OWNERSHIP, COMPETITION AND PRODUCTIVITY GROWTH: THE IMPACT OF LIBERALISATION AND PRIVATISATION UPON BRITISH TELECOM

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Abstract

Widespread public concern greeted the performance of British Telecom after liberalisation and privatisation, respectively under Acts of 1981 and 1984. This paper presents two methods of examining whether this dissatisfaction is warranted by comparison with what might have been expected from the earlier industry organisation. Both a total factor productivity approach and a small econometric model show that the regime change made little difference to efficiency growth.

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"There seems to be something fundamentally inexplicable about the British telephone system.... There's never any problem with the plumbing, the electricity, or even the gas"

Douglas Adams, Dirk Gently's Holistic Detective Agency, (1987)

With the Telecommunications Acts of 1981 and 1984, the British government allowed competition in the supply of telecommunications services and the sale of a 49% stake in the national carrier, British Telecom. The results of this experiment with the extension of market forces has not been widely regarded with satisfaction. Expressions of public concern about the services of the privatised and liberalised British telecommunications industry reached a peak in 1987. The proportion of customers rating BT's service as efficient dropped from eight out of ten in 1983 to seven (Which 1988 p.2) Total factor productivity analysis appeared to show a deterioration in performance in the post liberalisation period compared with earlier rapid progress (Pryke 1981, Molyneaux and Thompson 1987) These findings could be

construed as supporting the claim that the industry was a natural monopoly, whose costs were raised, or quality of service lowered for given costs, by the entry of a second carrier, Mercury (Labour Party 1986). The majority of academic observers however maintained that too little competition had been introduced into the reorganised industry, rather than too much (Kay and Thompson 1986, Vickers and Yarrow 1988). Only one competitive carrier had been licensed, Mercury, in 1982. (Accounts of the structure of the telecommunications industry are available in Vickers and Yarrow 1988 Ch 8 and in Foreman-Peck and Muller 1988 Ch11)

Yet even the evidence of the assumed efficiency differences is less clear cut than it seems. Although business users have been the principal immediate beneficiaries of the new policies, the real cost of the average residential telephone bill has fallen since the 1984 Telecommunications Act (Hartley and Culham 1988). So far as it could be objectively measured, general service quality had not deteriorated since privatisation until the 1987 engineers strike (Oftel 1987). British Telecom's total factor productivity was not clearly worse than the similar size German telecommunication system and was better than some other European networks' (Foreman-Peck and Manning 1988).

Although the best currently available indicator of the effect of liberalisation and privatisation, the time series total factor productivity (TFP) analysis is subject to at

least three caveats. First, the regime change may have altered industry behaviour in a way that changed the relationship between the TFP index and industrial efficiency. Second, the macro-economic environment in which the industry was obliged to operate certainly differed before and after the 1981 Telecommunications Act. The problem which the TFP analysis does not address is, controlling for the new environment, to chart the path that the British industry would have followed if, after 1980, a policy of liberalisation and privatisation had not been followed. Third, measurement of output of TFP might biass the indices. Connections to the telephone system are included as outputs, rather than as means of achieving an output, calls. During the 1960s and 1970s, residential connections (the majority) increased rapidly until most households had access to the network by the 1980s. Further expansions of "output" could not be achieved so easily by extending residential connections after the Telecommunications Acts.

The present paper offers some additional material for assessing the behaviour of the British telecommunications network before and after the regime change. Price dual total factor productivity indices are calculated for the two periods and biasses induced by the regime change are assessed. As a check upon these results a small econometric model of the British telecommunications system is employed

to simulate the behaviour of the system with the introduction of the new order in 1984.

TOTAL FACTOR PRODUCTIVITY AS A PERFORMANCE MEASURE

From the buyers point of view the beneficial impact if any of liberalisation and privatisation is felt in lower prices; that is, prices lower than they otherwise would have been. In itself this is an ambiguous criterion because the structure of prices is typically transformed. Prices of services that have been heavily subsidised rise while those for which prices have greatly exceeded costs are cut. Calculating the efficiency gains from this rebalancing of tariffs requires a knowledge of the price-cost margins and the price elasticities of demand (Wenders and Egan 1986). The total factor productivity approach is less demanding of information in considering a revenue weighted average of all telecom prices.

The regulatory regime established by the 1984 Telecommunications Act also focusses on this indicator for a subset of telecom output, accounting now for about 50% of BT's turnover. The RPI-X rule specified that the prices of inland calls and business and residential rentals may increase by no more than the retail price index minus 3% during the first regulatory period and 4.5% in the second. Consumers as a whole were thereby guaranteed a real annual

reduction in telecom prices, yet BT was given the freedom to align prices with costs.

Under control of the firm is the component of the price index that is net of input costs. Liberalisation is more of a success the more the output price average falls relative to input prices (although there may also be an effect on input prices). Once allowance is made for profits, this relative price change is a measure of total factor productivity change, either between time periods or between organisations.

An indicator of the success of liberalisation programmes is the extent to which industry cost or production functions are shifted by the regime change. Under special circumstances the TFP index will measure such shifts but in general the two indices will diverge with possibly major consequences for judgements about changing performance over time (see for example Kiss 1983). When there are constant returns to scale, when service prices are equal to marginal costs and input prices equal to marginal products, TFP indices do measure what liberalisation is believed to affect.

