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Economic Sector Data for Modeling the Impact of Less Ignition-Prone Cigarettes

Technical Study Group
Cigarette Safety Act of 1984

October 1987

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Mission and Members

Itie Technical Study Group on Cigarette arid Little Cigar Fire Salcty was established by Public Law 98-567 the Cigarette Safety Act of 1984. on October 30. 1984 Iis mission is io

"undertake such studies and other activities as it considers necessary arid appropriate to determine the lechnical arid commercial feasibility, economic impact, and olher consequences of developing cigarettes and little cigars that will havc a minimum propensity to ignite upholstered furniture or *mattresses* Such acfivifies *iriciude identification* of *the different physical characteristics of* cigarettes *and little cigars which have an impact on lhe ignition of upholstered furniturc arid mattresses.* ari *analysis of the feasibility of altering any pertinent characteristics to reduce ignition properisity, and an arialysis of the possible* costs *and benefils. both to the industry arid the public, associated with any such product modification."*

Copies of this or *any* oihcr reports of thc Technical Sludy Group may be obtained from Mr Colin B Church. Secretariat. Technical Study Group. Consumer Producl Safety Commission. 5401 Westbard Avenue Washington D.C 20207

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Preface

These five reports were commissioned by the Technical Study Group under the Cigarette Safety Act of 1984 The purpose was to obtain the best possible timely information as input for the mandated economic impact analysis of cigarettes with a reduced propensity to cause furnishings fires These reports have not been subjected to peer review by external technical experts

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Section 1

The Impact of Cigarette Modifications on the Tobacco Production Industry in the United States

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1. Introduction

This project on the agricultural impacts of reduced ignition cigarettes has been carried out in close contact with the Applied Economics group of the National Bureau of Standards The model is an extension of the log linear equilibrium model developed in Sumner and Wohlgenant [1] In Sumner and Wohlgenant we applied the model to the case of a cigarette excise tax increase In the present case cigarette modifications present a more complicated application but the core of the model and its solution remain The other extensions of the present effort are to draw more completely implications for the tobacco growing industry and to indicate more fully actual as well as proportional changes

The next section provides the mathematical model used in all the calculations It explains assumptions and provides further information necessary for interpretation Section 3 provides the baseline values lor all variables used in ttic model It contains a table sources. and associated discussion Section 4 contains a table of parameter values and sources for shares and elasticities used in the model Section 5 presents the baseline assumed values that are used in the illustrative calculations of the agricultural impact of the cigarette modifications. Since no final set of modifications were available. a set of feasible values that show the extreme agricultural impacts were used for the example Stephen Weber, of NBS. was consulted on the feasibility of potential cigarette modifications. The final section contains a table of results that applies the model lo the best available data as documented in the previous sections It provides proportional and actual projected changes in prices and quantities of the two major tobacco types. It also includes estimates of changes in incomes from quota. labor, land. management, and producer surplus or returns to non-quota quasi-fixed factors for each of the types of tobacco [2]

2. Model and Interpretation*

The "cigarette model" contained on the following pages is an adaptation of the model developed by Sumner and Wohlgenant in 1982 and published in 1985 [1]. The article provides further information on technical points. The most important underlying assumption of this sort of model is that the linear in logarithms formulation is a reasonably close approximation over the range of application. For changes in the order of magnitude discussed below this is no problem. The model applies to changes in industry conditions but does not provide information about the time path or dynamics of changes. The choice of parameter values, especially elasticities determines the "length of run" for the application In this case it is expected that several years would be required for a transition.

Notation used in the model is defined in the tables in the following sections. The symbol "E" denotes logarithmic change: $E(X) = d\ell n(X)$. The preliminary cigarette model as adapted by Stephen F. Weber consists of the following structural equations

Cigarette Model

Structural Equations

1. $EQ_{cd} = -\eta_{cd}EP_{cd} + \overline{ED}_{cd}$
2. $EQ_{ce} = -\eta_{ce}EP_{ce} + \overline{ED}_{ce}$
3. $EQ_c = \beta_{cd}EQ_{cd} + (1 - \beta_{cd})EQ_{ce}$
4. $EP_{cd} = \alpha_{td}(EP_{td} + \overline{ED}_{td}) + \alpha_K EK + \alpha_M \overline{EM}$
5. $EP_{ce} = \gamma EP_{cd}$, where $\gamma = [1/(1 - \alpha_T)]$
6. $EQ_{td} = -\alpha_{td}\sigma_{dd}EP_{td} + EQ_c + \overline{ED}_{td}$
7. $EQ_{te} = -\eta_{te}EP_{td}$
8. $EQ_t = \beta_{td}EQ_{td} + (1 - \beta_{td})EQ_{te}$
9. $EQ_t = \varepsilon EP_{td}$

The exogenous variables are defined in Table 1

Table 1. List of Exogenous Variables

Variable Symbol	Variable Meaning	Structural Equation(s)
$\overline{ED}_{cd}$	Proportional Change in Domestic Demand for Cigarettes	1
$\overline{ED}_{ce}$	Proportional Change in Export Demand for Cigarettes	2
$\overline{ED}_{td}$	Proportional Change in Domestic Tobacco per Cigarette and exogenous change in costs	4 6
EK	Proportional Change in Paper Cost per Cigarette	4
$\overline{EM}$	Proportional Change in all Other Cigarette Manufacturing Costs per Cigarette	4

*[Editors note The cigarette model discussed in this report is a preliminary version of the model that Stephen F Weber of the Applied Economics Group of the National Bureau of Standards developed and applied to the economic impact analyses presented in Volume 4 of this series For complete details of the final version of the economic impact model and the impact analysis results the reader is directed to that Volume.]

The model may be extended easily to provide information about the incomes from various sources for the two primary types of tobacco used in cigarettes. Tobacco program structure and industry conditions provide that the proportional change in price from cigarette modifications will be the same for each tobacco type. Therefore proportional responses will be the same but actual quantity pound or dollar changes will be different.

Proportional changes of quota income results from both lease rate and quantity changes. The formula is similar to that for revenue:

$$ELI = EQ_t + EL + EQ_tEL.$$

The other income changes are for inputs that are not fixed to the industry so their prices are unaffected and the proportional change in income is equal to the proportional change in tobacco quantity. These are changes in income derived from the tobacco industry and do not indicate net changes in income once factor mobility is accounted for.

Labor Income:	$EWI = EQ_t$
Land Income:	$ETI = EQ_t$
Farm management returns:	$EFI = EQ_t$

Producer surplus or economic rent is not appropriately calculated in proportional terms because that would entail extending the marginal cost function back to the vertical axis. However the change in producer surplus may be calculated following the approach in Sumner and Wohlgenant [1].

$$PS_1 - PS' = \mu EQ_t(P_{td} - L)(Q' + (1/2)Q_1 - Q').$$

3. Definitions of Variables, Baseline Values and Sources

The variables denoted by capital letters in the mathematical model, other than those exogenous shifts defined in Table 1, are defined in Table 2. That table also provides initial values for the level of the variable in the spring of 1986. The sources for the values are given in the table with complete citations in the list at the end of this report. For those variables about which there may be some approximation a range that suggests potential variation is also shown in the table. For completeness the totals for "burley" include small quantities of the minor cigarette types.

The tobacco production industry in the United States was in a state of considerable turmoil during the early and mid 1980s. The changes in the tobacco program that were enacted in April of 1986 seem to have ended the most obvious problems by reducing the domestic price. However large inventories and low production levels relative to disappearance indicates a period of transition for another few years. I have chosen to let the baseline values for quantities reflect the more permanent and stable disappearance figures rather than the clearly temporary production and quota levels in effect currently. Further background on this is available in Sumner [3]

Table 2. Initial Values for Prices and Quantities in the Tobacco Industry

Symbol	Definition (Source)	Value (Range)
Q_{cd}	Quantity of U.S. cigarettes sold in the domestic market [4]	580 billion (560, 600)
Q_{ce}	Quantity of U.S. cigarettes sold in the tax exempt market [4, (Table 1)]	70 billion (60, 70)
Q_c	Total U.S. cigarette quantity $Q_c=Q_{cd}+Q_{ce}$	650 billion (620, 680)
P_{cd}	Wholesale price of U.S cigarettes [4, Fable 5)]	$35/thousand (33, 36)
T_{cd}	Federal excise tax on cigarettes [4. (Table 5)]	$8/thousand
P_{ce}	Export price of U.S. cigarettes $P_{ce}=P_{cd}-T_{cd}$	$27/thousand (25, 28)
Q_{td}	Quantity of U.S. cigarette tobacco sold in the domestic market [4, Fable 16, 23. 24)]	900 mil. lbs (800, 1000)
Q_{te}	Quantity of U.S. cigarette tobacco exported [4. Fable 16, 23. 24)]	600 mil. lbs (500, 700)
Q_t	Total Quantity of U.S. cigarette tobacco	1500 mil. lbs
	$Q_t=Q_{td}+Q_{te}$	(1300, 1700)
	Quantity of burleyiflue-cured	6001900 mil. lbs.
P_{td}	Price of U.S. cigarette tobacco [3]	$1.50/lb (1.40, 1.60)
R_t	Total revenue in U.S. cigarette tobacco production $R_t=Q_t*P_{td}$	$2250 million (1820. 2720)
	Revenue of burleyiflue-cured	$900/$1350 million
L_t	Lease rate for tobacco quota [5]	$0.30/lb. (0.25, 0.35)
W_t	Labor costs per pound of tobacco burleyiflue-cured [6, Fable 34); 3, (Table 33)]	$0.60/0.30 (50,70/25,40)
T_t	Land costs per pound of tobacco	$0.02/lb.
	(Telephone response W.D. Toussaint. N.C. State Univ.	(0.015, 0.03)
F_t	Farm management returns per pound of tobacco [6, (Table 34); [4, Fable 33)]	$0.1011b. (0.05, 0.15)

4. Parameter Definitions, Values and Sources

An ddvantdge of a log linear model is that it uses shares and elasticities as parameters in the structural equations These values are often available lrom basic data and econometric research The quantity and cost shares listed in Table 3 are mostly taken from the USDA reports on the tobacco industry I also relied on conversations with industry experts The elastici ties are mostly taken lrom original econometric research that has been reported in a number of professional publications For most of the parameters a range is provided Further anal ysis at the National Bureau of Standards will use a computer simulation version of the model to indicate the sensitivity of the results to variation of parameter values within the range given iri the table

Recent changes in the tobacco industry have caused a decline in the cost share of domestic tobacco in US cigarettes Recent evidence has confirmed the price sensitivity of tobacco use to price and d relatively low response of tobacco production costs lo quantity shifts [7] These param eter values are different from those used by Sumner and Wohl genant based on 1982 information The recent period of changing tobacco policy has provided better evidence supporting a policy response elasticity in the range of 10 but ttie whole positive range from 0 to ∞ is included in the table

Table 3. Parameters Used in the Equilibrium Displacement Model, Shares and Elasticities

Symbol	Definition (Source)	Value (Range)
η_{cd}	Domestic wholesale price elacticity of demand for US cigarettes [18]	03 (02 05)
η_{ce}	Export price elasticity of demand lor US cigarettes [1]	30 (1050)
β_{cd}	Ouanlily share of the domestic market in US cigarette output [4 (Table 1)]	088 (085 091)
α_{td}	Share of domestic tobacco in wholesale level costs of Cigarettes [4 (Table 15 & 16)]	007 (005 0.10)
α_{k}	Share of cigarene paper in whole sale level costs of cigarettes [9]	0005 (0003 0010)
α_{T}	Share of federal excise tax in wholesale level costs of cigarenes [4 (Table 5)]	023 (020 025)
α_{m}	Share of all other costs in whole sale level of costs of cigarettes (lrom above sum of all costs = 1.0)	070 (064 075)
η_{td}	Domestic output constant demand elasticity for US tobacco $\eta_{td} = \alpha_{td}\sigma_{dd}$ [8] The above implies $\sigma_{dd}=15$	10 (05 15) (7 20)
η_{te}	Export demand elasticity lor US tobacco [8]	20 (1 0 50)
β_{td}	Quantity share of domestic market in demand for US tobacco [4 (Table 15)]	06 (05 07)
ε	Ouota policy response elasticity for the US Tobacco Program [8,1]	10 (0 ∞)

Table 3. (Continued)

Symbol	Definition (Source)	Value (Range)
μ	Elasticity of marginal costs of tobacco production with respect to quantity shifts [8]	0.2 (0.1, 0.4)
a_1	Implicit or explicit cost share of quota lease in tobacco production, burley/flue-cured [8,4 (Table 33): 6 (Table 34)]	0.15/0.2 (0.1, 0.3)
a_w	Cost share of labor in tobacco production burley/flue-cured [4 (Table 33); 6 (Table 34)]	0.4/0.2 (0.3,0.5/ (0.15.0.25)
a_r	Cost share of land in tobacco production burley/flue-cured (telephone response W.D. Toussaint, N.C. State Univ.)	0.015/.015 (0.01, 0.02)
a_f	Cost share of management in tobacco production burley/flue-cured [4 (Table 33)]	0.0710.07 (0.05. 0.10)

