THE ECONOMICS OF THE UNITED STATES SUPERSONIC TRANSPORT

By John A. Walgreen, E. H. Rastatter, and Arnold B. Moore*

The United States supersonic transport (SST) programme was terminated in 1971 after almost a decade of government support. It is generally believed that the SST was an economically attractive advanced technology programme which fell victim to the combination of environmentalist opposition and re-examination of social priorities in the Federal budget. This article will show that, even on economic grounds, the SST was an undesirable project.

The authors performed economic analyses of the SST to support Secretary of Defense Robert S. McNamara in his role as Chairman of the President's Advisory Committee on the Supersonic Transport. By drawing upon analyses completed while the authors were employed in the Defense Department, this article will show why from an economic cost-benefit standpoint the decision to terminate the SST development programme was correct, and why projects like the SST would retard rather than stimulate the economic development of the United States. The next section analyses the factors which influenced the profitability of the SST programme and shows why it was inferior to alternative investment opportunities available to society. The final section shows why a programme like the SST would retard rather than accelerate the rate of U.S. economic development.

THE SST PROGRAMME AS AN INVESTMENT

The analysis presented here utilised a computer model which simulated competition between the SST and the subsonic aircraft expected to be operating widely in the early 1970s, basically the Boeing 747 and the "stretched" McDonnell-Douglas DC-8s. Fare levels were calculated for each type of aircraft based upon its operating costs,[1] the airlines' target rate of return on investment, and aircraft productivity (seat-miles per year). The assumption that the choice between subsonic and supersonic flights turns on the value of the passengers' time (given passengers' income and the time and fare differentials between subsonic and supersonic aircraft) enabled us to estimate the number of passengers who would travel via SST.

This passenger demand was then translated into aircraft demand by utilising aircraft capacity and productivity data, and a 1974–1990 SST sales profile was

*The authors are respectively Associate Professor of Economics, Wheaton College, Norton, Massachusetts; Economist, Office of Management and Budget, Washington, D.C.; and Director of Planning, Center for Naval Analyses, Arlington, Virginia. They thank Sonia M. Walgreen for helpful comments. The views expressed herein are the authors' own and not those of the institutions with which they are affiliated.

[1]Operating costs for the SST and its subsonic competitors were calculated by using the Air Transport Association's formula for estimating direct and indirect operating costs.

generated. For given estimates of development and production costs,[2] the net cash flow and return on the investment in SST development and production were obtained. The effect of uncertainty about key parameter estimates was then analysed.

The results of this analysis of the economic feasibility of the SST differ from the conclusions drawn by the Federal Aviation Administration (FAA) in its studies, not because of significantly different methods of calculation, but because of the different values used for development costs, production costs, the value of passengers' time, etc. The values chosen here for the base case are more nearly consistent with research results than the parameter values used by the FAA.

The major parameter assumptions used in the base case of this analysis are as follows:

(1) air travel grows at an average rate of 10 per cent a year,

(2) passengers value their time at a rate equal to their average hourly earnings before taxes,

(3) the SST would weigh 675,000 pounds and cost $40 million without spare parts,

(4) development cost to certification would be about $2·4 billion,

(5) production plus development cost of 200 SSTs would be about $9 billion,

(6) disposable personal income *per capita* will grow at a rate of 2·5 per cent a year,

(7) fares are set to provide a 20 per cent pre-tax yield on airline investment in aircraft,

(8) supersonic flight would be restricted to routes over water and uninhabitated land areas, because of sonic booms.

The rates of return on investment and net cash flows in the tables reflect the shares of SST development cost paid by the United States government (USG) and the airframe and engine manufacturers (mfg) through Phase II (design competition) and the 90 per cent-USG/10 per cent-mfg cost-sharing formula agreed upon for Phase III (prototype development). The financial performance measures also reflect the scheme for the recoupment of government funds agreed upon when Phase III contracts were signed.

The recoupment arrangement called for a system of royalties, whereby the engine manufacturer would begin royalty payments with the first SST production engine sold and the airframe manufacturer had to start royalties not later than the 101st SST sold. The royalty rates were calculated so that the full USG cash contribution would be repaid by the 300th aircraft sold, and the full USG contribution plus 6 per cent interest would be repaid on the 1966 FAA-estimated market of about 500 aircraft.