In what follows a result of Denny, Fuss and Waverman (1981) is extended to take into account the deviation of TFP measures from true efficiency indices when there are monopoly profits or subsidies to the organisation as a whole. This permits a more informed judgement about the meaning of the TFP evidence for the British case.

TFP indices are derived by differentiating and rearranging the identity that revenue equals expenditure for the telecom organisation;

$$\Sigma\, p_i\, q_i = \pi + \Sigma\, w_j\, I_j$$

where p_i and q_i are the prices and volumes of the i services, π is the profit and w_j and I_j are the input prices and volumes.

$$-\Sigma\, r_i\, p^*/p + (\pi/R)\,\pi^*/\pi + \Sigma\, (w_j\, I_j/R)\, w^*_j/w_j =$$

$$\Sigma\, r_i\, q^*_i/q_i - \Sigma\, (w_j\, I_j/R)\, I^*_j/I_j = TFP \qquad \ldots\ldots\ldots(1).$$

where r_i is the revenue share of the ith service, * indicates a time derivative, $R = \Sigma\, p.q$ = total revenue and TFP is the proportionate change in the TFP index.

Suppose the industry cost function is

$$C = c(q_1, q_2, \ldots, q_i, \ldots, w_1, w_2, \ldots, w_j, \ldots, T)$$

where T is the shift term of the cost function.

Replacing the cost identity by the cost function, following the same procedure as before and using Shephard's lemma that $\delta C/\delta w_j$ is equal to the quantity demanded of the jth factor

input, $(\delta C/\delta w_j)\ w_j\ /C = w_j\ I_j\ /C$, then the price dual TFP index is;

$$TFP = dT/T + \Sigma\ (r_i - a_i)q^*_i\ /q_i + (\pi/R)\ (\Sigma\ a_i\ q^*_i/q_i - dT/T) \qquad .....(2)$$

The second term on the right hand side of (2) is the effect of scale. When returns are constant, the sum of the cost elasticities $\Sigma\ a_i = 1$ and the term might seem to be zero, since revenue shares sum to one; then the term would not be a source of divergence between shifts in the cost function and the TFP index. If all outputs are produced under increasing returns to scale then $\Sigma\ a_i < 1$ and on that account $dT/T <$ TFP. The third term shows the effect of monopoly profits. When there are none, π/R is zero and the term disappears. Under most circumstances $dT/T < \Sigma a_i\ q^*/q_i$ and therefore monopoly profits would lead to a further over-estimate of dT/T by TFP.

Time series of conventional TFP indices will therefore overstate technical progress in a telecommunications system which was used to subsidise the postal service or finance part of the government budget. In the United Kingdom during the mid-1970s the government paid a subsidy to telecommunications as compensation for holding down prices. π/R was then negative and a conventional TFP index therefore

understated technical progress for that period. However this was not a consistent policy; on other occasions the system earned a profit . Over the period 1964/5-1980/1 the biasses are likely to largely cancel out, even though the year to year variations will not reflect efficiency changes. In comparison the post liberalization period with positive profits will overstate efficiency improvements. Since realiable estimates of scale coefficients for the British industry are not available, judgements as to whether efficiency shifts were less than the TFP growth must remain in abeyance, but international comparisons below cast some light on the issue. (Bernstein's (1988) scale estimates for Canadian Bell in a dynamic model cast doubt even on the widely accepted range of estimates of scale economies for that much studied organisation)

Inspection of the second right hand side term of (2) suggests even with constant returns and no profits there will be biasses. Suppose there are only two services (international say) (1) growing at 10% p.a. and (inland) (2) growing at 5% p.a. Suppose also that a_1=0.25 and a_2=.75, but revenues are obtained from them in equal proportions because service 1 subsidises service 2. Then the net effect is for this term to be positive and to give an upward bias to TFP as a measure of dT/T. A subsidy to the fast growing sector would have the opposite effect. To compute the profit, in the third right hand term, the price markup on marginal

costs (MC) must be known. The effects of pricing policy on biasses in TFP indices can be modelled more explicitly by assuming prices are marked up on MC by b.

$$P_i = b_i \, MC_i$$

The profit to turnover ratio for each service is

$$\pi'_i/R_i = 1 - (AC_i / P_i)$$

where AC_i is the average cost of the ith service. From the definitions of the cost elasticity a and the mark up b,

$$\pi'_i / R_i = 1 - c_i/a_i \, b_i$$

where ci is the cost share of the ith service, and

$$\pi/R = \sum r_i \, (1 - c_i/a_i \, b_i) \, .$$

$a_i \, b_i$ is the revenue share in total costs of the ith service. To break even on each service ($c_i=r_i$) the mark up b must be greater the stronger the increasing returns (the lower is a). If each service breaks even then c_i/a_ib_i is unity for each and $\pi/R = 0$. If prices are set so that one service subsidises another, a variety of biasses can be introduced into the TFP index even when $\pi/R = 0$.

Substituting for π/R in the TFP equation above;

$$TFP=dT/T + \Sigma (r - a)q^*/q + \Sigma r (1 - c/a\ b)(\Sigma a q^*/q - dT/T)$$

.....(3)

In the numerical example above, when b_2 is 1 1/3 and b_1 is 4, profits are zero. The third right hand side term of (3) is zero but the second term still induces a bias. The significance of this result is that TFP measures for a system equally profitable before and after liberalization are likely to give a more favourable impression of the earlier period in which cross-subsidy between services was more pronounced. Unfortunately without knowing the extent of cross-subsidization before or after the regime change, the extent of the bias cannot be calculated.

