DEREGULATION AND THE CAPACITY, PRODUCTIVITY AND TECHNICAL EFFICIENCY OF EQUIPMENT OF FORMER TRUNK AIRLINES

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INTRODUCTION

The effect of deregulation on the use of aircraft technology is a somewhat neglected topic. The technological capabilities of the equipment in use are partly responsible for the break-even points in carriers' productivity and load factors. Deregulation has altered the environment in which the former domestic trunk carriers[1] operate. Therefore, its effect on their employment and acquisition of equipment can be economically significant, and is worthy of investigation.

This study is in four parts. The first reviews literature on the impact of deregulation on airlines' acquisition and deployment of advancing technology, and concludes that there is little to be found. It also identifies claims that this study tests. Part 2 discusses the data, and Part 3 the methodology. Part 4 reports the results and presents conclusions.

1. LITERATURE REVIEW AND STUDY OBJECTIVES

Deregulation of the US air transport industry has prompted many analyses of its effect on industry structure and efficiency, market contestability, economies of scale, quality of service, capital markets, route structures, welfare effects, and productivity. One sparsely treated topic is its effect on the rates of adoption and/or deployment of advancing technology embodied in newly procured aircraft.

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[1] American, Braniff, Continental, Delta, Eastern, Northeastern, Northwest, TWA, United, Western, and Pan Am.

Statements in the deregulation literature about equipment and technology are, for the most part, tangential to other concerns. Technology, for example, influences market structure in the long run; but what interests Bailey *et al.* (1985, pp. 23, 29) is market contestability, or the impact of deregulation on inefficiencies such as restrictive work rules which attenuate between technology and productivity. Morrison and Winston (1986), on the other hand, note that carriers composed much of their current stock of aircraft while under regulation. Consequently, they expect equipment inventories to adjust eventually to the deregulated environment, while increasing benefits already enjoyed as the result of deregulation (1986, p. vii). The part aircraft technology might play in these adjustments is, however, apparently not their concern.

More explicit analyses of air transport technology do exist. Caves *et al.* (1985) examine technological change in terms of production function shifts and unit-cost measures as functions of varying degrees of market contestability. Phillips (1971), Sahal (1981), Mowery and Rosenberg (1984) and Mechling (1986) explicitly analyse performance and acquisition rates of new equipment as a proxy for embodied technology. But these analyses do not consider the impact of deregulation.

Brenner, Leet and Schott (1985), however, do consider the impact of deregulation on carriers' stock of aircraft, and by implication on the technology it embodies. According to them deregulation has intensified airline competition in scheduling frequency along important routes, and has increased the number of competing carriers. This has fragmented traffic levels. "Hence, the desire of each competitor to maintain schedule frequency has led to an emphasis on smaller aircraft units", even though the offsetting effects of "hub and spoke routing, pricing strategies and the departure from many short-haul markets by the larger carriers may generate a need to retain some larger ones" (Brenner *et al.*, 1985, pages 95–96). An increased emphasis on smaller aircraft, we may conclude, has economic significance. That there are economies of scale in individual aircraft is a well established principle, and this implies that the production of unit seat-miles with smaller aircraft is costly by comparison with larger ones (Kahn, 1982, p. 13; Brenner *et al.*, 1985, p. 95).

This principle rests upon several assumptions, one of which is a given technology. That assumption, however, does not hold in practice, because airline managers often have no practical choice but to acquire new and more technologically advanced aircraft in order to be competitive (O'Connor, 1985, p. 82). This practice implies that (1) technology measures between carriers are highly correlated, and it is appropriate to average them (Mowery and Rosenberg, 1984, pp. 113–114); (2) the rates at which carriers acquire new technology in response to deregulation should also be measurable; and (3) variation in these measures and rates ought to be highly correlated.