5. Baseline Values for Shifts in Exogenous Variables

Table 4 repeats Table 1 but adds the assumed values for the proportional changes indicated in the table The baseline values are not those considered most likely Rather they are values chosen to reflect an example impact on the tobacco industry These values must be considered together with the shares in Table 3 to indicate their general expected impact For example even though a 50% increase in paper costs could occur cigarette paper has such a trivial share in all costs that the proportional impact on cigarette costs and quantities is very small The big factor for the tobacco production industry is the value of – 010 for ED_{td} This exogenous ten percent decline in tobacco per cigarette can by only partially offset by price reductions and substitutions and accounts for most of the declines in tobacco quantity and revenue reported below

Table 4. Example Baseline Values for Exogenous Variables

Symbol	Definition (Source)	Value (Range)
ED_{cd}	Proportional change in domestic demand for cigarettes	–001
ED_e	Proportional change in export demand for cigarettes	–001
ED_{td}	Proportional change in domestic tobacco per cigarette	–010
EK	Proportional change in paper cost per cigarette	+0.50
EM	Proportional change in all other cigarette costs per cigarette	1002
EC	Proportional change in all cigarette costs	
	$EC = \alpha_{td}ED_{td} + \alpha_k EK + \alpha_m EM$	+0.00725

"These preliminary values are example feasible values chosen to indicate potential impact in the domestic tobacco industry Stephen Weber a! NBS provided guidance in these choices

6. Changes in the Tobacco Industry from Cigarette Modifications

The model allows the calculation of the impact of cigarette modifications on various prices. quantities. incomes and other tobacco industry variables Initial values from Table 2, parameter values from Table 3 and baseline exogenous shifts from Table 4 are used to produce the results in Table 5 It should be stressed again that these do not reflect the most likely sceriario Notice that allowing Ihe quota policy response elasticity to equal 10 implies that the shift back in the demand function lor tobacco has equal negative proportional effects on lobacco price and quantity

Table 5. Results of the Example Baseline Values for Exogenous Variables for Proportional and Real Changes in the Tobacco Industry Variables

Symbol	Brief Definition	Proportional	Actual
P_{tc}	Domestic tobacco price	–0.028	–$0.043/lb.
Q_t	Domestic tobacco quantity	–0.028	–42 mil. lbs.
	burley quantity		–16.8 mil lbs.
	flue-cured quantity		–25.2 mil. lbs
R	Tobacco revenue	–0.055	–$125.4 million
	burley revenue		–$51.2 million
	flue-cured revenue		–$75.3 million
L_t	Tobacco quota lease rate	–0.118	–$0.035/lb.
LI	Quota lease income (L_t*Q_t)	–0.143	–$64.4 million
	burley lease income		–$25.7 million
	flue-cured lease income		–$38.6 million
W	Labor income or cost	0.028	–$17.6 million
	burley labor income		–$7.6 million
	flue-cured income		–$10.1 million
T	Land income or cost	-0.028	–$0.8 million
	burley land income		–$0.3 million
	flue-cured land income		–$0.5 million
F	Farm management returns	0.028	–$4.2 million
	burley management returns		–$1.7 million
	flue-cured management returns		–$2.5 million
PS	Tobacco producer surplus (economic rent)		–$10.1 million
	burley surplus		–$4.2 million
	flue-cured surplus		–$5.9 million

7. Conclusion

This report has provided estimates of the effects on the domestic tobacco growing industry due to cigarette modifications to reduce their ignition propensity. An economic model of the log-linear equilibrium displacement form has been developed and this report has described the model and its assumptions. Tables 2, 3 and 4 provide background information and sources that are used together with the model to produce the results in Table 5. This table provides preliminary estimates for the impact on changes in the price and quantity of both major types of tobacco affected. Estimates of changes in income are provided separately for revenue generated from quota, land, farm labor and farm management.

8. References

[1] Sumner. Daniel A and Michael K Wohlgenant 'Effects ol an Increase in the Federal Excise Tax on Cigarettes American Journal ol Agricultural Economics. Vol 67 No 2, May 1985

[2] Chase Econometrics. The Economic Impact ol the Tobacco Industry on the United States Economy in 1983 Bala Cynwyd Pennsylvania, 1985.

[3] Sumner Daniel A , 'Substitutability for Farrn Commodities The Demand for U S Tobacco in Cigarette Manufac turing.' American Journal of Agricultural Economics V 69, No 2, May 1987.

[4] U S. Department of Agriculture. Economic Researcti Service. National Economics Division Tobacco Outlook and Situation Report. Washington D.C.. September 1986

[5] U.S. Department of Agriculture Economic Research Service National Economics Division 'Effects of Terminating Lease and Transfer ol Flue-cured Tobacco Quotas and Allotments" Undated manuscript received from Verrier Grise. 1986.

[6] U S Depannient of Agriculture. Economic Researcti Service, National Economics Division Tobacco Outlook arid Situation Report Washington D C. March, 1985

[7] Sumner Daniel A . 'The Budget Costs of a 'No Net Cost Tobacco Program ' Current Issues iri Tobacco Economics Section 2: Tobacco in the Future Ecoriorriic Papers given at the 32nd Tobacco Workers Conference January 1987 Farrell Delman, ed with the assistarice ol Dolores Blakeney-Collin The Tobacco Merchants Associa tion. New York July 1987.

[8] Sumner. Daniel A., and Julian M Alston Effects of the Tobacco Program. An Analysis ol Deregulation American Enterprise Institute Washington. D C . 1986

[9] Lago, Armando. The Structure of Costs in the Cigarette Industry Undated draft copy of Chapter 2 in a report provided by the National Bureau of Standards. December 1986

Economic
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Section 2

The Employment Implications of Proposed Cigarette Design Modifications to Reduce Cigarette Ignition Propensity

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1. Introduction

The purpose of this report is to assess the potential employment effects of four proposed changes in cigarettes to reduce their propensity to ignite mattresses and upholstery. The four proposed cigarette design modifications are as follows:

- The addition of a chemical additive to cigarette tobacco blend
- Increasing the percentage of expanded tobacco used in cigarette tobacco blend
- Decreasing the cigarettes circumference while at the same time increasing its length in order to maintain a constant puff count
- Doubling the weight of cigarette paper.

As will be seen, each of these design modifications would have direct effects on employment by changing the cigarette manufacturing process and the demand for various inputs (for example, tobacco, paper and chemicals) used in producing cigarettes. In addition, and possibly more importantly, the design modifications may cause indirect employment effects by changing the taste or other characteristics of cigarettes and consequently, influencing consumer demand for them.

The analysis of the direct and indirect employment effects of the cigarette design modifications contained in this report is to be used as input to a benefit-cost study conducted by the Applied Economics Group of the Mathematical Analysis Division of the National Bureau of Standards. The estimates reported here should not be viewed as precise. The data do not exist to support such precision and, in any event, forecasts of adjustments by economic actors to proposed changes in policy are inevitably hazardous. Instead, the estimates should be considered indicators of the likely order of magnitude of the effects of the proposed design modifications on employment.

This report is organized as follows. The next section discusses several general issues and outlines the basic methodological approach that will be used. Then, potential employment effects of the proposed design modifications on various sectors of the economy — cigarette manufacturing; tobacco farming; tobacco auction warehousing; industries that provide inputs to the cigarette manufacturing process, such as paper and chemical manufacturing; cigarette wholesaling; and cigarette retailing — are each considered in turn. Both direct and indirect effects on employment in these sectors will be examined. In addition, when appropriate, consideration will be given to whether the employment effects are likely to influence wage levels and to impose hardships on the affected workers. A brief final section contains a summary of the report's major findings.

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2. Issues and Methodology

Predicting the employment implications of the proposed cigarette design modifications listed in the Introduction raises several difficult issues. These issues are discussed in this section and our treatment of them is briefly described Greater detail is provided. as appropriate, in later sections of the report

A natural starting point for an analysis of the employment impacts of proposed policy changes is to determine current employment levels in the economic sectors likely to he affected This is not as straightforward as it may seem on first blush. Although government statistics that appear in such publications as the Census *of* Agriculture. the Census of Manufactures. and Employment and Earnings are often useful for this purpose, specific breakdowns for certain relevant economic sectors — for example, cigarette paper manufacturing and tobacco auction warehousing — are not reported in these publications. In addition, in some economic sectors — for example. tobacco farming and tobacco auction warehousing — extensive use is made of seasonal and part-time workers For purposes of this analysis, it is important that employment levels be stated in terms of full-time, year-round equivalents. Fortunately, several of the employment level estimates required to augment the statistics reported in government publications can he found in two fairly recent examinations of the tobacco industry's contribution to the economy; one of these studies appears in a 1979 report by the Wharton Applied Research Center and Wharton Econometric Forecasting Associates and the other in a 1985 report by Chase Econometrics. When necessary, the employment level statistics found in the sources mentioned above have been supplemented by information provided in reports of several special government studies and by persons with expert knowledge of the various relevant economic sectors All the employment statistics that appear in this report have been adjusted to reflect 1986 levels on the basis of the data on trends in cigarette output. which are found in the October 1986 issue of Smith Barney Researchs Tobacco Monthly

It was suggested in the Introduction that the impact of cigarette design modifications on employment levels can usefully be divided into direct and indirect effects. One type of direct effect results from changes within the cigarette manufacturing industry itself. Examples of such changes include the production of more expanded tobacco or the use of a new chemical additive Both of these modifications require additional workers Another type of direct effect results when the design modifications change inputs that cigarette manufactures purchase from other industries (for example. tobacco or paper) and labor requirements in these industries are, as a consequence increased or decreased Indirect effects would occur if the design modifications affect consumer demand lor cigarettes and. as a result. change the number of workers required to produce the inputs used in cigarettes and to manufacture and sell cigarettes Since it seems reasonable to presume that cigarette firms presently produce as appealing a product as they can, we will assume that the design modifications will tend to reduce cigarette sales and, consequently, cause employment levels to fall

If cigarette sales decline. employment levels could also he potentially reduced through so-called "multiplier effects' These multiplier effects would arise because those whose incomes are adversely affected by the reduced consumption of cigarettes (for example. tobacco farmers and cigarette company stockholders and employees) have less money to spend on the various goods and services they typically purchase. As a result, employment levels in industries that have little to do with the production of cigarettes (for example. banking and automobile manufacturing) could fall Persons who derive their incomes from these industries would then also have to reduce their expenditures, and the process would continue. Fortunately, however these negative multiplier effects are likely to be more or less fully offset by positive multiplier effects These latter effects would occur because consumers who reduce their expenditures on cigarettes would be expected to increase their spending on other items thereby stimulating employment in sectors of the economy producing these items Since, on net. positive and negative multiplier effects that result from changes in consumer expenditure patterns should roughly cancel out. we shall ignore these effects in the remainder of this report.

In assessing both the direct and indirect effects of the proposed design modifications on employment levels. it is important to recognize that these changes will not take place instantaneously nor necessarily smoothly. For example. each of the design modifications directly require alterations in or additions to capital equipment. and these efforts will employ additional workers who will not be needed once this transitional phase is completed. Moreover, the design modifications are initially likely to reduce efficiency levels in producing cigarettes thereby engendering various adjustments throughout the production process as manufacturing firms attempt to offset these losses in efficiency Although most of these changes can probably be compieted Over the space of a relatively few years, the design modifications may also cause declines in consumer demand for cigarettes that continue to take place for a generation or more. The reason for this is that many current smokers are addicted to cigarettes and, consequently, may not modify their consumption patterns wen if the taste or other characteristics associated with cigarettes change. However. these changes could exert considerable influence over young persons at the time they decide whether or not to take up smoking. In this report, we shall emphasize the difference between current employment levels and employment levels in the new steady state, once all the necessary adjustments have been completed. Thus, we ignore changes in employment requirements while the transition to the new steady state is taking place.

Estimates of many of the direct effects of the design modifications on employment levels can be based on straightforward engineering projections of changes in the number of persons required to perform the potentially affected manufacturing functions – for example, the number of workers required to produce a given amount of chemical additive or the additional workers needed to expand a given amount of tobacco. Projections of this type were obtained on the basis of discussions with persons with expertise in the pertinent industrial processes.

Unfortunately obtaining estimates of the indirect effects of the design modifications on employment levels raises more complex problems than does obtaining estimates of the direct effects. As noted above, the indirect employment effects would be engendered by reductions in the demand for cigarettes by consumers. This demand reduction may, in turn, cause the producers and sellers of cigarettes to lower prices to consumers, thereby partially offsetting the initial reduction in demand for cigarettes. Obtaining estimates of responses by buyers and sellers in the cigarette consumer market to each Of the design modifications is far beyond the scope of this study, and, in fact, involves research being conducted elsewhere as part of the National Bureau of Standards' overall benefit-cost project. Since this research is not yet complete, we shall, for illustrative purposes only, examine the decrease in employment that would result were cigarette output to fall by 5 percent once the consumer market fully adjusted to a reduction in demand by smokers. If it were later determined that a particular design modification would actually cause a smaller or larger fall in cigarette output than 5 percent. the indirect effect estimates found in this report should, of course, be appropriately adjusted. For example, if cigarette output were to fall by 2.5 percent, instead of **by** 5 percent, the resulting employment effects should only be around half as large.