Table 1 shows the number of aircraft sold, rates of return for the USG, the manufacturers, and the total programme (both parties' investment), and the net cash flows of the USG and the manufacturers when the base case parameter assumptions of this analysis are used.

---

[2]The estimates of SST development and production costs were made by utilising the RAND Corporation aircraft cost model.

TABLE 1

Base Case Results

Aircraft Sold	*Rate of Return on Investment (%)*			*Net Cash Flow ($ Million)*	
	USG	*Mfg*	*Programme*	*USG*	*Mfg*
139	—*	1	—	−1183	+150

*A dash in any of the tables indicates a loss.

As already mentioned, there was uncertainty about the value of several key parameters, so sensitivity tests were performed. The results of these tests are shown in Tables 2 to 4.

Value of Time Saved

Higher operating costs and fares than for subsonics meant that the success of the SST depended largely on the willingness of air travellers to pay higher fares to fly faster. There is general agreement that this willingness is determined by the value air passengers place on their time; but there was uncertainty about this value. FAA-sponsored analyses concluded that the value of time was equal to a person's average hourly earnings. The FAA, after discussions with ten airlines, concluded that the value was 150 per cent of a person's average hourly earnings. Recent research at The National Bureau of Economic Research indicates that people value their time at as little as 60 per cent of their hourly earnings.[3]

Table 2 shows that—depending on passengers' value of time—USG could expect to lose between $552 and $1,382 million cash under the then existing SST financing arrangements. While the true "value of time" variable is not known, it is very unlikely that it lies above the FAAs more optimistic assumption of 150, and even this value gives an unsatisfactory result. The rate of return is low (3 per cent), and sales are less than half the FAA's 1966 estimates.

Sonic Boom Restrictions

Various sonic boom tests have indicated that about 25–30 per cent of the public would find repeated sonic booms unacceptable. Booms for these tests were about 1·0 to 2·0 lbs. per square foot. The SST was expected to create a boom during supersonic cruise of about 2·0 lbs. per square foot, and more during acceleration. Variable conditions in the atmosphere and on the ground could cause booms of 3·0 lbs. or more with surprising frequency. Thus it was prudent to assume that SSTs would be restricted to flight over unpopulated areas.

Table 3 shows that this restriction costs the SST about two-thirds of its potential sales. Only if SSTs were *not* restricted by sonic boom would USG be repaid its full cash contribution and the programme rate of return approach a commercially acceptable level.

[3]Reuben Gronau, "The Effect of Travelling Time on the Demand for Passenger Transportation". *Journal of Political Economy*, March/April 1970, p. 393.

TABLE 2

Sensitivity of Results to the Value of Time

Value of Time (% of Hourly Earnings)	*Aircraft Sold*	*Rate of Return on Investment (%)*			*Net Cash Flow ($ million)*	
		USG	*Mfg*	*Programme*	*USG*	*Mfg*
75	111	—	—	—	−1,382	−252
100	139	—	1	—	−1,183	150
150	225	—	6	3	− 552	1,689

TABLE 3

Sensitivity of Results to Sonic Boom Restrictions

Sonic Boom	*Aircraft Sold*	*Rate of Return on Investment (%)*			*Net Cash Flow ($ million)*	
		USG	*Mfg*	*Programme*	*USG*	*Mfg*
Restricted	139	—	1	—	−1,183	150
Unrestricted	443	4	14	10	1,050	6,495

TABLE 4

Sensitivity of Results to Operating and R & D Costs

Variation of Costs About Base Values	*Aircraft Sold*	*ROI (%)*			*Net Cash Flow ($ million)*	
		USG	*Mfg*	*Programme*	*USG*	*Mfg*
Operating Costs						
−10%	170	—	3	—	− 957	665
+10%	126	—	—	—	−1,275	— 43
R & D Costs						
−20%	139	—	3	—	− 953	480
+25%	139	—	—	—	−1,440	−199

Effects of Changes in Operating and R. & D. Costs

Operating and research and development cost estimates are subject to large errors. Given base case assumptions and restriction of the SST to over-water flights only, the profitability of the programme is relatively insensitive to reasonable variations in aircraft operating costs and the cost of SST R & D. Table 4 shows that even favourable variation in one or the other of these factors would not enable the

programme to earn an adequate rate of return for either the government or the manufacturer.