These implications permit us to form and test several hypotheses. First, we test claims that deregulation has prompted carriers to size-down the average unit capacity or potential physical output of their aircraft and has significantly influenced the rates at which they acquire, and the effectiveness with which they deploy, the technology embodied in their equipment. As a result of these tests we can test additional claims that differentials between acquisition and deployment rates of technology have changed since deregulation. A critique is then possible of the effectiveness with which the carriers match their stock to the markets they serve. We can infer from this critique the extent to which the competitive impact of technology on the industry is influenced by deregulation. This is strategically interesting. Deregulated carriers are free to devise more efficient ways to exploit and deploy their equipment. Thus, they can maintain some of their competitiveness while reducing the expenditure on new equipment they have customarily had to bear.

2. MEASURES AND DATA

This study uses annual observations from 1965 through 1985, with observations from 1979 to 1985 covering the deregulated period. We normalise both data series. Otherwise, the large differences in magnitude between these series would lead to serious rounding-off errors (Draper and Smith, 1966, p. 144).

These series pool both domestic and international fleet characteristics and operations measures of the former US trunk carriers, including Pan Am.[2] Taken together, these carriers form a relatively stable system, which, despite mergers or discontinuances of operation, remained virtually intact from 1965 to 1985 and is a vital part of the US air transport industry. The study of this system, therefore, can provide estimates of the effect of deregulation.

The dependent variables are average unit productivity, capacity, and technical efficiency. Measures of this sort have been proposed on numerous occasions. Sahal (1981, pp. 165–177) used wheels-off-wheels-on average airspeed for his system measure of technological advance in commercial aircraft. Rosenberg *et al.* (1978) used seat-miles per hour, and Mechling (1986) used both seat-miles and payload ton-miles per hour. These measures are more refined than Sahal's, and better reflect typical performance specifications of the aircraft. We use payload ton-miles per hour ($T{\cdot}M/Hr$) in this study as the potential productivity measure of the typical aircraft deployed in the system.[3] This variable is obtained by dividing total available system ton-miles by scheduled system miles and multiplying that result by the result of dividing revenue miles flown by revenue hours flown (*Handbook of Airline Statistics; Air Carrier Statistics*).

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[2] By combining international with domestic fleet characteristics and operations we conveniently avoid having to sort out the allocation of acquired equipment between domestic and international use. The fact that deregulation applies only to domestic use is no cause for concern. International operations as a proportion of miles flown to total (domestic and international) miles flown is consistently under 5% for the time period examined.

[3] Available seat-miles per hour ($S{\cdot}M/Hr$) is a particularly attractive potential productivity measure. However, we prefer to use measures based on weight, because we will eventually use a measure of technical efficiency which we define as the proportion of total possible take-off weight given to payload capacity. This will not distort any measures we use in which payload is a part, since we find that the payload capacity in weight per seat has remained virtually constant for the time period our study covers. Thus, we specify all the equipment performance measures we use (payload capacity, productivity, and technical efficiency) in terms of weight.

For all practical purposes revenue miles do not differ from scheduled system miles; the difference is less than 0.01 per cent. The use of revenue miles is necessary because the *Handbook of Airline Statistics,* which published airspeed data, was discontinued after 1977. *Air Carrier Statistics* is a continuation of the *Handbook* which we then used, but it does not publish airspeed data. Therefore, we had to construct our own; and for this purpose, since the only measure of time was in revenue hours, consistency dictated that we also used revenue miles for the whole of the time period we examined.

$PYLD_S$ is the maximum payload capacity of the typical aircraft in stock in use, not in use, and/or in storage, only. It is an annual year-end measure but reflects monthly transactions. If, for example, TWA sells two L-188s at the end of September, only one-half of an L-188 is actually out of stock for that year. Taking such transactions into account, we calculated proportions for the numbers of different types of aircraft in stock for each year. Multiplying these proportions against their respective maximum payloads and summing these products yields the annual weighted-average measure, $PYLD_S$. *Janes* is the primary source for the payload figures. *Fleet Personnel* and *Aviation Week and Space Technology* are secondary sources which we used to augment *Janes* and to track the continual modifications made to both new and old equipment. $PYLD_D$ is the payload capacity that could have been flown in the system by the typical aircraft, given fleet deployment. Dividing total available system ton-miles by scheduled system miles yields this variable.