The employment effects of a 5 percent reduction in cigarette output would not, of course, be limited to the employees of cigarette firms These firms would not only require less labor, but also less of the materials needed to produce cigarettes – tobacco, paper. electricity, and so-forth. Moreover. less tobacco would be stored in warehouses and sold in auctions and fewer cigarettes would be sold by wholesalers and retailers. All these changes may potentially reduce labor requirements

For purposes of this report, it will be assumed that a 5 percent reduction in cigarette output would be associated with a 5 percent decline in cigarette sales and would cause a 5 percent reduction in each of the materials purchased by cigarette manufactures. This assumption may be subjected to several different criticisms. First, if cigarette output and, hence. the scale of production were reduced, the mix of inputs used to produce cigarettes might change. However, unless the design modifications being considered caused very large decreases in the output of cigarettes – much larger than 5 percent – this Scale effect is likely to be of minor importance. Moreover, the scale of production should have little influence on the mix of many of the materials used to produce cigarettes – for example, tobacco, paper, material for filters, and so forth – which tend to *be* more *or* less used in fixed proportions.

A second possible *criticism* of the assumption **is** that a decrease in demand for various cigarette inputs would induce the producers of these inputs to lower their prices, mitigating the original demand decrease to some degree. Except possibly for tobacco, this effect would appear to be quite minor Many important cigarette inputs – such as paper, packaging materials, chemicals, and electricity – are obtained from large firms where administrative pricing prevails and purchases by cigarette companies comprise a relatively small fraction of total sales. On the other hand, U.S. cigarette firms are the dominant buyer of domestically grown tobacco. Consequently, any changes in the demand for tobacco by these firms could have important effects on tobacco prices. Moreover. tobacco production in this country is subject to federal quotas and support prices that could effectively be used to offset reductions in demand for tobacco by cigarette firms.

A third criticism is suggested by the possibility that a 5 percent reduction in cigarette output could be disproportionately caused by decreases in the sale of U.S. produced cigarettes in foreign markets. If this were the case. sales of U.S. cigarettes would fall by more than *5* percent in foreign markets and by less than *5* percent in domestic wholesale and retail markets. Since only about one of every ten cigarettes produced in the United States is sold in a foreign market, however, this possibility is likely to be relatively unimportant unless there is an enormous divergence between foreign and domestic consumers in their demand responses to the cigarette design modifications.

In summary then, it would seem that the assumption that a 5 percent reduction in cigarette output would be accompanied by a 5 percent decrease in input purchases by cigarette firms and by a 5 percent decline in domestic cigarette sales is a reasonable approximation, except possibly for tobacco. The more complex relationship between cigarette and tobacco production is presently being modeled elsewhere as part of the National Bureau of Standards' benefit-cost project. And the results of this modeling effort can later be used to make appropriate modifications to the 5 percent approximation being used here. In Section 4, we briefly indicate the ways in which these modifications would affect the results reported here.

Given a 5 percent reduction in cigarette output and sales, and in the purchases of materials used to produce cigarettes. the relevant question from the perspective of this study becomes: What will be the effects on *employment*? To answer this question, we utilize a simple analytic devise: the elasticity of employment with respect to output. In algebraic terms, this parameter may be defined as follows:

$$di = EE_i/EQ_i$$

where d is the elasticity of employment with respect to output, EE is the percentage change in employment, EQ is the percentage change in output, and i denotes a specific economic sector of interest (for example, cigarette manufacturing, cigarette paper manufacturing. or cigarette wholesaling).

The specific value of the elasticity parameter indicates the relationship between a change in output in a pertinent economic sector and the resulting change in employment within that sector For example, a value of 1 would imply that a decrease of (say) 5 percent in cigarette manufacturing output or in the purchase of an input used in producing cigarettes or in cigarette sales at the wholesale level would cause a 5 percent reduction in employment within that economic sector. Similarly, an elasticity value of 2 would imply that a 5 percent reduction in output in a given economic sector would he associated with a 10 percent decline in employment within the sector. An a value of zero would imply the absence of any effects on employment as a result of changes in output Thus, once the elasticity value is known for a particular economic sector. the effects of a given change in output on employment levels within that sector can readily be determined. The elasticity value will. of course, differ among the various economic sectors likely to be affected by cigarette design modifications. Thus, the techniques used to derive the value for each sector will be described in the individual section on that sector

Reductions in employment will usually put downward pressure on wage rates in the affected labor markets. If, as a result. wages actually fall in these labor markets, the initial, first-round effect on employment may be partially offset. Reductions in wage levels that are caused by the cigarette design modifications and any resulting mitigation of first-round employment effects are of considerable interest, and will be examined for specific economic sectors later in this report At this time, however, it may be useful to make two general points. First, downward pressure on wages is likely to be minimal if — as, in fact, is generally the case — the adversely affected workers account for only a small fraction of total employment in a particular labor market, Second, wage effects will not occur at all in labor markets where unions or minimum wage legislation keep wages from falling.

One of the major reasons for examining the employment impacts of policy changes is to assess any hardships that may result for the families of the affected workers. We shall conduct such assessments for several groups of workers later in this report. It will be pointed out that adverse effects are likely to be minimized if the transition to a lower employment level is lengthy. In such a situation. which, as suggested earlier, is likely to be the one resulting from the cigarette design modifications, it may be possible to reach the lower employment level largely through attrition, rather than through permanent layoffs. Still. some workers are likely to lose their lobs as a consequence of the design modifications. The extent to which the families of these workers undergo hardships as a result depends on the contribution that these workers make to total family income, the length of time the workers are unemployed, whether the workers receive transfer payments while unemployed, and whether the workers must accept new jobs that pay a lower wage than those they lost. This, in turn, is a function of the demographic characteristics of the workers (for example, their age, sex, and marital status), the specific human capital they have acquired on their current jobs, whether their current wage is above that received by other workers with similar characteristics (for example, as a result of union membership), whether they work in small geographically isolated labor markets. and so forth.

3. Cigarette Manufacturing Sector

According to Employment and Earnings, a periodic statistical report published by the U.S. Bureau of Labor Statistics. a total of 45,000 workers are currently employed in cigarette manufacturing Approximately 5.000 additional workers are employed in stemming, redrying. and storing the tobacco used by U.S. cigarette manufactures. Of this total of 50,000 workers, about 36.000 (72 percent) are classified as production workers, with the remaining 14,000 (which includes supervisors and administrators, marketing and research personnel. and engineers) classified as non~productionworkers.

As indicated in the first two sections of this report the proposed cigarette design modifications would have both direct and indirect effects on the size of the work force in the cigarette manufacturing sector Each of these two types of effects will be examined separately in this section.

Direct Effects

In this subsection we shall briefly discuss the potential direct employment effects of each of the four proposed cigarette design modifications

Addition of Chemical Additive to Blend

This design modification involves the addition of a chemical additive to the tobacco blend used in cigarettes, The specific additive under current discussion is called "Expantrol." Expantrol is a silica gel produced by 3-M Company. In the form it is now produced, it is not clear how well Expantrol adheres to tobacco To the extent it does not, its addition to the tobacco blend would cause major production problems in cigarette manufacturing. Our employment estimates are based on the assumption that these production problems can be overcome or alternatively, that a suitable substitute can be found for Expantrol that does not cause production problems (for example. some sort of water soluble chemical). It is also assumed - as, in fact, appears to be the case that the use of either Expantrol or a water soluble chemical would not alter the amount of tobacco use per cigarette.

Discussion with cigarette company representatives indicated that were Expantrol or some alternative added to the tobacco blend. 4 to 6 additional workers would probably be required per shift at each cigarette manufacturing plant. Since there are 11 major cigarette plants in this country. each of which usually operates with three shifts, it would appear that a total of 132 to 198 additional workers would be required in the cigarette manufacturing sector These additional workers would mainly consist of the operatives responsible for actually adding the chemical and quality control. maintenance. and cleaning personnel

Increased Use of Expanded Tobacco

The intent of this design modification is to increase the amount of expanded tobacco used in each cigarette. thereby increasing the rate at which cigarettes burn. The exact amount by which tobacco can he expanded varies with type of tobacco and the process that is applied. At maximum, tobacco can he expanded to about twice its original volume and. for simplicity. we shall assume a two-to-one ratio This would imply, for example, that if the amount of expanded tobacco in a cigarette was increased by 10 percentage points in terms of volume, the weight of the tobacco in the cigarette would decline by 5 percent Similarly, if the increase was 20 percentage points. tobacco weight would fall by 10 percent. if the increase was 30 percentage points. tobacco weight would fall by 15 percent. and so forth

To examine the direct employment effects of an increased use of expanded tobacco, we shall assume that no loss of productive efficiency in the manufacturing process results. This may not necessarily he the case, however, if the increase was very dramatic. A cigarette that consisted mainly of expanded tobacco would he more difficult to pack than a typical cigarette and the cigarette making machines that produce it might have to run at a slower rate. At present, no commercially sold U.S cigarette brand consists of more than 50 percent expanded tobacco

The employment effect estimates presented below are based on the further assumption that as a result of adopting the expanded tobacco design modification the volume of expanded tobacco found in a typical cigarette would increase by 20 percentage points Thus, for example if a particular brand of cigarettes presented consists of 25 percent expanded tobacco and 75 percent non-expanded tobacco, after the change, it would consist of 45 percent expanded tobacco and only 55 percent non-expanded tobacco. Obviously, if the increase was 30 percentage points, rather than 20, the employment effects would be approximately 50 percent larger than those reported here. Or. alternatively. if the increase was only 10 percentage points, the size of the employment effects would be only about half as large

Increasing the amount of expanded tobacco in cigarettes would have two direct employment effects, and these work in opposing direction. First, more tobacco will have to be subjected to the expansion process and this will require additional workers. Given our assumptions that the volume of the newly expanded tobacco would be doubled and that the volume of expanded tobacco in cigarettes would be 20 percentage points higher than at present, an additional 10 percent of the tobacco used in cigarettes would have to be subjected to the expansion process. Table 13 of the October 1986 issue of Tobacco Monthly indicates that the average U.S. cigarette uses .00176 pounds of tobacco, while Table 6a of this publication reports that 658.5 billion cigarettes were produced in the United States in 1986. This implies that U.S. cigarettes contained 1.16 billion pounds of tobacco in 1986 and, hence, that meeting the increased demand for expanded tobacco would require that an additional 116 million pounds of tobacco be expanded.

Relatively large existing expansion facilities can expand 6.000 pounds of tobacco an hour or, operating 24 hours a day, 5 days a week, about 36,000,000 pounds a year. A small expansion facility can expand 1,500 pounds of tobacco an hour or about 9,000,000 pounds a year Thus, the increased need for expanded tobacco could be met by 13 of the smaller facilities or, alternatively, by a combination of 3 of the larger facilities and 1 of the smaller facilities. Based on experience from running existing expansion facilities, cigarette company representatives estimate that if 13 small facilities were used, 624 additional workers would be required; but if 3 large facililies and just 1 small facility were used, only 228 additional workers would be required. Since there are 11 major cigarette manufacturing plants, and since it is usually more efficient to integrate the operations of expansion facilities and manufacturing plants, the actual increase in worker requirements would probably approach the larger of the two numbers reported above.

As indicated earlier. adoption of the expanded tobacco design modification would have a second direct effect on employment in the cigarette manufacturing sector This effect occurs because expanded tobacco occupies more space than unexpanded tobacco. Hence. in terms of weight, the total amount of tobacco used in a typical cigarette would fall. As a result, fewer workers would be needed for the processes that tobacco must undergo before it is blended (except, of course, to operate expansion facilities). Among these processes are stemming, redrying. moving tobacco from one place to another, storing tobacco, maintaining inventory control over it. In addition, the equipment used in these operations must be cleaned and maintained. Although precise figures are not available, discussions with industry representatives suggest that, perhaps, about 10,000 workers are presently employed by these operations. Around half of these 10,000 jobs are located at stemming and redrying facilities, with the other half located within the cigarette manufacturing plants themselves.

Although, according to our assumptions, the amount of tobacco subjected to these operations would diminish by 10 percent, the number of workers employed by the operations would probably fall by substantially less A few stemming and redrying facilities – facilities that tend to be relatively small and located separately from cigarette manufacturing plants – might be shut-down altogether; but the number of workers required to handle tobacco within cigarette manufacturing plants is to some extent determined by the equipment needed for this purpose and, consequently, cannot fall below some minimal threshold.

Although exact estimates cannot be made, in our judgement, a 10 percent reduction in the amount of tobacco used by the cigarette manufacturing sector would result in a labor savings of, perhaps. 5 to 7 percent in performing the affected operations – or around 500 to 700 jobs – an amount that more or less offsets the additional workers required to expand greater amounts of tobacco. Thus, it seems reasonable to conclude that, on net, the direct employment effects of the expanded tobacco design modification on the cigarette manufacturing sector could be either positive or negative. However, this net effect is likely to be small in overall magnitude, changing overall employment levels by probably no more than 100 to 200 workers.

Decreasing the Circumference of Cigarettes

Under this design modification, the circumference of cigarettes would be reduced from the current typical level of 25mm to some as yet unspecified level mnging between 24mm and 18mm. At the same time, a constant puff could would be maintained by increasing the length of the cigarette.

