.0054	0.126172	85.04002	76.56662	92.52465
6	-0.0287	0.085811	86.00440	77.43491	89.32491
7	0.0171	0.115546	92.54077	83.31999	92.49752
8	0.1059	0.188367	100.00000	90.03598	100.00000
9	0.0610	0.125803	89.21918	80.32936	94.42189
1930	-0.0256	0.020673	79.72215	71.77862	85.43957
1	-0.0979	-0.069640	79.19008	71.29957	78.46550
2	-0.1164	-0.104710	84.30785	75.90740	76.15368
3	-0.0408	-0.043870	95.35746	85.85603	81.35029
4	-0.0008	-0.018040	96.48882	86.87465	83.91138
5	-0.0011	-0.032400	91.06534	81.99157	83.14355
6	0.0663	0.021868	95.57472	86.05163	88.23499
7	0.0568	-0.000920	91.52154	82.40232	86.69355
8	0.0594	-0.011060	89.11753	80.23784	86.26368
9	0.0458	-0.036890	88.28439	79.48772	84.49889
1940	0.0141	-0.080220	86.07243	77.49616	81.33485
1	0.0407	-0.063970	90.55814	81.53491	83.09618
2	-0.0657	-0.180550	81.65443	73.51837	74.33461
3	-0.0401	-0.162720	87.20723	78.51788	76.06386
4	-0.0483	-0.177330	90.08940	81.11288	75.34915
5	-0.0750	-0.209090	87.12122	78.44044	73.37183
6	-0.0155	-0.152360	94.36571	84.96310	78.05686
7	-0.0311	-0.169920	91.48258	82.36724	77.09507
8	0.0017	-0.137320	92.61815	83.38966	80.06312
9	0.0151	-0.123110	93.21026	83.92277	81.62957
1950	0.0191	-0.117290	91.58101	82.45586	82.53117
1	0.0043	-0.129420	89.57434	80.64914	81.95827
2	0.0110	-0.118930	90.80139	81.75392	83.25145
3	-0.0077	-0.132970	89.60325	80.67517	82.51592
4	0.0016	-0.117830	91.12482	82.04512	84.20848
5	0.0194	-0.093460	93.31181	84.01421	86.73292
6	-0.0189	-0.124850	88.65915	79.82513	84.48870
7	-0.0129	-0.110640	90.20869	81.22028	86.14174
8	0.0204	-0.068050	94.92045	85.46256	90.35510
9	0.0439	-0.034530	95.39831	85.89280	93.91918

CAPACITY UTILIZATION
(Part B)

	u10a	u11a	u12a	u13a	u14a
1960	0.0632	-0.004660	94.61990	85.19196	97.26820
1	0.0750	0.017868	93.75658	84.41466	100.00000
2	0.0681	0.021811	91.69221	82.55598	99.12169
3	0.0035	-0.032170	85.72711	77.18524	92.72101
4	-0.0342	-0.058710	85.56161	77.03624	89.14771
5	-0.0823	-0.094960	85.89715	77.33834	84.88317
6	-0.0904	-0.090080	89.06925	80.19437	84.21656
7	-0.1225	-0.108910	88.77107	79.92591	81.59747
8	-0.1032	-0.075390	92.43304	83.22299	83.30874
9	-0.0869	-0.044600	94.59269	85.16745	84.82349
1970	-0.0621	-0.005630	95.23970	85.75000	87.07565
1	-0.0288	0.041453	96.40908	86.50000	90.11630
2	0.0110	0.093918	97.32229	87.25000	93.76590
3	0.0710	0.164977	99.41524	89.75000	99.39425
4	0.0812	0.183818	95.23443	88.75000	100.00000
5	0.0660	0.174541	90.17698	87.00000	98.42924
6	0.1003	0.212605	93.21950	88.50000	100.00000
7	0.0875	0.200473	90.75383	84.75000	99.69924
8	0.0783	0.189293	88.56090	83.75000	97.94664
9	0.0888	0.195111	90.12200	83.25000	97.87441
1980	0.1243	0.223152	92.93033	84.25000	100.00000
1	0.0309	0.118185	82.26056	77.50000	93.57604
2	-0.0080	0.065510	80.92078	75.75000	92.26556
3	-0.0869	-0.029320	79.60772	73.00000	87.21735
4	-0.0812	-0.039990	84.77304	74.00000	89.68527
5	-0.0454	-0.021260	90.97447	77.75000	94.97474
6	-0.0142	-0.008270	91.78296	82.50000	100.00000
7	-0.0190	-0.032810	88.14794	80.75000	100.00000
8	-0.0582	-0.092780	83.48348	79.50000	99.26547