Advances in airframe, materials, control systems, and fuel technology increase the maximum payload of new aircraft relative to maximum take-off weight, given constant operating requirements such as speed, length of flight stage and cruise altitude. Technical efficiency, then, is the proportion of maximum take-off weight to maximum payload. This measure applies to the stock ($PYLDPROP_S$) and deployment ($PYLDPROP_D$) of equipment. $PYLDPROP_S$ is $PYLD_S$ divided by the total take-off weight of the typical system aircraft in stock, determined in the same way as we determined $PYLD_S$. $PYLDPROP_D$ on the other hand, is the sum of the payload proportions for each aircraft type, weighted according to the miles it has flown in a given year, divided by the total miles flown by all types. *Aircraft Operating Cost and Performance Report* (1965–1985) provides the data to generate these proportions.

The independent variable, *CUMDEL,* is the cumulative delivery to the trunks of new aircraft, either purchased or leased. Thus, if we have 100 deliveries in year one, 50 in year two, and 75 in year three, the data series of *CUMDEL* is 100, 150, and 225 aircraft in years one, two and three, respectively. *A Complete History of Commercial Aircraft Fleets* (1987) reports these deliveries, new or otherwise, on a monthly basis. Thus, two B-737s delivered in September represent only two-thirds of an aircraft in the total delivered for that year. By regressing *CUMDEL* against the dependent variables $T{\cdot}M/Hr$, $PYLD_{S,D}$, and $PYLDPROP_{S,D}$, we attempt to explain their variation as a function of the variation in the number of new aircraft delivered. Assuming that the deliveries of new aircraft over time constitute on average the introduction into the trunks' fleets of generally larger aircraft as well as advancing technology, we expect positive relationships between *CUMDEL* and these dependent variables.

3. METHODOLOGY AND DESIGN OF THE STUDY

Sahal (1981, pp. 125–130) suggests that a process of technological development involves significant time lags as a result of the role that accumulated experience plays in the development. Suppose the total stock of previously accumulated know-how determines the present state of technology. The simplest case yields

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + \ldots + e_t \qquad (1)$$

where Y_t is some measure of technology, X_{t-i} is some measure of an infinite backlog of accumulated know-how up to time period t, and $e_t \sim N(0, \sigma^2)$. We lend structure to the parameters of Equation 1 by adopting a geometric lag. The result may be written:

$$Y_t = \beta_0 + \beta_1 \frac{X_t}{(1 - L\lambda)} + e_t \qquad (2)$$

Klein (1958) suggests a division between the observed and unobserved portions of the data. This yields an estimable parameter referred to as the truncation remainder

$$(\alpha_0 = \sum_{i=0}^{\infty} \lambda^i X_{-i}),$$

which is the pre-sample history of X_t.

$$Y_t = \alpha_0 \lambda^t + \beta_0 + \beta_1 \sum_{i=0}^{t-1} \lambda^i X_{t-i} + e_t \qquad (3)^4$$

Augmenting Equation 3 with a dummy intercept (β_D) and slope (β_2) coefficient which are in force during the deregulated period, we can estimate the significance of deregulation:

$$Y_t = \alpha_0 \lambda^t + \beta_0 + \beta_D \cdot D + \beta_1 \sum_{i=0}^{t-1} \lambda^i X_{t-i} + \beta_2 \cdot D \sum_{i=0}^{t-1} \lambda^i X_{t-i} + e_t \qquad (4)$$

Using labels we give to the variables, Equation 4 becomes:

$$\left.\begin{array}{l} T{\cdot}M/Hr, \\ PYLD_S, \\ PYLD_D, \\ PYLDPROP_S, \text{ or} \\ PYLDPROP_D \end{array}\right\} = \alpha_0 \lambda^t + \beta_0 + \beta_D \cdot D + \beta_1 \cdot CUMDEL_t^* + \beta_2 \cdot D \cdot CUMDEL_t^* + e_t, \qquad (5)$$

where

$$CUMDEL_t \equiv X_t$$

and

$$CUMDEL_t^* \equiv \sum_{i=0}^{t-1} \lambda^i X_{t-i}.$$

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4 See Dhrymes (1981), p. 105, for the manner in which division by $(1 - L\lambda)$, the lag operator, transforms all observations on X_t, the independent variable.