As detailed in a paper by Armando Lago (see Report on Cigarette Modification Costs to the *Technical Study* Group on Cigarette and Little Cigar Fire *Safety,* Ecosometrics. January 1987), changes in cigarette circumference would necessitate changes in the most important cigarette manufacturing machinery – including cigarette makers, cigarette packers, and plug makers. However. once these modifications were completed, no additional workers should be required to operate and maintain these machines, assuming that the modifications do not affect production efficiency.

Another implication of the reduction in cigarette circumference – and one that would have a direct effect on employment within the cigarette manufacturing sector – is that the amount of tobacco and paper required to produce cigarettes would fall. For example, according to Table 1 in Lago's paper, if the circumference of a cigarette were reduced from 25mm to 22mm, the weight of the tobacco used would decrease by 14.3 percent and the weight of the paper used would fall by 2.1 percent. If. alternatively, the circumference were reduced to 18mm, the decrease in tobacco weight would be 34.9 percent and the decrease in paper weight would be 9.0 percent.

This implies that fewer workers would be needed within the cigarette manufacturing sector to perform the processes that tobacco must undergo before it is blended (for example. stemming. redrying. moving and inventorying tobacco, expanding tobacco, and cleaning and maintaining the equipment needed to perform these functions) and to handle cigarette paper before it reaches the cigarette making machines. However according to discussions with industry representatives, the effect of the reduction in the weight of cigarette paper on employment levels would be trivial, involving no more than a dozen jobs industry-wide even if circumlerence of cigarettes fell to 18mm. The employment effect of the reduction in the amount of tobacco used in producing cigarettes. on the other hand, could be quite appreciable. As suggested during our discussion of the expanded tobacco design alternative. a 10 percent decrease in the tobacco used to produce cigarettes could result in the elimination of, perhaps, 500 to 700 jobs, Simple extrapolation implies that the 14 percent decrease in tobacco associated with reducing cigarette circumference to 22mm would cause employment to fall by between 700 to 1,000 workers and the 35 percent decrease associated with reducing cigarette circumference to 18mm would cause employment to fall by between 1,800 and 2,500 workers.

It might be useful to mention at this point that these employment reductions should, in principle, be viewed as first-round effects In Section 2, it was suggested that if the amount of tobacco used in cigarettes decreased, the price of tobacco might lall. This, in turn, would reduce costs to cigarette firms. These firms might pass some of these savings on to consumers, stimulating the demand for cigarettes and, therefore, employment within the cigarette manufacturing sector. As mentioned in Section 2, these possibilities are being modeled elsewhere as part of the National Bureau of Standards' benefit-cost analysis. However, considerable existing evidence suggesting that the price elasticity of demand for cigarettes is quite small in absolute magnitude[1] would appear to imply that it is highly unlikely that the modest decrease in cigarette prices. which might result from reductions in demand for tobacco of the sort we are discussing, would have very much effect on employment levels in the cigarette manufacturing sector.

Doubling the Weight of Cigarette Paper

The final design modification involves doubling the weight of the paper used to wrap cigarettes, while adjusting the paper's porosity to maintain a constant puff count. Cigarette paper is received by cigarette manufacturing firms on a roll called a "bobbin." At present, one bobbin can be used to wrap 100,000 cigarettes. If cigarette paper weight were doubled, the weight of each bobbin would probably be held constant and, consequently, cigarette firms would require twice as many bobbins as they presently purchase.

In examining the direct employment effects of doubling the weight of cigarette wrapping paper we shall assume that any potentially serious production problems can be overcome. At present, for example, it is not known whether the two edges of a heavier paper can be glued together as quickly and as well as the edges of the cigarette paper being presently used. If this bonding process took longer or the bonding did not hold, the production of cigarettes would be slowed.

The most obvious effect on employment within the cigarette manufacturing sector that would result from doubling the weight of Cigarette paper is that about twice as many workers would be needed to unload the paper received at cigarette plants, prepare it lor delivery to cigarette making machines, and actually deliver it. A cigarette firm representative estimates that his company presently uses about 7 workers to perform these tasks lor an amount of paper required to wrap around 50 billion cigarettes. Since 685.5 billion cigarettes were produced in the U.S. in 1986, this implies that fewer than 100 paper handling jobs are currently needed industry-wide. Thus, doubling the weigh! of cigarette wrapping paper would require that no more than 100 additional such lobs be created.

It was mentioned above that doubling the weight of cigarette paper would double the number of bobbins received by cigarette manufacturing plants. This would mean that the operators of cigarette making machines would have to change twice as many bobbins This. however, would not require that more operators be hired. It would simply mean that the work load of existing operators would be slightly increased and, as a result, these workers would receive a small raise in wages. However; every time a bobbin must be changed a very slight loss of production results. As a consequence, doubling the number of bobbin changes would lower the industry's current output level. However, this reduction would amount to something less than one billion cigarettes, a loss of output that could more than be replaced if only one additional cigarette making machine was put into operation. Thus, the increased number of bobbin changes would have only a negligible effect on worker requirements.

Indirect Effects

In this subsection, we examine the effect of a 5 percent reduction in the demand for cigarenes on employment within the cigarette manufacturing sector To do this, it is first necessary to discuss the value lor the sector of d, the elasticity of employment with respect to output. An instructive way to begin exploring this issue is to consider what sort of cigarette plants or parts of plants would be shut-down should cigarette output decline. It seems reasonable to anticipate that these would be among the least efficient, most marginal operations. Such operations. in turn, are likely to produce less output per worker than the more efficient ones that continue in production.

Under the circumstances lust described, the value *of* d would simply equal the inverse of the ratio of output-per-worker at the remaining operations within the sector To see this, let us briefly consider a completely hypothetical example For purely illustrative purposes, we shall assume that only half as many cigarettes are produced per worker at the least efficient cigarette plant in the industry as at the typical remaining plant. Hence, to produce a given amount of cigarettes, our hypothetical plant would require twice as many workers as is typical in the res! of the industry. Let us further assume that the low efficiency plant just happens to produce 5 percent of the total national output of cigarettes. If this low efficiency operation were closed, allowing cigarette output to fall by 5 percent, it follows that total employment at cigarette plants would decrease by 10 percent. Thus, for the illustrative situation just outlines, the value nl d would equal 2; that is, a 5 percent reduction in output would be associated with a 10 percent reduction in employment.

[1] *See for example, Daniel A. Surnner and Michael K. Wohlgenant, "Effects* of *An Increase in the Federal Excise Tax on Cigarettes, American Journal* of Agricultural Economics. *May 1985*

To obtain an idea of the variation in output-per-worker among cigarette manufacturing operations, we ideally would have liked to have divided the number of cigarettes produced at each cigarette manufacturing plant by the number of production workers employed at each plant. However, the information necessary to construct such a ratio is considered proprietary by cigarette manufacturing firms and is not available. Consequently, we constructed two alternative ratios, each of which is far less than ideal. The data used in constructing these two ratios appear below:

	Total Cigarette output (in billions)	Total Employment	Total Union Membership
Philip Morris	254.6	20,000	8,700
R.J. Reynolds	205.0	14,542	7,000
Brown & Williamson	78.1	5.776	1,450
Lorillard	48.3	6,000	2,025
American	45.3	7,250	1,725
Liggett	296	1,970	865
TOTAL	6609	56.538	21,765

The first of the columns appearing above. which reports the total number of cigarettes produced by each of the six major U.S. cigarette firms during 1985. is used as the numerator of both ratios. The figures appearing in this column was obtained from the *Maxwell Report* for February 3, 1986.

The second column contains the denominator used to compute the first of the ratios. The total figure for the second column may he compared to the 45,000 workers that the Bureau of Labor Statistics reports as being employed in cigarette manufacturing. The data for the second column are based on employment figures for 1985 that were reported in the *Directory* of Corporate *Affiliations,* which was published in 1986 by the National Register Publishing Company. These data pertain to corporative subsidiaries and divisions that produce tobacco products. Since, at several firms, these tobacco products include cigars and chewing tobacco. as well as cigarettes, the total number of workers required to produce the cigarettes output listed in the first column is overstated for some companies by an unknown amount. The figures for American and Lorillard are particularly suspected of being overstated.

The third of the columns appearing above contains information on the number of workers at each company who are members of the Bakery. Confectionery, and Tobacco Workers International. the major union in the cigarette manufacturing industry. This information, which is used as the denominator of the second ratio, was provided directly by the union. Since R.J Reynolds is the one cigarette manufacturing firm that is not unionized, the figure for Reynolds is a union estimate of potential union membership at the company In contrast to the second column, the third column provides an understatement of employment at the tobacco manufacturing firms. This is true for at least four reasons First. the figures pertain only to production workers. Second, an unknown (but fairly small) number of production workers at each firm have chosen not to join the union. even though they are covered by the contract the union negotiates. Third. most workers who are employed in stemming and redrying operations are not union members. although a few are. Fourth, at some companies, certain groups of skilled workers (for example, machinists and carpenters) belong to craft unions, rather than to the Bakery. Confectionery. and Tobacco Workers International

The two ratios, which were constructed from the data just described. appear below:

	Cigarette Output Per Employee (in millions)	Cigarette Output Per Union Member (in millions)
Philip Morris	12 7	293
R J Reynolds	13 2	293
Brown & Williamson	135	539
Lorillard	81	239
American	6 2	263
Liggett	150	34 2
Average all firms	117	304

As previously indicated, the denominator of the first of these ratios is overstated and the denominator of the second is understated. Since our primary interest is in how the ratios vary across firms, this would cause no problems if the errors in the denominators of the ratios were similar from one firm to the next. Unfortunately, however. there is no reason to think that this is the case. Consequently, some of the interfirm variation in the ratios appearing above is attributable to true differences in output-per~workeramong the firms, but some is almost certainly attributable to measurement error. Nevertheless, we can take some comfort. perhaps, in the fact that the two ratios imply very similar rank orderings among the six firms.

Taking the ratios at face value, the one based on total employment suggests that average output-per-worker for the industry as a whole is 89 percent higher than for the lowest ranked firm (11.7 – 6.2). while the ratio based on union membership implies that average output-per-worker for the industry is 27 percent higher than for the lowest ranked firm (30.4 – 23.9). Keeping in mind that these measured differences in output-per-worker *undoubtably* overstate the true differences, it would appear that the value of d in the cigarette manufacturing sector is probably greater than 1, but well below 2. For our purposes, we shall assume that the value of d equals 1.5, a value that in out judgment is likely. if anything. to exceed the actual value.

Given our assumed value for d and the fact that about 50,000 workers are presently employed in the cigarette manufacturing sector, we predict that a 5 percent reduction in cigarette sales would cause employment in the sector to fall by 3,750 workers

Implications

The preceding analysis suggests that, with the exception of changing the circumference of cigarettes, the direct employment effects *of* the design modifications are unlikely to increase or decrease the number of jobs within the cigarette manufacturing sector by more than a few hundred positions. Even the direct effects of the cigarette circumference modification are likely to be relatively modest, unless the change in circumference is quite large The indirect employment effects of the design modifications, on the other hand, could cause fairly large reductions in the number of lobs in the cigarette manufacturing sector if a substantial decline in the demand for cigarettes were to occur.

Even if the decline in employment were fairly large. however, it is unlikely that there would be much effect on wage levels. Production workers at all the cigarette manufacturing firms in the United States, but one, are covered by union contracts And the one non-union company pays wages that are at or above those paid by the union firms. The union presence at cigarette manufacturing firm. in effect, places a floor under the wages of production workers, keeping these wages from falling. However, the wages 01 most non-production employees and workers at stemming and redrying operations. who together account for about 40 percent of the work force within the cigarette manufacturing sector, are not similarly protected by unions. Reductions in employment levels among these workers, however, would be spread over a number of different local labor markets, with relatively few jobs affected within any specific local market. Thus, the downward pressure on wage rates should be minimal.

We suggest in Section 2 that reductions in employment levels, which result from declines in the demand for cigarettes engendered by the design modifications, are likely to be relatively gradual and, consequently, that these reductions could be effectuated mainly through attrition. rather than through permanent layoffs. However, if layoffs do occur, the transition *to* new jobs would probably be difficult for cigarette manufacturing production workers. The reasons lor this are suggested by a July 29, 1986 column in the *Wall* Street *Journal* by economist A. Gary Shilling. According to Shilling, production workers in the cigarette industry receive wages that are 93 percent higher than wages lor non-union workers with a similar mix of skills. Thus, if these workers were laid off, they could probably only find new jobs at a much lower wage rate than the one they presently receive. And, if they were only willing to accept a job at their old wage rate, they would probably suffer a long bout of unemployment.

Non-production workers and the employees of stemming and redrying operations, in contrast to production workers at cigarette firms, appear to receive wages that approximate those set by labor markets Thus, if some of these workers are laid off they should be able to find new lobs that pay wages comparable to those received on their old jobs. However, if the laid off workers were relatively old or competed in local labor market that were relatively loose, lengthy periods of unemployment could result for some of them.