This analysis shows that the SST could not have been a profitable investment in the face of sonic boom restrictions without simultaneous favourable variations in several of the key parameters from the assumptions used in the base case presented here. This was not impossible, since there was uncertainty about the correct value of each of these parameters, but it was highly unlikely that such a rosy prospect would actually materialise.

Given the pessimistic forecast of investment returns, one might wonder why the manufacturers were eager for the programme to continue. The answer may be the asymmetrical financing arrangements agreed to by USG in 1967. The royalty recoupment plan has been described above. An alternative arrangement for the financing of SST development and the recoupment of USG monies was the "pooling" proposal.[4]

"Pooling" was a euphemism for partnership. Under this arrangement, all parties would contribute in some agreed ratio, and, when the net receipts turned positive, would withdraw funds in a ratio based upon their respective contributions plus imputed compound interest on these sums. No market estimates would be required, and proportionate sharing of profits and losses would be assured.

The manufacturers balked at pooling, presumably because they preferred not to share either profits or losses, and because the royalty scheme required a market estimate. Thus, by estimating an unreasonably high sales volume on which to pay back USG monies, the royalty per plane would be lowered and total recoupment postponed. In addition, if the estimate were not fulfilled, USG would bear all losses while the manufacturers earned some returns; if estimates were exceeded, the manufacturers would earn dramatically high returns, while the USG returns approximated nominal interest charges.

One may surmise that the terms of SST development financing agreed to by the manufacturers reflected their private opinions about the prospective success of the SST programme. The programme was likely to be profitable to them only if the USG would assume the major risk of financial loss while they captured the potential profits.

THE SST AS A STIMULUS TO ECONOMIC DEVELOPMENT[5]

The preceding section has shown why the SST was not a good prospective investment, and the major reasons why it was not. Continuation of the SST programme would have retarded rather than stimulated U.S. economic development by diverting resources from alternatives which would have been more productive, as measured

---

[4]For a more extended discussion of "pooling" as the ideal form of government and industry participation in a risky joint venture see J. A. Stockfisch and D. J. Edwards, "The Blending of Public and Private Enterprise: The SST As A Case In Point," *The Public Interest* (Winter 1969), pp. 108–117.

[5]It has been argued that even if the SST was not commercially profitable the programme was justified because it would stimulate U.S. economic development. See David S. Lawrence, "The Initial Decision to Build the Supersonic Transport," *The American Journal of Economics and Sociology*, October 1971, pp. 403–412.

by their higher rates of return on investment, to the SST, where the rate of return might even have been negative. Unless the SST were permitted to operate over populated areas, the programme rate of return would have fallen short of the approximately 10 per cent per annum which Baumol has argued is "the correct rate of discount on government projects."[6]

If the financial success of the SST were ensured by permitting overland operations (as many opponents of the project feared might happen if the government went ahead with the project and realised later that it was locked into a losing programme because of sonic boom restrictions), the rate of return would have been an inadequate measure of net social benefit because it would not have taken account of the social costs imposed by the sonic boom.

The SST could not have been a development stimulant with a sub-marginal rate of return unless it had also produced significant external benefits. Benefits of this type were claimed by its supporters in the areas of job creation and technical advance. One might argue that the improvement in the balance of payments alleged to be associated with SST production and sales could also have had an indirect effect on U.S. economic development by relieving balance of payments constraints on growth-generating monetary and fiscal policies.

The proponents of the SST programme claimed that 50,000 jobs would be directly created by SST manufacture, plus induced creation of 250,000 jobs. But, because the SST would earn a lower rate of return than foregone alternative investments, it would have generated a lower value for real output than the nation would have attained without it. Thus, if it had any effect, one would expect it to reduce employment rather than increase it. Unless one assumes that monetary and fiscal policies would be ineffective in achieving full employment, the jobs generated by spending on the SST would not have been new jobs for the economy as a whole but only added employment in the aircraft industry. Such an effect would only be worth while if there were no more productive means of employing these workers. This proposition has yet to be demonstrated.

Another external benefit often claimed for the SST was that there might be technological discoveries of value in military or other civilian programmes, such as improved titanium production techniques.[7] Even if some such "technological fall-out" resulted, if the United States government were to spend over a billion dollars (the unrecouped SST development funds) on aircraft technology it would be more productive to spend the money directly on solutions to the technical problems of interest. More important, this argument for technical advance ran counter to the claim for the SST programme that as a result of military aircraft programmes, such as the XB-70, the technology was in hand and it could now be exploited for commercial purposes. This argument was wrong. When the decision was made to initiate

---

[6]William J. Baumol, "On the Social Rate of Discount," *American Economic Review*, September 1968, p. 793.