We estimate Equation 5 for each dependent variable by means of a grid search for $\hat{\lambda}$. The squared residual sum is minimised, or the log-likelihood function is maximised if autocorrelation is present, in which case we also search for $\hat{\rho}_1$ or $\hat{\rho}_1$ and $\hat{\rho}_2$ (the autocorrelation parameter estimates) as well as $\hat{\lambda}$. We derive the information matrix for Equation 5 from its log likelihood function in the usual manner (Johnston, 1984, p. 276) and replicate Schmidt's block-diagonal matrix (Schmidt, 1971).[5]

Three difficulties arise in testing the claims this study has advanced. First, the productivity and capacity measures ($T{\cdot}M/Hr$, $PYLD_D$, and $PYLD_S$) do not account for the fact that capacity has increased relative to overall aircraft size, $PYLDPROP_D$ and $PYLDPROP_S$. Our estimates will understate *CUMDEL*'s role as an independent variable if we assume that only aircraft size has changed, and not technical efficiency. $T{\cdot}M/Hr$, $PYLD_D$, and $PYLD_S$ are, however, the numerators of the proportions which form $PYLDPROP_D$ and $PYLDPROP_S$ respectively.[6] Dividing the independent variables, *CUMDEL* and *D·CUMDEL*, by the appropriate *PYLDPROP* denominator transforms *CUMDEL* and *D·CUMDEL* so as to take into account changes in technical efficiency. Thus, we doubly transform *CUMDEL* when used with $T{\cdot}M/Hr$, $PYLD_D$, and $PYLD_S$ – first by this adjustment and secondly by dividing by the lag operator when it is normalised. We indicate this double transformation with *CUMDEL*** and *D·CUMDEL***.

The second difficulty arises because $T{\cdot}M/Hr$, $PYLD_{D,S}$, and $PYLDPROP_{D,S}$, are measures of fleet composition which are altered by the introduction of new equipment and the reduced usage or retirement of old equipment. We assume, however, that the reduction in usage of equipment types is a constant linear function of the new equipment being delivered. Thus, statistically significant relationships between accumulated deliveries of new aircraft (*CUMDEL*) and these variables is sufficient to establish empirically a valid linear relationship between the two sets of variables.

A third difficulty arises because average stage length, aircraft velocity, and take-off weight determine $PYLDPROP_D$ and $PYLDPROP_S$ along with increased technical efficiency. These performance requirements generally increase over time, requiring that proportionately more of an aircraft's cartage capacity be dedicated to fuel for a given technology. Consequently they partially offset whatever is gained from advancing aircraft technology by way of increases in the average payload proportions of the fleet.

We attempted to compensate for these offsetting effects by introducing into Equation 5 stock or deployed technical efficiency indexes inversely related to flight stage length, airspeed, and total takeoff weight. We constructed these indexes by extrapolating from the requisite 1966–1985 data, weighted cross-

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[5] Following the accepted practice, we omit the truncation remainder's cross-partials and main diagonal element from the information matrix, because its estimate is inconsistent, since in the limit it approaches zero (Dhrymes, 1981, p. 108).