4. Tobacco Farming Sector

Tobacco is by far the most important input used in the production of cigarettes Hence it is important to examine how employmerit levels in the tobacco farming sector would be affected by the proposed cigarette design niodibcations As indicated in the previous section, two of the design modifications - increasing ttie use of expanded tobacco and decreasing ttie cigarettes circumference would reduce the amount of tobacco used per cigarette and. therelore. have direct effects on employment in the tobacco farming Sector In addition. if any of the design modifications result in a decrease in consumer demand for cigarettes. they would also reduce ttie demand for tobacco arid, consequently. indirectly cause employment to fall in the tobacco farming sector These effects are analvzed in this sectiori

Size of the Work Force

The U S Department of Agriculture collects statistics each year on the number ai acres on which each type of tobacco is grown and on the average annual hours of larm labor used per acre in growing tobacco According to Verner N. Grise a USDA agricultural economist who is an expert on tobacco the statistics for 1986 are as follows:

Tobacco Type	Total Acres	Hours Per Acre
Flue-cured	315.000	160
Burley and Southern Maryland	242.000	280

The three tobacco types listed above account for virtually all the domestically grown tobacco used in U.S. cigarettes In 1986. approximately 57000 full-time equivalent workcrs were employed in growing ttiese three types of tobacco (This estimate was derived by obtaining the product of ttie total acres and hours per acre figrrres appearing above and then dividing by 2000. the number of hoirrs in a work year)

According to Grise. about hall the flue-cured tobacco and one-quarter of the burley and Southern Maryland tobacco grown in tlie Uriited States is exported Moreover, of tlie flue cured, burley. and Southern Maryland tobacco that remains in the country, about 5 percent is used lor products other than cigarettes Taking ttiese corisiderations into account suggests that around 35000 full-time equivalerit workers arc employed in growing the domestic tobacco used in U S cigarettes

Direct and Indirect Employment Effects

To predict tlie effects of the proposed cigarette design modifications on the approximately 35,000 jobs that are at risk. wc first must determine a value lor the tobacco farming sector of the elasticity of employment with respect to output (d) To do this we use an approach similar to that utilized in Section 3 That is. we first assume that it is the least efficient. most marginal tobacco farms that would discontinue growing tobacco. should demand lor this crop fall Then. on the basis of this assumption. we compare output-per-worker on low efficiency farms with that on more typical farms

One could argue. of course that the least efficient farms are not necessarily the ones that would discontinue growing tobacco For example, the owners of these farms could have lew alternative employment opportunities. Moreover, it may he easier for relatively more capital intensive farms to begin growing new crops than lor less capital intensive farms However. there is considerable evidence that many operators of the smaller tobacco farms. which tend to be the least efficient ones, are currently farming on only a part-time basis and are employed at paid off-farm lobs tlie rest of the time More over, the evidence also indicates that, in addition to tobacco, most tobacco farmers raise other crops or livestock.[2] Furthermore, much of the equipment used by highly capital intensive tobacco farmers is specialized in nature and could not be easily utilized in producing other crops. Thus, we feel that our assumption that the more marginal tobacco growers are the most likely to leave the industry if the demand for tobacco falls is a reasonable one.

Table 1. Hours of Labor Used to Grow 100 Pounds of Burley Tobacco in 1976

Acres of Tobacco Grown	Geographic Region 1	2	3	4	5	Average
2 acres or less	21.1	17.4	17.2	19.0	21.1	19.7
2.1–5.9	13.5	16.3	14.4	16.5	16.7	15.3
6.0–14.9	13.0	13.3	12.5	18.0	17.2	13.7
15.0 and over	11.4	14.9	12.2	N.A.	N.A.	
Average, all size groups	13.2	15.1	14.3	17.9	19.8	15.7

SOURCE: Verner N. Grise and Owen K. Shugors, *Burley Tobacco Farming Characteristics and Potential for Change*, U.S. Department of Agriculture, Economics, Statistics, and Cooperative Service, Report No. 460, 1980, Table 17

KEY
N.A.: Not available
Region 1: Inner Blue Grass of Kentucky
Region 2: Intermediate Blue Grass of Kentucky
Region 3: Outer Blue Grass of Kentucky
Region 4: South Central Kentucky and North Central Kentucky
Region 5: Eastern Tennessee

Table 1 and 2 provide information that allows comparisons of the labor required to produce 100 pounds of tobacco on farms that fall into different size categories and are located in different geographic areas. This information is provided for two tobacco types: burley and flue-cured. Together, burley and flue-cured account for about 98 percent of the domestically grown tobacco used in U.S. cigarettes, with Southern Maryland tobacco accounting for the remainder.

A comparison of the two tables indicates that much more labor is required to grow burley tobacco than flue~cured tobacco. This partially reflects differences in the amount of mechanization used in growing these two types of tobacco. More importantly from the perspective of this report, however

Table 2. Hours of Labor Used to Grow 100 Pounds of Flue-Cured Tobacco in 1979

Acres of Tobacco Grown	Geographic Region A	B	C	D	Average
Less than 9 acres	32	24	42	29	35
21–59	23	24	32	22	26
60–149	20	24	25	19	23
150 and over	18	20	26	18	21
Average all size groups	22	22	32	21	25

SOURCE: Verner N. Grise, *Trends in Fiue-Cured Tobacco Farming*, U.S. Department of Agriculture, Economics Statistics, and Cooperative Service, Report No. 470. 1981, Table 17.

KEY
Region A: Pee Dee-Lumber River boarder area of North and South Carolina
Region B. The Coastal Plain of North Carolina
Reyion C: The Piedmont of North Carolina and Virginia
Region D: The Southern Georgia Coastal Plain

is the fact that the two tables imply that, in growing either burley or flue-cured tobacco, there is considerable variation in output-per-hour of labor across farms of different size and farms located in different geographic areas. For example, Table 1 indicates that it requires about 34 percent more labor to grow 100 pounds of burley tobacco on a relatively low efficiency farm than on a typical burley farm (21.1 ± 157) Similarly, Table 2 implies that 68 percent more labor is required to grow 100 pounds of flue-cured tobacco on a relatively low efficiency farm than on a typical flue-cured farm (4.2 − 2.5) These figures suggest that the value of d in the tobacco farming sector is probably between one and two and that 1.5 should provide a reasonable approximation.

Given the assumption that d = 15 in the tobacco farming sector and the finding that about 35,000 full-time equivalent workers are required to produce the domestic tobacco currently being used in U.S. cigarettes, we next predict the effects of the cigarette design modifications on tobacco farm employment. These predictions appear in Table 3.

[2] *See for example,* Daie *M. Hoover and Leon B Perkinson*, Flue-Cured Tobacco Harvest Labor Its Characteristics and Vulnerability to Mechanization, *Department of Economics* and *Business, North Carolina State University at Raleigh, Report No 38, June 1977, Verner N Grise.* Trends in Flue-Cured Tobacco Farming, *U.S. Department of Agriculture, Economics and Statistics Service, Report No 470, 7981, and Verner N Grise* and Own *K. Shugars,* Burley Tobacco Farming Characteristics and Potential lor Change, US Department of Agriculture, Economics Statistics and Cooperative Service Report No 460 1980

Table 3. Effects of Design Modifications on Tobacco Farm Employment

Change	Percentage reduction tobacco used in U S cigarettes	Percentage reduction in farm workers needed to produce tobacco used in U.S cigarettes	Number of full-time equivalent jobs lost
(1) Increasing the use of expanded tobacco by 20 percentage points	10%	15 %	5.250
(2) Decreasing cigarette circumference from 25mm to –			
(a) 22mm	14%	21.0%	7,350
(b) 18mm	35%	52.5%	18,375
(3) 5 percent reduction in consumer demand for cigarettes	5%	7 5%	2625

It is important to emphasize that the employment reduction figures in the ttiird column of Table 3 above represent first-round effects As iridicated in Section 2, it is possible that the reductions in the demand for tobacco implied by the first column of the table could be substantially offset by market responses that decrease the price of tobacco and quota program Even if these changes had little effect on the amount of tobacco used by the domestic cigarette industry, they could tiavc a major impact iri stimulating exports. If so. the predicted reductions in tobacco farm employment that appear in Table 3 could bc largely mitigated As indicated earlier, the considera-lions just outlined are being examined elsewhere as part of the National Bureau of Standards cost-benefit study

Implications

The analysis in the previous subsection suggests that ttie proposed cigarette design modificatioris could cause substantial reductions in the number of full-time equivalent jobs in the tobacco farming sector Moreover since most persons who work on tobacco farms do so on a seasonal basis. each full-time equivalent job that is lost would affect several different workers

Nevertheless, there is much to suggest that the reductions iri tobacco sector employments would result in few instances of real hardship[3] To understand this. it is important to recognize that workers on tobacco farms include several different groups the farmers themselves, members of the farmers' families: local persons. most of whom are employed seasonally. and migrant workers who are employed seasonally Relatively few members of any of these groups live in families where most income is derived from tobacco farming For many of the more marginal tobacco farmers. tobacco iricome is presently merely ari income supplement to off-farm work Such farmers should be able to make a fairly smooth transition to full-time non farm work. As noted earlier, moreover it is also the case that crops in addition to tobacco are often grown on tobacco farms Some of these farms. presumably. could fairly readily discori tinue growing tobacco altogether Many local persons who work seasonally on tobacco farms do so for comparatively few hours a year Consequently, for these persons, most of whom are teenagers, tobacco farm earnings usually account for a minor fraction of total family income. Finally, migrants who work seasonally on tobacco farms could presumably make a fairly easy transition to other crops and to other farming areas

Workers whose employment would be adversely affected by the design modifications can be viewed as being scattered among a considerable number of more or less distinct labor markets. As suggested above. several different groups of workers would be affected. To some extent, at least. these persons compete in different labor markets In addition. ttie farms on which burley and flue-cured tobacco are grown are located in a number of different areas spread over six states

Because tobacco farm workers are dispersed among many different labor markets. ttie number of lobs affected by the design modifications in most individual markets would terid to be relatively small This should reduce downward pressure on wages rates in these markets However. some downward pressure would exist in some markets Whether wages would actually lall as a result depends, in part on what happens to the minimum wage over the next few years. At present the federal minimum wage is $335 According to Verner Grise. hired workers on burley tobacco farms currently receive a wage of about $5 an hour, while hired workers on flue-cured tobacco farms receive from $3.50 to $4 an hour. If the minimum wage remains at its present level. the wages of hired tobacco larm workers. especially those of burley workers, could fall somewhat as a result of ttie design modifications. However, the minimum wage. which historically has been raised every five

[3] *Indeed Paul R Johnson (The Economics of the Tobacco Industry ...ger Publishers New York, 19?4, pp. 88-93) presents evidence suggesting that adjusting to mechanical harvesting in tobacco farming. which probably adversely affected far more persons than would the cigarette design modifications, was a relatively smooth and costless transition*

years or so, was last raised in 1981, and Congress is currently considering new minimum wage legislation. If the minimum wage is increased by any appreciable amount during the next year or two, the wages of hired tobacco farm workers would be restrained from falling.

5. Tobacco Auction Warehousing Sector

[redacted]

Almost all the domestic tobacco used by U.S. cigarene makers is purchased through auction warehouses. In this section, we examine how the proposed cigarette design modification would affect employment within the tobacco auction warehousing sector

There is relatively little reliable information about employment levels in the tobacco auction warehousing sector, partially because much of the work is seasonal and many of the workers migrate from one marketing center to another during the marketing season. which extends from July through February. However, based on survey information collected by the U.S. Department of Agriculture, Verner N. Grise has estimated that, in 1974. 4.1 million hours of labor were employed in tobacco auction warehouses that sold flue-cured tobacco'[4] Dividing this figure by 2080 hours implies that nearly 2.000 full-time equivalent workers were employed in flue~cured tobacco auction warehouses in 1974 However, a figure on page 21 of the Tobacco *Outlook* and Situation Report, which *was* published March 1986 by the U.S. Department of Agriculture. indicates that the amount of flue-cured tobacco currently being marketed is only about two-thirds as high as in 1974 This suggests that at present full-time equivalent employment in flue~cured tobacco auction warehouses may be only about 1,300 workers

Perhaps. an additional 1,000 full-time equivalent workers are currently employed in tobacco auction warehouses that sell burley and Southern Maryland tobacco This is suggested by Tables 22 and 25 of the Tobacco *Outlook* and Situation Report, which indicate that the combined weight of burley and Southern Maryland tobacco marketed in 1986 equaled 77 percent of the weight of flue~cured tobacco sold in that year.