Finally some attention must be given to factor market imperfections Trade Union control could cause a divergence of employment from optimum levels. Procurement "clubs" may have had a similar impact upon capital equipment. Shepherd's lemma then no longer holds. With over-employment of inputs

$$\delta C/\delta w_i = g_i I_i$$

where the markup $g_i>1$. Consequently the true input price weights in the TFP index $(w_i I_i g_i/C)$ are understated.

Efficiency growth is therefore overestimated by the TFP index. Insofar as liberalization eliminates these practices, comparisons of TFP before and after will be biassed against the liberalization.

In sum two possible behaviour changes (factor market imperfections and the pattern of cross-subsidy) bias TFP measures against the private industry and one (profits) biasses in favour. Scale effects could amplify some distortions.

THE EVIDENCE OF TOTAL FACTOR PRODUCTIVITY

Table 1 shows the course of a revenue weighted index of telecom prices between 1963/4 and 1980/1. The first four annual growth rates show a decline in nominal prices which, taken with the growth in the retail price index (column 5 , Table 1), indicates annual real declines in price of 3-6%. The financial stringency of the years after 1967/8 revealed a new tendency for substantial price increases until 1970/1-1971/2. Compared with the rises during the inflationary surge of the mid 1970s these were however small. The 1970s saw the same cyclical pattern as the 1960s. As inflation accelerated, the growth of telecom prices lagged behind until 1974/5-1975/6 when a massive 60% jump in telecom prices restored the profitability of the system. The final upward leap in the series of column 1 comes with the election of the Thatcher government.

Averaging out the political pricing cycle, the entire period before the regime shift saw telecom price increases of about 8% per annum and retail price rises of 9.9%, an average real price decline of 1.9% over 17 years. Input prices over that period grew at an annual average rate of 9.6%, slightly less than the general rate of inflation. After 1967/8, changes in profits amounted to significant proportions of total revenue (column 4), the really large swings coming in the mid 1970s. Columns 1-3 permit the calculation of the price dual total factor productivity measure. Not surprisingly in view of the cycle in the component series, the index has a cyclical pattern, recording productivity decline in 1972/3-1975/6. The above discussion of the relationship between TFP indices and shifts in cost or production functions suggest that true productivity growth did not necessarily follow that trajectory. The average growth is about 2%, a little more than the average real price decline.

What would have happened to the total factor productivity index in the absence of a regime change? The series of Table 1 imply that holding down prices gave an incentive to increase productivity, at least as measured by the price dual index, whereas when large price increases were allowed, that encouraged slack. 64% of the variance in TFP growth was explained by output prices. A prediction of what TFP would have been can therefore be obtained by feeding in the price

index for the regulated basket of services during the post privatisation period.

OLS 1964/5-1980/1

TFP growth = -3.69 - 0.2183Output prices growth

(5.17) (5.26) R^2=0.64 DW=1.19 Q=11.41

t statistics in parentheses

Table 2

TFP Growth Forecast from BTs regulated prices

Year	1984	1985	1986	1987	1988	
	3.26%	2.89%	3.76%	3.69%	3.69%	avge.=3.46%

Most telecommunications data series were no longer published at some time between the Telecommunications Acts of 1981 and 1984, and therefore comparisons with the above series during the liberalised period are problematic. The RPI-X price control rule does provide some evidence though. Under certain circumstances thé X in the RPI-X rule will correspond to the price dual total factor productivity increase. When the constraint is binding

$$\Sigma \; r \; p = RPI^{*}/RPI \; - \; X$$

If, as Table 1 suggests , telecom input prices rise on average at about the same rate as retail prices, and if there is no change in profits, then

$$X = \Sigma r p^* - \Sigma w I/R \cdot w^*/w = TFP.$$

When the constraint is not binding the same assumptions imply

$$TFP = RPI^*/RPI - \Sigma r p^*$$

A caveat is that the coverage of the regulated basket is more restricted than the telecom index of Table 1. That TFP indices do not always correspond to cost function shifts over short periods should also be born in mind. Table 2 shows the price experience since 1984 and possible TFP increase on the assumptions already stated.

Table 3, BT's Price and Productivity Increase 1984-1988

	1984	1985	1986	1987	1988	
	%	%	%	%	%	
RPI^*/RPI	5.1	7.0	2.5	4.2	4.6	
$RPI^*/RPI - 3$	2.1	4.1	(0.1)	1.3	2.8	
$\Sigma r p^*$	2.0	3.7	(0.3)	0.0	0.0	
?TFP	3.1	3.3	2.8	4.2	4.6	avge. 3.6

Source: British Telecom Supplementary Report 1989 .

If these assumptions are approximately correct then TFP growth in 1984-1988 was virtually the same as it would have been without the regime change. The average 0.14% p.a improvement must be within the margin of error of these calculations. Towards the end of the period TFP growth

accelerates, a trend that is encouraged by the new higher X of 4.5 from August 1989.