[7]Predictions have been made that 1975 titanium product prices would be significantly below 1966 levels because of the more efficient production techniques expected to be used in response to large increases in demand generated by the SST programme. See T. F. Cartaino, *Air Transportation in the 1970s: Problems and Opportunities*, Memorandum RM-5268-PR, January 1968, the RAND Corporation (Santa Monica, California), pp. 24–25.

SST development the technology was not in hand; this was demonstrated by the design problems and rising development cost estimates as the programme proceeded. The technology argument was paradoxical. The SST programme was approved both because of the technological discoveries it would produce and because the necessary technological discoveries for a commercial SST had already been made in previous military programmes.

The final, though indirect, assistance to economic development that the SST was supposed to generate was improvement in the U.S. balance of payments over what it would have been in its absence. Much of the balance of payments case was grounded in fears of the development of a commercially successful Anglo-French SST and the resultant adverse effect of sales of Concordes on the U.S. balance of payments. But Miss Mary Goldring, business editor of *The Economist* and a well-informed analyst of the Concorde programme, said: "If the future of Concorde is now seen as lying exclusively in the first-class market, on overseas routes only, then on the best possible assumptions its market is going to be a restricted one and fears of a huge drain on the U.S. balance of payments do appear grossly exaggerated".[8]

In considering the effect on the balance of payments one cannot look at the aircraft sales account alone, but must also study the interrelationships of this account with others, such as the travel account, which would be affected by development of an SST.

FAA funded studies examined these interrelationships and concluded that an SST would cumulatively improve our balance of payments by less than one billion dollars between 1975 and 1990. To gain this improvement would cost the U.S. government much more than a billion dollars in direct subsidies to the manufacturers, and far more in foregone returns from other programmes that could have used these funds. In addition, most of the improvement occurs near 1990, while the U.S. government costs would be incurred before 1975. Public financing of the SST would be an expensive way to purchase foreign exchange.

The previous analyses have shown that the SST would not have assisted U.S. economic development by creating positive externalities which would have more than compensated for its negative or substandard rate of return. The SST was also likely to result in some negative externalities beyond the sonic boom, which has already been discussed.[9] The SST's operating altitude, speed, and technical characteristics such as fuel consumption would probably have required investment of from several hundred million to over $1 billion in special weather forecasting facilities to meet its operational needs.

In air traffic control the SST would require longer separation times between operations. Therefore, in any given time period air traffic control would be able to handle fewer aircraft with SSTs than in a purely subsonic environment. In addition, the inefficiency of the SST during subsonic flight required shorter holding times for

---

[8]Testimony of Mary Goldring at hearings before the Subcommittee on Economy in Government of the Joint Economic Committee, Congress of the United States, 7, 11 and 12 May 1970, *Economic Analysis and the Efficiency of Government*, Part 4—*Supersonic Transport Development*, p. 925.

[9]The Concorde will also generate these negative externalities. This raises the issue of whether other nations should have to bear these burdens to support the technological base of the British and French aviation industries.

this aircraft than for subsonics. Thus more controllers would have to be provided to accommodate it.

The SST's noise contour differed from that of present and expected subsonics. This meant that airports handling both SSTs and subsonic planes would inflict high noise levels on a larger part of their neighbouring communities and intensify this major problem of the airports and the airlines.

CONCLUSION

This paper has shown the factors which made the SST a poor allocation of resources. It has also examined the externalities claimed for the SST and shown that they either were nonexistent or were being purchased at too high a price relative to alternative means for attaining them. A number of potential negative externalities were indicated as being associated with the SST.

The conclusion is unavoidable that the SST, by allocating resources in an inferior manner, would have retarded rather than assisted economic development. It is regrettable that in the face of this evidence, which was available by late 1966, a decision was taken to go ahead into Phase III development. It took ecological arguments to finally terminate the SST programme in 1971, but not before several hundred million dollars were spent on it. This experience reflects the power of producer interests, but even more the inertia in government programmes, which once started tend to keep going even in the face of adverse evidence on their continued desirability.