In Section 4. we noted that about 50 percent of the flue-cured tobacco and about 25 percent of the burley and Southern Maryland tobacco grown in the United States is exported. Taking this into account suggests that tobacco auction warehouses employ, perhaps. 1.400 full-time equivalerit workers in marketing the domestic tobacco used in U.S cigarette

To determine the value of d lor the tobacco auction warehouse sector, *we* follow an approach very similar to one used in Section 4 to establish the value of d tor the tobacco farming sector Our approach is based on iriforrnation which is found in Table 2 of Grises 1974 paper on flue~cured tobacco auction warehouses This information, which appears below indicates how the number of hours of labor used in such warehouses to market 1,000 pounds of tobacco varies across geographic regions

Geographic Region	Hours of Labor Used to Market 1,000 Pounds of Tobacco in 1974
Pee Dee-Lumber River Area of North and South Carolina	3.3
Coastal Plain of North Carolina	3.2
Piedmont of North Carolina and Virginia	2.9
Southern Georgia Coastal Plain	3.9
Average, all regions	3.3

[4] *Verner N. Grise,* Flue-Cured Tobacco Warehouses. Handling Systems. Labor Use and Work Force Characteristics. *U.S. Department of Agriculture, Economic Research Service, 1974, p. 10*

Table A Effects of Design Modifications on Tobacco Auction Warehousing Employment

Change	Percentage reduction tobacco used in US cigarettes	Percentage reduction in farm workers needed to produce tobacco used in US cigarettes	Number of full-time equivalent jobs lost
(1) Increasing the use of expanded tobacco by 20 percentage points	10%	12.0%	168
(2) Decreasing cigarette circumference from 25mm to			
(a) 22mm	14%	16.8%	235
(b) 18mm	35%	42.0%	588
(3) 5 percent reduction in consumer demand for cigarettes	5%	6.0%	84

As can be seen the variation across the four regions is relativeij moderate, For example, dividing the values for the Southern Georgia Coastal Plain area by the average value for all regions implies that 18 percent more labor is required for a relatively inefficient auction warehouse to market 1,000 pounds of tobacco than for a typical auction warehouse. Given this information. we shall assume that d = 1 2 for the auction warehousing sector

Given this value for d and our estimate that marketing the domestic tobacco used in U.S cigarettes currently requires 1,400 tobacco warehouse auction workers. we can now predict the effects of the proposed design modifications on employment in the auction warehouse sector These predictions appear in Table 4

The employment reduction figures in the third column of Table 4 are relatively small reflecting the fact that the full time equivaient work force in the tobacco auction warehouse sector is itself quite small These figures should be viewed as estimates of first round effects For reasons discussed in Section 4 they could considerably diminish if as a result of reductions in the domestic demand for tobacco tobacco prices were to fali or the government made certain adjustments in tobacco quotas and price supports

6. Other Support Industries

The principle input to cigarette manufacturing is. of course. provided by the tobacco farming sector which was discussed in Section 4 But numerous other inputs are also purchased by cigarette manufacturing firms. These include paper, fiber for filters. aluminum foil. chemicals, containers, machinery. transportation energy, advertising. and many others To meet the demands of the cigarette manufacturing sector, the industries producing ttiese inputs must, in turn purchase inputs of their own This, in turn. generates still further purchases of goods and services with the process continuing in ever dwindling increments

It should be evident that most industries in the economy will tie affected by this process at one point or another. Thus. in a sense most industries can be viewed as support industries for the cigarette manufacturing sector. In this section. we consider the direct arid indirect effects of the proposed design modifications on employment in all the cigarette manufacturing support iridustries. but the tobacco farming sector

Direct Effects

Adoption of the design modifications would result in only a few relatively moderate direct employment effects within the support industry sector Each of these is briefly discussed below

Addition of Chemical Additive to Blend

The addition of a chemical additive to the tobacco blend used in cigarettes would of course require cigarette firms to purchase a new input This in turn would generate jobs within the chemical industry For example the 3M Company has suggested that 15 grams of Expantrol be added to each cigarette Since 6585 billion cigarettes were produced in 1986 this implies that about 109 thousand tons of Expantral would he required for this purpose A representative of the 3M Company has indicated that the firm would have to hire about 125 additional workers to produce this quantity of Expantrol

Doubling the Weight of Cigarette Paper

The production of cigarette wrapping paper wittiiri the United States presently employs about 1,600 workers at two differenl firrns According to a representative of one of these firms doubling the weight of cigarette paper would essentially double the time required to produce it Siiice the productive capacity to do this is not currently available, tlie existing plant size and capital equipment would have to be nearly doubled, as would the number of workers involved in the production of cigarette paper Hence, if the weight of cigarette paper were doubled employment levels at the firms producing this paper would increase by around 1.500 workers

Decreasing the Circumference of Cigarettes

We noted in Section 3 that if cigarettes were reduced in circumference, but at the same time lengthened sufficiently to maintain a constant puff count. ttie weight of the paper used to wrap cigarettes would fall For example. if tlie cigarettes circumference was reduced from 25mm to 22mm. the weight of the paper would fall by 21 percent And if the reduction was from 25mm to 18mm. the weight 01 the paper would decrease by 9 percent This reduction in paper weight would permit some labor savings at the firms producing cigarette paper However, even in the case of a very large reduction in cigarette circumference – say from 25mm to 18mm ttie decrease in jobs would be quite moderate. probably numbering less than 100

Indirect Employment Effects

In principle. a reduction iri the demand for cigarettes would filter through all the industries that support the activities of ttie cigarette manufacturing sector, reducing the demand for the output of these support industries and hence the number of workers they ernploy. At the same time, however, consumers would use the funds they are no loiiger spending on tobacco to purchase other products. stimulating employment among the firms producing these products and among the support industries for these firms. To examine these effects a bit more closely, it may be helpful to discuss them in the context of a specific support industry: the electric power industry

The electric power industry directly services cigarette manufacturing plants. It also services enterprises that supply inputs used by these plants (such as tobacco farms, paper companies. chemical companies. and so forth) and. in addition, firms that provide inputs to the suppliers Furthermore. electricity is also used by cigarette wholesalers and retailers. If the demand for cigarettes declined by (say) 5 percent, the demand for electric power would fall in the cigarette manufacturing sector itself, in industries that support the cigarette manufacturing sector, and among cigarette wholesalers and retailers. And, in principle, this could cause employment to fall at electric power companies and also at firms that provide the inputs used by electric power companies.

These effects are likely to be quite small, however. To illustrate this, let us look at a hypothetical power company that services a cigarette manufacturing plant. Assume that 20 percent of the total power generated by the company is sold to the cigarette plant, an amount that is surely much higher than is likely to occur in any actual situation. Further. assume that a 5 percent decline in the demand for cigarettes results in the plant reducing its use of electricity by 5 percent. In this case, demand for the power company's total output would fall by exactly one percent (.20 x .05), an amount that certainly would not cause a substantial decrease in the number of workers the power plant employs. To look at just one more example, consider a chemical plant that sells 30 percent of its output to cigarette firms and purchases 20 percent of the total power generated by the electric company that services it. In this case, a 5 percent decrease in the chemical plant's sales to the cigarette industry would cause the chemical firm to reduce its use of electricity by around 1.5 percent (.30 x .05). This, in turn, would cause demand for the power company's output to fall by 0.3 percent (.015 x .20), once again having a very small effect, if any, on employment at the electric power company

It was pointed out above that if the demand for cigarettes fell, the demand for other products would increase The firms producing these products would, of course, increase their use of electricity, as would industries that support these firms. Once again, however, the magnitudes involved are likely to be small. Consequently, although employment levels in the electric power industries may increase. as demand rises for products other than cigarettes, this increase would tend to be slight.

It should be apparent from this discussion that as consumers reallocate their expenditures from cigarettes to other products, the overall use of electricity in the nation might either increase or decrease a bit In addition, depending on the specific geographic locations of the firms affected by the reallocation of consumer resources. individual electric power companies might experience either small increases or small decreases in the demand for their product Thus. the size of the total work force in the electric power industry could either slightly rise or fall; and, even if it remained the same. small increases in employment might occur at some individual power companies, while small decreases might occur at others

The electric power industry example lust discussed has three major implications for this study, First. it implies that a reduction in demand for cigarettes could, in principle at least. cause changes in employment levels at firms throughout the economy. Second, the example suggests that most of these changes in employment would be so diffused and complex that it is virtually impossible to predict where they would occur with any precision. Third. and most important. the example implies that, in most instances. the changes in employment levels would be very small and inconsequential.

Thus, it would appear that for most industries, it is not important to take account of any indirect employment effects resulting from the cigarette design modifications The only industries for which this is not the case are those that contain firms that, unlike electric power companies. supply a product that can only (or almost only) be used by cigarette companies Tobacco farms, which were discussed in Section 4, provide the most obvious examples of such firms. There are only a few other examples. These include the firms that produce highly specialized machines used by cigarette companies – such as cigarette makers, plug makers, and cigarette packers – and companies that manufacture items that become part of the cigarette itself – such as wrapping paper, tipping paper, filter material, and flavorings. The manufactures of such materials as aluminum foil or cardboard cartons would not be included in this list since the inputs they provide cigarette firms. like those provided by electric power companies. could also be used by non-cigarette firms.

Most of the highly specialized machines that are used in making cigarettes are produced in Europe Consequently. we will not attempt *to* predict the effect of a decrease in the demand for U.S. cigarettes on employment at firms manufacturing this machinery. According to Table 3.26 of the Wharton study, purchases hy cigarette companies of materials that are incorporated into cigarettes – for example, wrapping paper. tipping paper, filter material, and flavoring – generated about 7,000 lobs in 1977 at the firms that manufactured these products. If the demand for cigarettes fell by 5 percent and. consequently, cigarette companies used 5 percent less of these products, some reduction in employment would occur within firms manufacturing the products There is no way to predict the exact number of such lobs that would be lost but 200 to 500 positions would appear to he a reasonahle order of magnitude (Note that if d ≈ 1. 350 positions would be lost.)

7. Wholesaling

Manufactured tobacco products require two steps to reach the buying public. First. they are distributed by wholesalers to retailers. Then, these retailers sell them to consumers. The proposed cigarette design modifications should have no direct effects on employment in either the wholesaling or retailing sectors, but indirect employment effects could occur as a result of a reduction in the demand for cigarettes. In this section, we assess these indirect effects on the wholesaling section. and, in the following section. we examine the effects on the retailing sector.

Two estimates exist of the number of persons employed in the wholesale distribution of manufactured tobacco products: the Chase Econometrics study reports that 35,300 workers were engaged in this activity in 1983, while the Wharton study indicates that 42.000 workers are engaged in this activity in 1977 These two figures pertain to workers involved in both wholesaling cigarettes and wholesaling other manufactured tobacco products. such as cigars and pipe tobacco Table 6b of the October 1986 issue of Tobacco *Monthly* reports that 1977 cigarettes accounted for 92.2 percent of total consumer expenditures on manufactured tobacco products, while Table 6a of this publication indicates that the number of cigarettes sold in this country in 1986 was only 94.7 percent as large as in 1977 Adjusting the employment figure reported by Wharton to account for these two considerations implies that in 1986 around 37,000 workers (that is, 42,000 x .922 x .947) were employed in the wholesaling of cigarettes. Similarly, Tobacco *Monthly* reports that in 1983 cigarettes accounted for 93.5 percent of consumer expenditures on tobacco products and that the number of cigarettes sold domestically was only 97.3 percent as high in 1986 as in 1983 Adjusting the employment figure reported by Chase Econometrics for these factors implies that in 1986 about 32,000 workers were employed in the wholesale distribution of cigarettes (35,300 x .932 x ,973). Thus. once adjusted. the Chase and Wharton estimates suggest employment levels of a similar order of magnitude.

What would be the reduction employment in the wholesaling sector as a result of a 5 percent reduction in cigarette sales? It seems likely that it would be in the order of 5 percent, in other words. d, the value of the elasticity of employment with respect to output probably approximates one for the sector. The major reason for this is that the reduction in sales would probably be relatively evenly distributed among wholesalers throughout the country. There is no reason to expect that employment effects would be particularly concentrated among those wholesale operations where output per worker is especially either low or high.

Given our assumption that the value of d approximates one in the wholesaling section, we predict that a 5 percent reduction in sales would cause employment to fall by 1,600 or 1.850 workers. The lower of these estimates is based on the Chase Econometric employment level figure. while the higher estimate is based on the Wharton figure

Since these employment reductions are likely to be distributed throughout the country accounting for very few jobs in any specific local labor market, effects on wage levels should be negligible. The employment reductions should also impose little real hardship. If the reductions take place gradually over a relatively long period of time, which, as suggested earlier. appears likely, few direct lay-offs need occur; instead. attrition can serve as the principle mechanism for obtaining the reductions. Even if lay-offs do occur, however those workers who are affected are likely to be relatively low in seniority and, as a consequence, currently receive relatively low wages and be fairly young and mobile. Such persons should be able to find jobs comparable to those they lost fairly easily and quickly.