In their 1989 Supplementary Report, British Telecom published a price index movement relative to the RPI apparently for all their telecommunications services, as well as one for telephone calls (local , national and international). The real annual average price decline since March 1984 for all telecom charges has been 1.7% and for telephone calls, 3.2%. The result for calls is roughly comparable with the TFP calculation based on RPI-X and not too dissimilar in coverage. For all charges the result if taken at face value looks poor against the historical record, but long term changes in the quality and variety of services may make this index misleading.

A certain amount of evidence as to the effects of scale economies and pricing and employment policies on these indices can be gleaned from international comparisons. Table (4) shows the measures for Canada and the United States before liberalisation but under a regime which was more like the post 1981 order in Britain than that before 1981. TFP for both countries appears to have grown considerably faster than in Britain. One explanation is that telecom output has rose more rapidly in Canada conferring an advantage in cost reduction if economies of scale were significant. Year to year changes (not shown here) in all cases presented in

Table 4 show wide swings and therefore short periods may not be comparable between countries. The general impression though from the British and German time series is that European TFP growth has been rather slower than North American. Can this be attributed to differences in the efficiency of the two types of regime or is it to be explained by different output growths together with scale economies, by labour market or by pricing policies?

Since US output grew more slowly than either of the European systems and the Canadian output growth was virtually identical to the British, scale economies (if they exist) together with similar rates of shift of cost functions cannot account for the pattern of TFP growth in Table 4.

Insofar as it is possible to generalise, it is unlikely that the pattern of cross-subsidy in Europe was less marked than in North America. The British Office of Telecommunications estimated price cost margins in 1986 (Culham 1987), after substantial rebalancing had taken place, that were in excess of those in the US (Wenders and Egan 1986). Spanish international calls were priced in 1985 at 2.66 times cost whereas local calls were less than one half (Foreman-Peck and Muller 1988 Ch 10). If the pattern of cross subsidy is more extreme in Europe then the TFP index will overstate technical progress more in the European systems than in the

privately owned, arms-length regulated North American systems.

The aggregate pricing policy which means that German telecom users were subsidising the postal service tends to bias the TFP index in favour of greater efficiency and therefore that cannot be a reason for the apparently superior North American performance. Where the slower British productivity growth is concerned, the receipt of a subsidy in the mid-1970s could give a misleading impression. But that was probably compensated for in other periods and the German evidence indicates that correcting for this bias would not close the gap with the North Americans.

Factor market distortions were unlikely to have been more extreme in North America. On that account the biasses in TFP favour Europe. At least British TFP growth is consistent with a slower rate of growth of internal efficiency in European telecommunications than in North American systems. Can this be explained by the then different ownership types? There is now quite a substantial literature on why, how and when ownership might affect performance (surveyed in Chapter 2 of Vickers and Yarrow 1988). The conclusion of these analyses is broadly speaking that the institutional environment is crucial; it cannot merely be competition in this instance. State ownership may be linked with more politicised regulation as the price and profit cycle of Table 1 suggests. Slower growth in the state regimes of

Europe may be a consequence of capital rationing either directly or through price controls. This would influence the pace at which new technology could be diffused. The pervasive waiting list for connection to the system, until recently at least, is consistent with this explanation although low domestic prices in relation to costs may be behind this excess demand.

Another explanation may be that the capital used was not employed efficiently because of the lack of incentives, once state ownership removed the capital market constraint. An intermediate case is the delayed introduction of the System X exchange into the British network. Only when the competitor System Y was ordered by a BT facing privatisation did deliveries take place at the contracted rates. Restrictions on wages imposed by civil service scales have imposed an added burden in some organisations such as the Norwegian NTA. Labour turnover is high and employees do not stay long enough to recoup the costs of training them before they are lured away by higher wages elsewhere..

The conclusion from the time series seems to be that the Europeans would have done better to have adopted a North American style of telecom organisation. But private ownership has not proved the philosophers' stone in Europe. Spain and Italy adopted the private monopolist regulated company form in the 1920s and their performance has not been

noticeably more dynamic than other European countries. Both Telefonica and SIP have been used as instruments of government policy to a greater extent than have the companies of North America, Telefonica as an industrial midwife and SIP as a weapon against inflation. That seems to be the most obvious reason for their failure to emulate North American performances. Elsewhere in Europe, where there is no private network ownership, such as in Germany, the constraints imposed by state policy are not very different. British state telecommunications performance was apparently not bad by European standards but it was in comparison to North America. Yet unless the TFP indices are substantially affected by the regime changes in 1981 and 1984, privatization and liberalization, moves in a North American direction, did not improve matters.

SIMULATING THE IMPACT OF BRITISH LIBERALIZATION

As a check upon the importance of this last qualification and as an independent means of testing the general conclusion, an alternative model of the British telecommunications service is estimated. If the regime change altered supply conditions after 1980, the equilibria that actually occurred will increasingly diverge from those "retrodicted " by the equations. Improvements in the efficiency of supply, because of the elimination of capital

rationing, or transactions costs, would lead the equations to underpredict actual demands and supplies. By contrast, reduced efficiency, because of entry by Mercury into a natural monopoly telecom service industry say, would generate overpredictions. Unfortunately a misspecified set of equations will fail to predict correctly what would have happened out of the sample period. There is always the possibility that the divergence between predicted and actual values arises from this source rather than from the regime change.