[6] $PYLDPROP_D = PYLD_D$·velocity/(Max Take-off weight$_D$·velocity) $= PYLD_D$/Max Take-off weight$_D$, and $PYLDPROP_S = PYLD_S$/Max Take-off weight$_S$. All these measures are of course measures for the average deployed aircraft or aircraft in stock.

sectional models which we estimated from 1965 deployed and stock performance requirement data. Either index then represents the adjustments in technical efficiency hypothetically made in 1965 trunk technology as operating requirements increased from 1965 to 1985. Their use in Equation 5 was intended to force the coefficients of *CUMDEL* and *D•CUMDEL* to be positively larger in order to compensate for the negative effects of increasing operating requirements. These variables, however, introduced multicollinearity into the model. The R^2s exceeded 0.99, correlations in the correlation matrix were high, unanticipated sign changes occurred (the coefficients associated with declining technical efficiency due to increased operating requirements were positive, contrary to expectations), and some coefficients had dramatically low *t*-ratios even though they were significant at any reasonable level in simple regression models. Thus, the attempt to take increasing operational requirements into account did not prove useful, and we abandoned further attempts to do so. This does not, however, necessarily invalidate the results of this study. Since operating requirements generally increased in a well-behaved fashion during the time period covered, a significant positive relationship between *PYLDPROP* and *CUMDEL* is sufficient to indicate that those requirements are more than offset by advancing technology introduced into and deployed throughout the fleets.

4. RESULTS AND CONCLUSIONS

We estimated relationships between $T{\cdot}M/Hr$, $PYLD_D$ and $PYLD_S$ and $CUMDEL^{**}$ to test claims that deregulation has led to sizing-down equipment. Given our expectations that the estimates will assume definite signs, one-tailed tests of significance are appropriate. The asymptotic *t*-ratios appear in parentheses.

$$T{\cdot}M/Hr = -0.038558\,\hat{\lambda}^t + \underset{(51.7966)}{1.296392} + \underset{(0.4999)}{0.084971{\cdot}D} \qquad \text{(R.1)}$$

$$+ \underset{(5.5109)}{0.010703\,CUMDEL_t^{**}} - \underset{(-0.3683)}{0.001116\,D{\cdot}CUMDEL_t^{**}}$$

$$\underset{(2.72)}{\hat{\rho} = 0.51} \qquad \underset{(15.2752)}{\hat{\lambda} = 0.805} \qquad \begin{aligned} R^2 &= 0.9943 \\ S &= 0.023678 \\ n &= 21 \\ LLF &= 48.65926 \end{aligned}$$

$$PYLD_D = 0.02121\,\hat{\lambda}^t + \underset{(45.5196)}{0.968814} + \underset{(1.1119)}{0.159183{\cdot}D} \qquad \text{(R.2)}$$

$$+ \underset{(8.5340)}{0.011949\,CUMDEL_t^{**}} - \underset{(-1.1366)}{0.00287\,D{\cdot}CUMDEL_t^{**}}$$

$$\underset{(3.18)}{\hat{\rho} = 0.57} \qquad \underset{(23.9561)}{\hat{\lambda} = 0.832} \qquad \begin{aligned} R^2 &= 0.9933 \\ S &= 0.019675 \\ n &= 21 \\ LLF &= 52.50215 \end{aligned}$$

$$PYLD_S = -0.062971\,\hat{\lambda}^t + \underset{(50.3053)}{1.013659} + \underset{(2.3632)}{0.418444 \cdot D} \tag{R.3}$$

$$+ \underset{(19.1373)}{0.026910\,CUMDEL_t^{**}} - \underset{(-2.5974)}{0.01301\,D \cdot CUMDEL_t^{**}}$$

$$\underset{(3.82)}{\hat{\rho} = 0.64} \qquad \underset{(31.9199)}{\hat{\lambda} = 0.646} \qquad R^2 = 0.9972,\ S = 0.016581,\ n = 21,\ LLF = 56.02835$$

Autocorrelation is significantly positive in all three regressions at any reasonable level of significance ($\alpha < 0.10$). The dummy slope coefficients in R.1 and 2 are not significant, but the coefficient of the independent variable (*CUMDEL*) and the decay rate estimate ($\hat{\lambda}$) are. The dummy slope coefficient of R.3 is, however, significantly negative. Thus, deregulation has not sized down the average capacity of equipment in stock, but has significantly reduced the rate at which that capacity increases with the acquisition of new aircraft.