8. Retailing

It appears likely that in most parts of the retailing sector the value of d ttie elasticity of employment with respect to output would approximate zero In other words reduction is cigarette sales should have negligible effects on employment levels The reasons for this is that few retail employees are employed for tlie sole purpose of selling cigarettes In such major cigarette retail outlets as supermarkets, drug stores. convenience stores, gas stations, and bars. cigarettes usually constitute a small fraction of total sales. Indeed. according to Table 34 of *The* Tobacco *Outlook and Situation* Report. which was published March 1986 by the US Department of Agriculture. cigarette sales in these outlets typically account for less thari 5 percent of total sales. However even if cigarettes accounted for as much as (say) 10 percent of total sales in a particular retail outlet. a 5 percerit reduction in cigarette sales would only cause the outlet's total sales to fall by one half of one percent (.05 x 10) And even this would he partially offset if consumers who make fewer cigarette purchases. spend the money they save on other products sold by the outlet. Thus it seems unlikely that the size of the outlet's work force would be reduced as a result of a 5 percent decline in cigarette sales

The one possible exception to tlie above analysis concerns cigarette vending machine operations within the retailing sector The workers employed by such operatioris do principally derive their livelihood from ttie sale of cigarettes However, even these workers may not be very threatened by a relatively moderate reduction in cigarette sales. such as 5 percent Under these circumstances. sales at each vending machine would fall somewhat. hut the total number of machines would probably not he reduced by very much Thus it would appear likely that within the vending part of the retailing sector the value of d is well below one For our purposes we shall assume that d = 05

An estimate in the Wharton study indicates that in 1977, 33.000 workers were employed in cigarette vending (a comparable figure is not provided in the Chase Econometrics study.) Adjusting this estimate to reflect ttic fact that the riumber of cigarettes sold in 1986 was only 94 7 percent as high as in 1977, implies that. in 1986. around 31.000 persons were employed in cigarette vending. Coupling tliis estimate with our assumption that d = 05 implies that a 5 percent decline in cigarette sales would reduce the employment of cigarette vending workers by 775 For reasons very similar to lhose suggested in Section 7. where we discussed ernploy ment reductions in the wholesaling sector this loss of 775 jobs should tiave virtually no effects on wage levels and should impose little hardship on most affected workers

9. Conclusions

The major purpose of this report is to present estimates of potential employment effects resulting from implementation of four proposed cigarette design modifications intended to reduce cigarette igntion propensity. These estimates are reported in summary form in Table 5.

As can be seen from the total column in Table 5, the direct employment effects of two of the design modifications would be positive, while the direct effects of the other two would be negative. Unless the Circumference of cigarettes is decreased to less than 22mm or the use of expanded tobacco is increased by around 40 percentage points, none of the direct employment effects is predicted to cause a total gain or loss of more than 10,000 jobs. Compared to the 110 million persons who are currently employed in the United States or the 8 million who are unemployed. these numbers pale into insignificance. The figures appearing in the bottom row of Table 5 imply that the indirect effects of the design modifications would also be relatively moderate, unless consumer reaction to the modifications results in far more than the assumed 5 percent reduction in cigarette output upon which the estimates are based. Table 5 further indicates that the most important direct employment effects would occur in the tobacco farming sector, while the largest indirect effects on employment would be within the cigarette manufacturing sector

It is important to emphasize that none of the negative estimates appearing in Table 5 represents a net loss of jobs to the economy as a whole. There are two reasons for this. First the estimates in the table are predictions of first-round effects. For reasons discussed at several points in this report, the predicted effects for the tobacco farming and tobacco auction warehousing sectors could be substantially mitigated by price responses or governmental interventions in tobacco markets. The same factors could also result in small partial offsets to the predicted indirect effects for the other four sectors.

The second, and more fundamental, reason why the negative predictions in Table 5 do not represent a net reduction of jobs in the economy is that any job reductions within the cigarette manufacturing sector and its support industries would be more or less offset by job increases occurring elsewhere in the economy. For example, job losses that result from declines in consumer expenditures on cigarettes would be offset by job increases that take place as a consequence of consumers raising their expenditures on other items. In a somewhat similar fashion, the job losses that can be directly attributed to increasing the use of expanded tobacco or decreasing the circumference of cigarettes would also be offset Either of these modifications would cause less tobacco to be used in cigarettes. This. in turn, would result in substantial cost savings in producing cigarettes. These savings mtght be passed on to the customers, stockholders. or employees of cigarette firms or they could be used by the firms themselves for new capital investments. In any event, recipients of the savings would eventually spend most of them, thereby stimulating employment.

Although the job losses that appear in Table 5 would tend *to* be canceled by job gains occurring elsewhere in the economy. the individuals employed in these new positions would rarely be the same persons as those who lost their existing job. Thus, there would be a transitional period during which costs may be imposed on some individual workers. As suggested throughout this report, the total sum of such costs would probably not be large. First, according to Table 5, the total number of jobs lost would not be large. Second, the indirect effects result from decreases in consumer expenditures on cigarettes. and these are likely to occur quite gradually, allowing reductions in employment levels to take place through attrition, rather than through layoffs. Third. if lay-offs do occur, many of those affected depend on tobacco for only a relatively small share of their total income

Table 5. Summary of the Estimates of the Direct and Indirect Employment Effects of the Proposed Cigarette Design Modifications

	Sector						
Change	Cigarette Manufacturing	Tobacco Farming	Tobacco Auction Warehousing	Other Support Industries	Wholesaling	Retailing	Total[a]
				Direct Effects[b]			
Addition of Chemical Additive	+165	NONE	NONE	+125	NONE	NONE	+290
Increasing Use of Expanded Tobacco by –							
20 percentage points	NEG	–5,250[c]	–168[c]	NONE	NONE	NONE	–5,418
40 percentage points	NEG	–10,500[c]	–336[c]	NONE	NONE	NONE	–10,836
Decreasing Cigarette Circumference from –							
25mm to 22mm	–850	–7,350[c]	–235[c]	NEG	NONE	NONE	–8,435
25mm to 18mm	–2,150	–18,375[c]	–588[c]	NEG	NONE	NONE	–21,113
Doubling the Weight of Cigarette Paper	+100	NONE	NONE	+1,500	NONE	NONE	–1,600
				Indirect Effects[b]			
Consumer Demand Response to Modification Causing a 5% Reduction in Cigarette Output And In Cigarette Purchases of All Inputs	–3,750	–2,625[c]	–84[c]	–350[c]	–1,725	–775	–9,309

NOTES:
[a]Effects of negligible magnitude are ignored in computing total.
[b]When a range. rather than a point estimate. appears in text, the mid-point of the range is reported in table.
[c]Estimate represents first-round effect only. This first-round effect could be substantially diminished by adjustments occurring within tobacco markets.

NONE: The design modification would not cause an employment effect to occur within the sector.
NEG: Negligible Effect; less than 100 jobs gained or lost.

It has also been argued in this report that wage rates would be little changed by employment effects resulting from the cigarette design modifications. The major reason for this is that the total number of affected jobs is not large, and those that are affected tend to be dispersed through many different labor markets Consequently. in most individual markets. these jobs would account for only a very small fraction of total employment. Moreover, in the cigarette manufacturing sector and the tobacco larm sector, union negotiated wage rates and the minimum wage. respectively, establish wage floors that help keep wages from falling

Economic
Sector Data
for Modeling
the Impact
of Less
Ignition-Prone
Cigarettes

Section 3

Cost Analysis of Options for Self-Extinguishing Cigarettes

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1. Introduction

The Cigarette Safety Act of 1984 (Public Law 98 567 98 Stat 2925) created the Technical Study Group on Cigarette Fire Safety to investigate the technical and commercial feasibility of developing cigarettes and little cigars with minimum propensity to ignite upholstered furniture and mattresses

This study concerns the development of costs for the technical options considered for reducing the propensity to ignite cigarettes

Study Objectives

The objectives of the study were two-fold namely

1 to develop cost element data through interviews with industry representatives and by literature searches
2 to develop and quantify a cost model lor the process alternatives listed below

Options for Reducing Ignition Propensity

Four product modification alternatives were specified for the cost study[1] These are

1 Reductions in cigarette circumference from 25mm to 21 mm
2 Adding chemical additives to the blend
3 Changes in percent of expanded tobacco in the blend
4 Increasing the thickness of the cigarette paper

The actual specifications of the options as submitted by the National Bureau of Standards are presented in Table 1

[1] *These options appear described in the memorandum "Cigarette Ignition Propensity A Benefit-Cost Study " Second Progress Report Prepared by the Applied Economics Group Mathematical Analysis Division of the National Bureau of Standards for the Technical Study Group on Fire Safety, July 31, 1986*

Limitations in Scope

Due to the limitations in funds allocated to the cost analysis task, several limitations in study scope were specified These limitations in scope included:

1. The number of options studied would not exceed three.[2]
2 Due to possible problems with data acquisition. given ttic proprietary nature of some of the cost data, only incremental costs would be estimated
3 No assessment would be conducted of the technical effectiveness of the options in reducing ignition propensity. nor would assessments be made of the impact of the options on taste and demand characteristics

Data Problems and Difficulties

The major problem facing the cost analysis concerns the confidentiality and proprietary nature of the data needed for the cost analysis Because of the difficulty of securing some of this proprietary data from both paper manufacturers and cigarette manufacturers the cost analysis makes extensive use of information in the published literature

Cost Summary

Table 2 provides a summary of the cost analysis presenting the incremental costs per 1000 cigarettes and their percent increase over the wholesale cigarette price of $33 75 per 1000 cigarettes As shown in Table 2 there are two options use of chemical additives in the blend and increases in paper thickness which result in cost increases ranging lrom 0 4 percent to 2 0 percent of the wholesale cigarette price The most economical of the options is the reduction in cigarette circumference from 25mm to 21mm which results in cost reductions of about 3 percent of the wholesale cigarette price

[2] *The study departed from the original contract specifications to include the costing of additives to lhe blend, such as the silica gel option*

Table 1. Potential Product Design Modifications to Reduce the Ignition Propensity of Cigarettes Included in the Benefit-Cost Study

Design Modification	Description	Assumptions
Chemical Additives to Blend	Silica Gel. Specific quantities to be targeted	• Additive causes self-extinguishment when cigarette is on substrate • Tar and nicotine assumed unchanged • No direct health effects of additive • Homogeneous mixing of additive throughout tobacco blend prior to cigarette making
Change in Percent Expanded Tobacco in blend	Specific percent expanded has not been targeted. Cost functions will be developed for a range of percentages	• Increasing percent expanded decreases density and thereby increases burn rate. This reduced the propensity to ignite substrate
Cigarette Circumference	Specific circumference has not been targeted. Cost functions will be developed for the range of 21mm to 25mm	• Decreasing circumference decreases the substrate contact area, thereby reducing the ignition propensity • A constant puff count can be maintained by adjusting tobacco column length
Paper Thickness	Twice the current thickness will be evaluated	• Thicker paper is more insulating, and thereby reduces the ignition propensity on the substrate • A constant puff count and delivery can be maintained by adjusting porosity • Taste effects may not be fully compensated

Source: National Bureau of Standards. Applied Economics Group "Cigarette Ignition Propensity: A Benefit-Cost Study". Second Progress Report. Prepared for the Technical Study Group on Cigarette Fire Safety, July 13, 1966.

Table 2. Summary of Incremental Costs of Options for Reducing Cigarette Ignition Propensity

(In 1986 Dollars per 1,000 Cigarettes)

Options	Four Year Grace Period		Instantaneous Implementation	
	Total	As Percent of Whole-sale Cigarette Price	Total	As Percent Of Whole-sale Cigarette Price
1. Reduction in Cigarette Circumference, from 25mm to:				
21mm	8 -0.966	-2.91	$ -0.966	-2.90%
2. Additions of Chemical Additives to the Blend	$ +0.667	+1.98%	$ -0.667	+1.98%
3. Increased use of expanded tobacco from 25 percent expanded tobacco in blend to:				
50%	$ - 0.400%	-1.18%	---	---
4. Increments in paper thickness from 24 grams/m^2 basis weight to:				
32 grams/m^2	$ +0.154	+0.5%	---	---
45 grams/m^2	$ +0.252	+0.8%	---	---

Source: See text in Chapters 3, 4, 5, and 6.

2. The Structure of Costs in the Cigarette Industry

The Aggregate Cost Structure

The point of departure for the analysis of the costs of the cigarette industry is the aggregate cost structure published by Smith Barney Research This aggregate cost structure presented in Table 3 shows the wholesale price of cigarettes at $33 75 per 1000 cigarettes as of October 1986 The aggregate cost figures presented in Table 3 have been adjusted to reflect more detail on manufacturing costs and recent trends in tobacco leaf costs

Manufacturing Costs Adjustments

The aggregate cost structure presented in Table 3 does not include the detail on the manufacturing operations needed for the analysis so it was decided to apply to the aggregate numbers disaggregation factors developed by James E Morris[3] adjusted in accordance with estimates from the 1982 Census of Manufacturing as explained below The cigarette manufacturing costs of $1 40 per 1000 cigarettes (shown in Table 3) have been allocated between labor and energy costs based *on* their relative proportions shown in the 1982 Census of Manufacturing After this initial alloca tion both energy and labor costs were allocated to each manufacturing operation or process based on James E Morris estimates of the percentage of total manufacturing costs in plant operations

[3]*James E Morris "This Tobacco Business Par! XIII Manufacturing Costs of Cigarettes - Tobacco International, Vol 182, No 2, December 26, 1980, pp 47-52*

The costs of materials were distributed by industrial opera tions following a similar procedure with a few pertinent modifications The aggregate costs of materials shown in Table 4 were similarly distributed over manufacturing opera tions by using relative cost factors presented in James E Morris article[4] with the exception of cigarette paper

Paper Costs

In the case of the cigarette paper the costs were estimated in accordance with the following formula

$$C_p = (22 \times 10^{-3})(BW)(L)(W)(P)$$

where

C_p	=	paper costs per cigarette
BW	=	basis weight of paper (24 grams/m²)
L	=	length of the tobacco column (0065 m)
W	=	bobbin width (00275 m)
P_p	=	price of paper per lb ($1 75 per lb)
22×10^{-3}	=	represents the number of lbs per gram

The paper costs are presented in Table 5 The remainder of the costs of the cigarette making materials were allocated among the remaining cigarette making materials in accor dance with James E Morris relative percentages

[4]*Ibid, page 48*

Table 3. Representative Aggregate Cigarette Industry Cost Structure[1] – 1986

	Cost/1,000 Cigarettes[2]	Percent of Average Wholesale Price[3]
Leaf Tobacco		
Purchased Leaf	$ 3.70	11.0%
Carrying, Processing and Storage Costs	2.05	6.0
Total Cost of Tobacco	$ 5.75	17.0%
Other Materials		
Filter Materials	$ 0.83	2.4%
Cigarette making (paper, etc.)	0.66	2.0
Packaging	1.30	3.9
Total Other Materials	$ 2.79	8.3%
Direct Cigarette Manufacturing Labor[4]	1.40	4.1
Total Manufacturing Costs	$ 9.94	29.4%
Overhead and Transportation	0.80	2.4%
Advertising	3.75	11.1
Federal Excise Tax	8.00	23.7
Total Costs	$22.49	66.6%
Operating Profits[5]	$11.26	33.4
Total Wholesale Price	$33.75	100.0%

1 Based on full-priced brands.

2 LIFO or current cost basis.

3 $33.75 as of June 1986, based on averaged pricing within the industry of 85 mm and 100 mm; including manufacturers discount of 3%-4%.