As the modifications to the TFP indices above may have suggested, modelling the state owned monopoly British telecommunications industry need not necessarily best be undertaken by assuming the existence of a production function and cost minimisation. The telecommunications arm of the British Post Office was operated as a government department, albeit the biggest. Since the nineteenth century the Post Office Engineering Union had been a powerful bargainer over wages, manning levels and conditions of employment (Clinton 1984). After privatisation, the Chief Executive of BT, Ian Vallance, who had spent his entire career in the predecessor organisation, remarked that the Unions had previously virtually run the old telecommunications service. The Auditor General in 1968 criticised the telecommunications division as not been sufficiently concerned to minimise costs (Post Office Annual

Report 1968). When the Post Office chose to buy competitvely it could do so at prices 20% below those normally paid in the long standing Bulk Supply Agreements with large domestic manufacturers. Moreover none of the 41 major orders due in March 1968 was completed on time.

As a government department the Post Office's investment funds were voted by Parliament every year. Contingencies of national politics and the economy therefore influenced the availability of investment funds as well as pricing. State industry prices could be held down as a weapon against inflation or raised to improve the governments budgetary position. Even in the absence of political pressures pricing policy was principally determined only by the need to break even and by some notion of a universal service obligation or equity. Customers were to be charged the same price for the same service even if the cost of supply differed between them. Prices did not reflect costs. While technical progress reduced costs most rapidly in transmission and therefore for long distance calls, equity or political pressures suggested these gains should be distributed equally to local callers.

In the model of the state telecommunications business estimated here, the output of the system is assumed to be three different types of telephone calls. Residential and business connections are necessary for the calls to take place (and so of course are the associated transmission and switching equipment). The model therefore consists of five

quasi-reduced form equations; two for access and three for calls. The equations for residential and business access first predict the number of connections that would have been attained if policy had not been changed. Then the predicted connections are used to forecast national, local and international calls. Other outputs of the telecommunication system, a small proportion during the estimating period 1954-1980, are ignored.

Predetermined investment is assumed to be the principal influence upon the supply of connections. That capital to the telecommunications arm of the British Post Office was predetermined is implied by the waiting list for connections which shows that demand did not balance with supply. Technological progress appears to have prevented labour being a constraint. Compared with investment, employment was relatively static over the period. Although at least a portion of output was supply constrained, demand cannot be ignored. Investment sanctioned by the government for the Post Office had to be responsive to demand pressure ultimately, albeit with a lag. For business, capital rationing was felt more in the quality of service and in new services not introduced or added only slowly. In both cases an "error correction" process is assumed to describe the interaction of economic and political behaviour (e.g. Nickell 1985).

The simplest version of the model is

$$\Delta y = a_0 + a_1 \Delta x + a_2 \Delta z + a_3 x_{t-1} + a_4 z_{t-1} + a_5 y_{t-1}$$

where the variables y,x,z are all in logarithms, Δ is a first difference operator, and t-1 indicates a one period lag.

The long run (steady state) solution is found by setting Δy, Δx and Δz equal to zero, that is $y_t = y_{t-1}$. When the coefficient a_4 on z_{t-1} is zero, z is a variable that affects the adjustment path but not the steady state of y . y and x are cointegrated but y and z are not. In long run equilibrium when y and z do have the same order of integration;

$$y = (a_0 / a_5) + (a_3 / a_5) x + (a_4 / a_5) z$$

If economic activity (x) grew faster than business connections (y), eventually there would be an offsetting temporary acceleration of business connections as the Post Office expanded supply to accomodate the backlog of demand. The pace of expansion was dependant upon the transmission and switching equipment being in place before connections were made. Once in place, the indivisibilities of this capital allowed connections to grow faster than investment for some time. In due course the relative rates of expansion of investment and connections would have to be reversed as building ahead of demand again became necessary.

On the demand side, business connections differ from residential because of the use of PABXs in larger firms. As economic activity increases, the number of main lines per firm does not expand proportionately with the growth of the firm, even though the number of extensions may do so. An increase in the number of firms is expected to have a greater impact on the demand for connections than a comparable expansion of economic activity that was supplied from the same number of businesses growing larger. One version of the business equation therefore included a variable to capture the effects of newly registered firms on demand.

For residential connections the household is assumed the principal telephone choosing unit. Once each household has a main line, the market is judged saturated although of course that does not preclude households acquiring more extension phones as economic conditions improve. An S-shaped diffusion curve is expected for household connections. The error correction model was modified to;

$$\Delta R = b_0 + b_1\{1-(R_{t-1}/H_{t-1})\} + b_2\{1-(R_{t-1}/H_{t-1}).Z + b_3\ R_{t-1}$$

where R is residential connections, H is households and Z is the explanatory variable set. When there are few connections

per 1000 households, as in the earlier part of the period, then R_{t-1}/H_{t-1} is small and hence $\{1-(R_{t-1}/H_{t-1})\}$ is large. This indicates rapid adjustment towards the saturation or desired level of connections. As time passes and the number of connections per 1000 households increases, the curve continues to rise more steeply. In later periods the rate of adjustment falls until the saturation level is approached. As R/H 1, $\{1-(R/H)\}$ 0. Thus the only determinants of ΔR become the lagged value and the constant b_0 . In the steady state , $\Delta R = 0$ and $R = -b_0/b_3$. That is, the level of residential connections remains constant.