The following two models estimate the effect of deregulation on deployed and stock technical efficiency:

$$PYLDPROP_D = -0.215366\,\hat{\lambda}^t + \underset{(156.5220)}{1.148428} - \underset{(-0.6906)}{0.04550 \cdot D} \tag{R.4}$$

$$+ \underset{(4.7674)}{0.002627\,CUMDEL_t^{*}} + \underset{(0.4901)}{0.000609\,D \cdot CUMDEL_t^{*}}$$

$$\underset{(1.60)}{\hat{\rho} = 0.33} \qquad \underset{(10.1527)}{\hat{\lambda} = 0.732} \qquad R^2 = 0.9912,\ S = 0.00859,\ n = 21,\ LLF = 70.05$$

$$PYLDPROP_S = -0.013436\,\hat{\lambda}^t + \underset{(79.3505)}{0.970894} + \underset{(1.4291)}{0.116123 \cdot D} \tag{R.5}$$

$$+ \underset{(12.5389)}{0.025802\,CUMDEL_t^{*}} - \underset{(-1.5891)}{0.011532\,D \cdot CUMDEL_t^{*}}$$

$$\underset{(7.09)}{\hat{\rho} = 0.84} \qquad \underset{(-6.1853)}{\hat{\lambda} = -0.461} \qquad R^2 = 0.9933,\ S = 0.00846,\ n = 21,\ LLF = 76.444$$

Autocorrelation is present in R.4 ($\alpha \leqslant 0.10$) and in R.5. The coefficient for *CUMDEL* and the decay rate estimate ($\hat{\lambda}$) are also significant at any reasonable level for both models. Furthermore, the coefficient associated with $D \cdot CUMDEL$ in R.5 is significantly negative ($\alpha \leqslant 0.10$). Thus, there is a decrease in the rate at which technical efficiency of equipment in stock increases with the advent of deregulation. However, no reasonably significant change occurs in the rate of increase in the technical efficiency of the deployed equipment.

It is particularly interesting that the sign of $\hat{\lambda}$ in R.5 is negative. Normally, the expectation is $0 \leqslant \hat{\lambda} \leqslant 1$. A negative sign is often found in development economics, where negative autocorrelation occurs because the investment driving an economy is lumpy. Similarly, the accumulated acquisition of new equipment is an investment proxy which drives the stock-dependent variables, $PYLD_S$ and $PYLDPROP_S$. The influx of new equipment is not lumpy with respect to the changes in average unit payload capacity of the fleet in stock ($PYLD_S$). $PYLDPROP_S$ is, however, a measure quite independent of $PYLD_S$. It is not the capacity but the technical efficiency of the equipment acquired for which the influx of new equipment is lumpy.

Comparing the differences in rates at which deployed and stock unit capacity increases in R.2 and 3 during the regulated period, we form the following hypothesis:

$$H_0: CUMDEL_{R2}^{**} - CUMDEL_{R3}^{**} \geqslant 0 \tag{H.1}$$

A pooling technique described by Kleinbaum and Kupper (1978, pp. 101–102) generates a test statistic (–7.40) which indicates that the rate at which deployed capacity increases per unit increase in accumulated deliveries is significantly smaller than the corresponding rate at which stock capacity increases.[7] A second hypothesis test, which includes the significant effects of deregulation on stock capacity, generates a test statistic (–0.35) which suggests that the deployed rate is now statistically the same:

$$H_0: CUMDEL_{R2}^{*} - (CUMDEL_{R3}^{*} - D{\cdot}CUMDEL_{R5}^{*}) \geqslant 0\ ^{8} \tag{H.2}$$