The impact of the recession upon demographic variables between 1980-82 presents a particularly formidable task for the above equation in forecasting over the liberalisation period. The long run tendency for average household size to fall was reversed during the recession and population actually declined between 1981 and 1982. In the period 1980-1982 the number of households fell by around 800,000 (having dropped by 200,000 the previous year) and between 1982 and 1983 they rose by approximately 400,000. These changes from past experience were so radical that the residential connections equation estimated over a less traumatic period may not capture the full effects and in any case the consequences will be hard to disentangle from those of liberalisation.

In addition to the variables already mentioned (households for residential connections and numbers of businesses for business connections), both of the full versions of the connections equations included demand variables(real gross domestic product for businesses and real disposable income for households) and real fixed assets for supply.

The calls equations were also specified in error correction form, partly because other well known models, adaptive expectations and stock adjustment, are special cases. The propensity to make calls is expected to be considerably higher for a business connection than for a residential connection. Calls increase with economic activity, proxied by real gross domestic product, and with the ease of making them. In the case of national (trunk) and international calls, this last means direct dialling facilities (respectively STD and IDD). For international calls, the rapid internationalisation of business after 1967, which undoubtedly increased demand, was measured by the ratio of trade (exports plus imports) to GDP. (Between 1954 and 1967 this index showed a tendency to decline).

Once connections are in place, the telephone system must supply at prevailing prices the demands of subscribers. The price measures for different calls were too complex to identify demand responses. In any case the specifications adopted should be regarded as quasi-reduced forms in

quantities with price effects implicit. The changed structure of prices (tariff rebalancing) as well as the levels will be captured by the difference between the "no-liberalisation" forecast for 1984-88 and the actual volume of calls.

The effects of liberalisation are calculated on the assumption that the same investment would have been undertaken as under the pre-1981 regime; it is merely utilised more or less efficiently. If liberalisation boosted investment then the effects will be under estimated. The converse would be true if liberalisation reduced investment.

Since the system is recursive, consistent estimates may be obtained by OLS. However efficiency may be improved by utilising contemporaneous cross-equation correlation of errors and estimating by multivariate regression. Statistically insignificant variables with incorrect signs were dropped from the reported equations. Most surprisingly this rule eliminated both the level and change in business connections from all calls equations. Calls did not vary with business lines, although other telecom services may have done so.

Coefficients from both OLS and GLS estimation are presented in Table (5). Table (6) displays the long run elasticities and Table (7) shows the implied effects of liberalisation and privatisation derived from dynamic simulation with these equations.

The residential equation coefficients have the correct signs. They are tolerably well determined in OLS and well determined in GLS. The GLS income effect is considerably higher than the OLS but the other coefficients are similar. Business connections proved difficult to explain. Unlike residential connections they were not constrained by investment, nor did new firm registration have the expected sign or a statistically significant coefficient. Demand as measured by gross domestic product was marginally significant in the OLS equation. Both equations imply similar long run elasticities, greater than unity (Table 6). GLS improves the t statistics in the calls equations but at the expense of introducing autocorrelation in local and international calls. The exception is IDD which takes the wrong sign in the GLS international equation. However IDD was available to all telephone connections throughout the liberalisation period and this coefficient should not greatly affect the simulations. Long run income effects are above unity for both local and trunk calls although point estimates differ between estimation methods. Both methods agree that income effects were much stronger for international calls. Residential connections exercised a positive but smaller influence upon local and national/trunk calls. The impact effects of new connections were however substantial. Increasing openness of the national economy boosted international calls from the late 1960s, but the OLS

equation estimates the (poorly determined) long run elasticity at less than unity, whereas the GLS equation estimates the well determined elasticity at well above.

The OLS dynamic simulation (Table (7)) suggests that as a result of liberalisation and privatisation, business connections were 26.15% higher in March 1989 whereas residential connections were lower by 12.43%. This striking divergence of experience between the two sectors is consistent with the reorientation of the telecommunication business towards profitable areas. Possibly technological developments in the 1980s encouraged business connections independently of the regime change. Equally possibly some of the over-prediction of residential connections may have been due to the 1981-2 recession and/or to a failure of the equation to fully capture market saturation effects. GLS gives qualitatively similar results, a considerably greater over-prediction of residential connections and a slightly smaller under-prediction of business access..

The OLS calls simulations indicate that despite the reorientation, the regime change had virtually no effect. Even the rapid growth of international calls, reaching 14% p.a. in some years, would almost have been achieved without the new order.. The GLS simulation suggests a more substantial fall in inland calls and a rather greater rise in international calls.

On balance the conclusion is little different in this second exercise; measured by the volume of telephone traffic, privatisation and liberalisation made little difference in aggregate although they changed the composition of output. That compositional shift suggests a reason for the spate of public complaints. Those that lost out relative to what they might have expected, objected, while those who gained kept quiet.
These simulation results confirm the conclusions based on the price dual TFP indices. Unless inputs would have been higher under the old regime, since output in aggregate is much the same, productivity did not increase beyond levels that would anyway have been attained.

CONCLUSION

Two different methods using two different data sets point to the same conclusion ; that the regime change had little effect on the growth of efficiency. Yet there was scope for improvement. Before the current wave of liberalisation, time series TFP evidence seems to show that not only British but European "internalised" regulation was more constraining than the arms length style of North America. Productivity seems to have grown faster in North America even when output was expanding more slowly. The comparison with Britain cannot be vitiated by scale economies, by monopoly profits or subsidies, by different pricing policies, or by the effects of different labour policies, that could lead TFP

indices to understate shifts in the cost function. Extrapolating efficiency growth beyond 1984 indicated that the regime change did not further utilise the potential for productvity growth.