Comparing differences in rates at which deployed and stock technical efficiency increase in R.4 and 5 during the regulated period, we form the following hypothesis:

$$H_0: CUMDEL_{R4}^{*} - CUMDEL_{R5}^{*} \geqslant 0 \tag{H.3}$$

Pooling generates a test statistic (–10.88) which indicates that the rate at which deployed technical efficiency increases per unit increase in accumulated deliveries is significantly smaller than the corresponding rate at which stock technical efficiency increases. $D{\cdot}CUMDEL^{*}_{R5}$ however, is significantly negative, and this suggests that deregulation has reduced the difference between the two rates. Unlike H.2, a follow-up hypothesis test to H.3 using $D{\cdot}CUMDEL^{*}_{R5}$ fails to show that in the deregulated period the deployed and stock rates are essentially the same ($\alpha = 0.10$). However, the test statistic generated is –1.54, which is decidedly less than the –10.88 generated by H.3.

Several conclusions follow from the results of this study. First, the former trunk carriers do not appear to be sizing-down their fleets with the aircraft they acquire under deregulation. The misperception that they are may have arisen because deliveries of relatively large aircraft like the B747 series virtually ceased

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[7] Despite the relatively small sample size of this study, it uses a large sample size pooling technique because of the asymptotic properties of its estimates.

[8] Being orthogonal to each other permits pooling the variances of the coefficients of $CUMDEL_{R3}^{*}$ and $D{\cdot}CUMDEL_{R3}^{*}$.

after 1978 (*Complete History,* 1987). That has been offset by the increased technical efficiency of the aircraft added to stock; so the former trunk carriers have continued to size-up the average payload capacity ($PYLD_S$) of their fleets, even though the rate at which they do so has significantly declined in the deregulated period (R.3).

Deployed average payload capacity ($PYLD_D$) has, however, increased at a constant rate through both periods, despite the significant decline in the rate of increase of stock capacity in the deregulated period.[9] This suggests that, though the acquisition of equipment since deregulation has slowed down the growth of average stock capacity, the deregulated environment permits the former trunk carriers to offset that slower growth with equipment usage which exploits units of larger capacity.

Furthermore, the average productivity measure $T{\cdot}M/Hr$ also appears to have increased in both periods at a constant rate, even though in general the average wheels-off-wheels-on velocity is somewhat less in the deregulated period.[10] Thus it would seem that no case whatsoever can be made, for the trunks at least, that deregulation has brought about the sizing-down of their equipment. Rather, the rates of increase in the average capacity and productivity of their equipment have not slackened where it counts most, in deployment.

Next, the rate at which $PYLDPROP_S$ increases significantly declines in the deregulated period (R.4), while the rate at which $PYLDPROP_D$ increases remains the same in both periods (R.5).[11] This decrease in the rate of increase of acquired technical efficiency parallels the change of pace in acquiring capacity. This implies that the deregulated environment permits the former trunk carriers to make more efficient use of their technology in stock.

Third, the improvement in deployment of equipment relative to the stock on hand in the deregulated period results no doubt from abandonments of routes, imaginative pricing policies, etc. This not only promotes the reduction in excess capacity but encourages use of aircraft of relatively larger capacity. This certainly benefits the trunks. Whether or not it benefits the social infrastructure is a much debated question (Stanbury and Tretheway, 1986).

Finally, changing route and service strategies suggest that the trunks might be less dependent on technology in competing with each other in the deregulated period because of the relatively increased significance now given to the deployment of that equipment. But less technological competition at this point under deregulation is probably a short-term phenomenon. Once the trunks have exhausted the exploitation of route, service, pricing novelties, etc. made possible by deregulation, they will probably have little recourse but to return to competing with each other on the basis of the equipment they acquire.

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[9] The rate of increase in deployed capacity appears to increase slightly but insignificantly in the deregulated period (R.2).

[10] Here there appears to be a slight insignificant decline in the rate of increase of $T{\cdot}M/Hr$ in the deregulated period (R.1).

[11] The rate of increase of $PYLDPROP_D$ increases slightly and insignificantly in the deregulated period.

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