The reorientation of British telecommunications policy in 1981 and 1984 transformed most possible influences on performance. Private ownership and competition were introduced, and the government ceased to use the system as a policy instrument on any significant scale. Yet the simulation suggests no substantial improvement in productivity and calls (the principal output) growth since liberalisation.

North American comparisons imply that in the long term at least a 50% increase in productivity growth should be possible. In the short run a higher rate could be achieved as the technological backlog is made up. The increase in the regulatory X to 4.5 in August 1989 recognised this scope for a more rapid pace of advance. Natural monopoly arguments predict that even the TFP growth achieved between 1964/5 and 1980/1 cannot be maintained in the face of effective competition. From the other end of the theoretical spectrum, the accelerated pace would be judged impossible to sustain without more competition. If the new rule lasts the full term, both views will have lost some credibility.

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TABLE 4

Telecom Total Factor Productivity Growth

	%Output Growth	%TFP Growth
United Kingdom (1963/4-80/1),	8.84	2.0
Germany (1970-85)	13.19	2.6
Canada (1953-80)	8.74	3.44
USA (1947-1979)	7.4	3.2
Norway (1976-86)		3.4
Italy (1981-86)		3.0

Sources: Own calculations, Muller and Haid (1987), Kiss (1983), Christensen (1981), NTA and SIP.

Year	Price Index (Percentage) $\Sigma r_{it-1} \frac{\Delta P_i}{P_{it-1}}$	Input Prices	Profits as a percentage of revenue $\Delta\Pi/R_{t-1}$	Factor Productivity	Retail Price Index
1963/4-1964/5	- 1.2	+ 4.0	+ 0.3	+ 5.5	3.3
1964/5-1965/6	- 1.2	+ 3.7	- 0.1	+ 4.8	4.8
1965/6-1966/7	- 1.0	+ 2.7	- 0.4	+ 3.3	3.9
1966/7-1967/8	- 0.5	+ 3.6	- 0.5	+ 3.6	2.5
1967/8-1968/9	+ 6.2	+ 4.8	+ 3.0	+ 1.6	4.7
1968/9-1969/70	+ 4.2	+ 4.3	+ 2.0	+ 2.1	5.4
1969/70-1970/1	+ 9.5	+ 7.1	+ 4.9	+ 2.5	6.4
1970/1-1971/2	+ 0.5	+ 8.3	- 4.5	+ 3.3	9.4
1971/2-1972/3	+ 1.0	+12.0	- 7.6	+ 3.4	7.1
1972/3-1973/4	+ 4.9	+11.9	- 7.1	- 0.1	9.2
1973/4-1974/5	+14.7	+22.6	-11.5	- 3.6	16.0
1974/5-1975/6	+60.9	+26.8	+25.1	- 9.0	24.2
1975/6-1976/7	+14.8	+11.1	+ 9.7	+ 6.0	16.5
1976/7-1977/8	- 1.1	+ 7.3	- 1.5	+ 6.9	15.8
1977/8-1978/9	- 0.3	+ 6.0	+ 0.3	+ 6.6	8.3
1978/9-1979/80	+ 3.7	+10.2	- 6.4	+ 0.1	13.4
1979/80-1980/1	+20.7	+16.9	+ 1.4	- 2.4	18.0
Average :	+ 7.99	+ 9.60	.42	2.03	9.93

Notes and Sources :

Calculated from Post Office Accounts, B.P.P. and British Telecom Accounts, Supplementary Statements A(S)1, B(S)2. The telecom price measure is a linked Laspeyres index exclusive of VAT. The input index is calculated from the term "Additional expenditure due to changes in price and pay levels", assumed to be $\Sigma_i \Delta w_i I_{i\ t-1}$ where w_i are input prices and I_i are inputs. Dividing through by last periods' revenue R_{t-1} and multiplying and dividing each price term by the previous periods corresponding input price yields input expenditure/revenue share weighted factor price increases

$$\Sigma_i \frac{\Delta w_i}{w_{it-1}} \cdot \frac{w_{it-1} I_{it}}{R_{t-1}}$$

Retail Price Index : Annual Abstracts of Statistics. Monthly average to 1974 - Annual averages thereafter. Calendar years corresponding to beginning of fiscal year.

Table 5

Estmation period 1954-1980
(R=residential connections, H=households, B=business connections, L=local calls, N=national or trunk calls, I=international calls, Rfa=real fixed telecom assets, Dispinc=real disposable income per household, GDP=real gross domestic product, STD=subscriber trunk dialling, IDD=international direct dialling, For=trade/gdp. All variables in logs except STD and IDD which are proportions of subscribers with the facility.)

OLS $\Delta R = -0.3977 + 0.3501V1 + 0.3894V2 + 0.3370V3 + 0.1359R_{t-1}$
(-2.6405) (1.664) (2.0317) (2.4208) (3.7941)

ssr=0.00789 R^2=0.516 DW=1.740 F(4,20)=7.40

GLS $\Delta R = -0.2528 + 0.8038V1 + 0.3787V2 + 0.2014V3 + 0.1249R_{t-1}$
(-2.4864) (4.3757) (4.2939) (2.2559) (3.9929)

ssr=0.00938 R^2=0.544 DW=1.863

$V1=(1-R_{t-1}/H_{t-1})Dispinc_t$, $V2=(1-R_{t-1}/H_{t-1})\Delta Rfa$,
$V3=(1-R_{t-1}/H_{t-1})$

OLS $\Delta B = -0.9371 + 0.2635\Delta GDP + 0.2749GDP_{t-1} - 0.2365B_{t-1}$
(-1.9873) (1.2644) (2.002) (1.8365)

ssr=0.00986 R^2=0.1279 DW=2.058 F(3,21)=2.17

GLS $\Delta B = -0.6183 + 0.1481\Delta GDP + 0.1815GDP_{t-1} - 0.1492B_{t-1}$
(-1.4823) (0.6341) (1.4944) (1.3089)

ssr=0.0101 R^2=0.251 DW=2.216

OLS $\Delta L = 0.0583 + 0.6494\Delta R + 0.6196\Delta GDP + 0.0849R_{t-1} + 0.6621GDP_{t-1}$
(0.0628) (2.2934) (2.1933) (0.7922) (3.5416)
$-0.3370L_{t-1}$
(-2.7127)

ssr=0.0120 R^2=0.663 DW=1.228 F(5,19)=10.46

GLS $\Delta L = 2.0753 + 0.6108\Delta R + 0.7092\Delta GDP + 0.3516R_{t-1} + 0.7664GDP_{t-1}$
(2.9629) (3.0167) (2.7267) (4.7686) (4.9050)
$-0.6628L_{t-1}$
(-10.8455)

ssr=0.0175 R^2=0.651 DW=0.728

OLS $\Delta N = -0.4888 + 0.5004\Delta R + 1.0660\Delta GDP + 0.0042STD + 0.4872R_{t-1}$
(-0.3782) (1.7767) (4.4204) (3.6630) (2.6718)
$+1.3011GDP_{t-1} - 0.8770N_{t-1}$
(4.6949) (-4.9998)

ssr=0.00764 R^2=0.821 DW=1.908 F(6,18)=19.3

GLS $\Delta N = -2.3621 + 1.1160\Delta R + 0.8928\Delta GDP + 0.0036STD + 0.4346R_{t-1}$
(-3.5295) (4.9728) (4.0198) (6.3289) (5.2343)
$+1.8769GDP_{t-1} - 0.9401N_{t-1}$
(10.5769) (-12.0777)

ssr= 0.0124 R^2=0.810 DW=1.936

OLS $\Delta I = -3.8057 + 0.0742\Delta For + 0.6228\Delta GDP + 0.00227IDD + 0.2029For_{t-1}$
(-3.2315) (0.5640) (1.4210) (2.5992) (1.7741)
$+1.0856GDP_{t-1} - 0.2247I_{t-1}$
(3.3472) (3.4136)
ssr=0.0248 R^2=0.435 DW=2.110 F(6,18)=4.084

GLS $\Delta I = -5.2403 + 0.0173\Delta For + 0.9795\Delta GDP - 0.0009IDD + 0.3854For_{t-1}$
(-4.7207) (0.2441) (2.1553) (1.8496) (4.9301)
$1.4875GDP_{t-1} - 0.2286I_{t-1}$
(5.0486) (4.2892)
ssr= 0.0509 R^2=0.314 DW=1.194

Table 6 Long Run Elasticities

		OLS	GLS
Business connections:	GDP	1.16	1.22
Local calls	: GDP	1.96	1.16
	: Residential connections	0.25	0.53
Trunk calls	: GDP	1.48	2.00
	: Residential connections	0.55	0.46
International calls	: GDP	4.83	6.51
	: Foreign business	0.90	1.69

Table 7 Simulations 1984-1988

Residential connections OLS

Year Change ending 31 March	No Regime Change	Actual	Effects of Regime
1985	17.19	16.60	-3.43%
1986	18.34	17.12	-6.65%
1987	19.44	17.55	-9.72%
1988	20.45	18.14	-11.29%
1989	21.40	18.74	-12.43%
	GLS		
1989	23.60	18.74	-20.59%

Business connections OLS

Year Change ending 31 March	No Regime Change	Actual	Effects of Regime
1985	3.79	3.93	+3.69%
1986	3.84	4.14	+7.81%
1987	3.92	4.36	+11.22%
1988	4.02	4.71	+17.16%
1989	4.13	5.21	+26.1%
	GLS		
1989	4.22	5.21	+23.46%

Inland Calls (Local and National/Trunk) OLS

Year Change	No Regime Change	Actual	Effects of Regime
1985	23619	22686	-3.95%
1986	25083	24500	-2.38%
1987	26725	26216	-1.94%
1988	28694	28051	-2.29%
1989	31137	30616	-1.67%
		GLS	
1989	33815	30616	-9.46%

International Calls OLS

Year Change	No Regime Change	Actual	Effects of Regime
1985	189	197	+4.2%
1986	212	218	+2.8%
1987	238	242	+1.68%
1988	270	276	+2.22%
1989	311	312	+0.32%
	GLS		
1989	294	312	+6.1%

Notes: Actual connections (in millions) from British Telecom Supplementary Report 1989. Calls data (in millions) computed from growth rates in the Supplementary Report and the March 31 1984 figures in BT's Statistics 84.