4 Excluding leaf processing labor.

5 Before interest expense, other corporate expenses, and income taxes.

Source: Smith Barney Research. Tobacco Monthly, October 22, 1986, p. 16.

Table 4. Disaggregate Cost Structure of Cigarette Manufacturing Operations – 1986
(per 1,000 cigarettes)

	Cost Categories				
	Labor	Energy	Materials	Depreciation	Total
1. Purchased Leaf Tobacco			$2.93		$2.93
2. Carrying, Processing and Storage	N.A.	N.A.	0.00	N.A.	2.82
a. Receiving					0.085
b. Storage					2.296
c. Dispatch					0.085
d. Transport to Plant					0.023
e. Stemming	N.A.	N.A.		0.016	0.331
3. Plant Operations	$1.285	$0.115	$2.790	$0.206	$4.396
a, Tobacco Storage	0.026	0.003		--	0.029
b. Vacuum Process	0.002	negl		0.002	0.004
c. Flue-Cured Line	0.004	negl		0.002	0.006
d. Barley/Maryland Line	0.005	negl		0.004	0.009
e. Oriental Line	0.003	negl		0.01	0.004
f. Reconstituted Tobaccos	0.073	0.007		0.039	0,119
g. Blending	0.001	negl		0.002	0,003
h. Casing	0.002	negl	0.016	0.001	0,019
i. Cutting	0.003	negl		0.002	0.005
j. Crushed Rolled Stem	0.005	negl		0.001	0.006
k. Drying & Cooling	0.003	negl		0.003	0.006
1. Bulking	0.016	0.001		0.008	0.025
m. Plug Making	0.206	0.019	0.830	0.011	1.066
n. Cigarette Making	0.376	0.035	0.644	0.092	1.147
o. Packaging	0.539	0.048	1.300	0.036	1.923
p. Shipping	0.010	0.001		--	0.011
q. Quality Control	0.011	0.001		0.002	0.014
4. Building Depreciation				0.037	0.037
5. Overhead and Transport					0.558
6. Advertising					3.750
7. Federal Excise Tax					8.000
TOTAL COSTS					$22.490
8. Operating Profits					11.260
TOTAL WHOLESALE PRICE					$33.750

Table 4. Disaggregate Cost Structure of Cigarette Manufacturing Operations – 1986 (continued)
(per 1,000 cigarettes)

Note: negl. denotes negligible amounts.

Source: Disaggregation of cost figures from Table 2-1 using relative allocation factors from James. E. Morris "This Tobacco Business, Part XIII: Manufacturing Costs of Cigarettes." Tobacco International, Vol. 182, No. 26, December 26, 1980, pp. 47-52.

Table 5. Cost of Materials Used in the Manufacturing Operations per 1,000 Cigarettes – 1986

Materials	cost
Leaf Tobacco	$ 2.93
Casing (Flavoring)	$ 0.016
Plug Making	$ 0.830
Filter Materials	0.638
Plasticimers	0.039
Adhesives	0.001
Paper Wraps	0.076
Flavorings	0.076
Cigarette Making	$ 0.644
Paper	0.170
Tipping Materials	0.386
Starch	0.033
Adhesives	0.043
Ink	0.012

Table 5. Cost of Materials Used in the Manufacturing Operations per 1,000 Cigarettes – 1986 (continued)

Packaging	$ 1.300
Packets	0.282
Foil	0.270
stamps	0.016
Plastic Wraps	0.242
Tear Tapes	0.071
Adhesives	0.022
Cartons	0.270
Cases	0.127

Source: Estimated by disaggregating the cost of materials figures presented in Smith Barney Research, Tobacco Monthly, October 22, 1986, p. 16; by the relative percentages shown in James E. Morris, "This Tobacco Business: Part XIII Manufacturing Costs of Cigarettes." Tobacco International, December 26, 1980, p. 48.

Purchased Leat Tobacco Costs

The costs of purchased leaf tobacco costs presented in Tables 3 have been adjusted to reflect the downward trend in tobacco prices

In terms of the prices paid to tobacco farmers the costs of leaf (including the costs of transportation to the warehouse and warehouse commissions) are $2 93 per 1000 cigarettes as shown in Table 6

The residual between the $293 farm gate tobacco costs and the $3 70 leal tobacco costs presented in Table 3 have been allocated proportionately between the stemmery and warehousing operations in accordance with the disaggrega tion factors developed by James E Morris [5]

Depreciation Costs

Another adjustment made to the aggregate figures concerned depreciation costs According to the 1982 Census of Manufacturing depreciation costs of machinery per 1000 cigarettes grew 10 7 percent annually during the period 197782 while depreciation of buildings and struc tures Der 1000 cigarettes grew at 2 6 percent annually during the same period Projection of the depreciation costs to 1986 resulted in the figures presented in Table 7 The projected depreciation costs for 1986 were deducted from Smith and Barney Researchs overhead costs and in the case of the machinery and equipment depreciation costs were allocated by manufacturing process proportionally to Morris relative percentages of the costs *of* equipment used in cigarette manufacturing [6] The allocation of depreciation costs by manufacturing processes appear in Table 4

Cost Summary

To interface with the economic impact model developed by the National Bureau of Standards, the overall cost structure has been disaggregated into the lour components presented in Table 8

[5] *Ibid* page 47

[6] *James E Morris Op Cit p 50*

Table 6. Tobacco Leaf Costs Paid to Farmers/Importers -- 1985
(all figures expressed per 1,000 cigarettes)

	Unstemmed Processing Weight[a] (lbs)	Farm-Sales Weight, (lbs)	Prices Paid to Farmers/ Importers[b] ($)	Leaf Costs Paid to Farmers/Importers ($)
Flue-cured -				
Domestic	0.587	0.657	$1.719	$1.129
Burley -				
Domestic	0.491	0.551	1.594	0.878
Maryland -				
Domestic	0.045	0.045	1.320	0.059
Imported -				
All Types	0.585	Not Appl.	1.480	0.866
	1.708	1.253		$2.932

[a] Correspond to 1984 cigarette weights from U.S. Department of Agriculture. Economic Research Service. "Tobacco: Outlook and Situation Report." September 1985, Page 33.

[b] 1985 prices for domestic purchases of tobacco from U.S. farmers were supplied by the U.S. Department of Agriculture.

Table 7. Depreciation Costs per 1,000 Cigarettes – 1986
(in current dollars)

	1977	1982	1986p	Annual Rate of Growth 1977-1982
Machinery and Equipment	$0.089	$0.148	$0.222	10.7%
Buildings and Structures	0.029	0.033	0.037	2.6%
TOTAL	$0.118	$0.181	$0.259	8.9%

Source: U.S. Bureau of Census. 1982 Census of Manufacturing for 1977 and 1982 figures. The 1986 figures are projected.

Table 8. Summary of Cigarette Cost Structure – 1986
(Per 1,000 Cigarettes)

Cost Components	cost	As Percent of Wholesale Price
Domestic Leaf Tobacco	$2.066	6.1%
Paper	0.170	0.5%
Federal Excise Tax	8.00	23.7%
All Other Costs	23.514	69.7%
Total Wholesale Price	$33.750	100.0%

3. Option 1: Decreases in Circumference

[redacted]

This option consists of decreasing the circumference of cigarettes from current typical values of 25mm to 21 mm.[7] No effort has been made to maintain the same number of puffs per cigarette, by lengthening the tobacco column of the cigarette to compensate for the reduction in circumference Table 9 shows the combinations of circumference and length analyzed.

[7] *Earlier analysis of this option covered decreases in circumference to 18 mm*

The costs associated with the option of decreasing circumference include changes in the costs of material inputs. both tobacco and paper, and the capital costs of equipment modifications.

Changes in Costs of Material Inputs

On the basis of the information presented in Table 9 regarding the requirements of tobacco and paper needed for various cigarette circumferences. Table 10 estimates the

Table 9. Tobacco Volume, Weight, and Paper Area for Various Cigarette Circumferences for American Blend Types[a]

Tobacco Circumference (mm)	Tobacco Volume (cmm)	Tobacco Column Length (mm)	Tobacco Weight (grams)	Paper Area (smm)	Paper Weight (grams)
25.00	3233.05	65.00	0.853	1625.00	0.03900
21.00	2281.29	65.00	0.602	1365.00	0.03276

[a] Assumes a tobacco packing density of 0.264 grams/ccm, 0.339 puffs per mm of circumference, 0.138 puffs per mm of length, and paper with 24 $grams/m^2$ of basis weight.

Table 10. Changes in the Material Costs Associated with Changes in Circumference — 1986
(per 1,000 cigarettes)

			Changes in Material Costs from 25 mm Circumference		
Circumference (mm)	Tobacco Costs[a]	Paper Costs[b]	Tobacco (%)	Paper (%)	Total (%)
25.00	$3.228	$0.150	---	---	---
21.00	2.278	0.126	$-0.950 (-29.4%)	$-0.024 (-16.0%)	$-0.974 (-28.8%)

[a] Estimated from Table 3-1 assuming tobacco prices of $1.72 per lb. The tobacco prices were estimated by dividing the $2.932 leaf costs per 1,000 cigarettes by the weight of 1.708 lbs. of tobacco per 1,000 cigarettes. (See the analysis presented in Table 2-4.)

[b] Estimated from Table 3-1 assuming paper prices of $1.75 per lb.

changes in material costs which result from circumference changes, exhibiting significant savings in tobacco leaf costs resulting from the changes in circumference

Cost of Equipment Modifications

Changes in circumference will also require modifications of the most important cigarette manufacturing equipment, such as: cigarette packers, cigarette makers, and plug makers.

Three types of equipment modifications may be distinguished: 1) changes within the drum ranges, 2) major changes, that is changes within the equipment specifications, and 3) changes outside the specifications of the equipment, that is. changes requiring new equipment designs. These changes are discussed next for each major equipment type.

Cost of Parts

Small changes in diameter of 0.1-0.2mm, from the current 25mm circumference level, can be accommodated without significant equipment modifications As a general rule modifications on the cigarette packers are more expensive because of the tri-dimensional changes required on these machines. Changes in excess of 0.6mm begin to require aopreciable modifications in equipment.

The specifications of most cigarette makers, plug makers and cigarette packers range in circumference from 20mm to 28mm, so that it is possible to modify equipment within this range of specifications without having to order new machines or specially-made equipment.

Based on interviews with selected equipment manufacturers, it is estimated that changes from 25mm to 23mm of circumference can be accommodated by replacing approximately 55 to 66 percent of the variable parts of the equipment. These minor changes are within drum ranges. However, changes in circumference below 23mm to the 22-20mm level will require changing almost all the movable parts of the equipment. In the case of the cigarette makeriplug maker combination, these movable parts include: every drum in the tipping, at hopper, at rails, cut-offs and catcher drums. In none of these cases does it becomes necessary to change the process parts. Tables 11 and 12 present the costs of parts for the modification of the cigarette maker/plug maker Combination and for the cigarette packers respectively. The costs of parts should be amortized over the service lives of the equipment in question.

Table 11. Costs of Parts in Equipment Modifications of Cigarette Makers/Plug Makers (Per Cigarette Maker/Plug Maker)

	Circumference Changes	
	From 25mm to 23mm	From 25mm to 22-20mm
Percent Process Parts Changes	0%	0%
Percent Movable Parts Changed	66%	100%
Cost of Movable Parts as Percent of Machine Costs	20%	20%
Part Coats in Modifications of Cigarette/Plug Maker Combinations:		
Performance: 8,000 Cigarettes per Minute	$89,100	$135,000
Performance: 5,000 Cigarettes per Minute	69,300	105,000

Source: Interviews with selected equipment manufacturers.

Labor Costs

The costs of labor have been estimated in Tables 13 and 14 on the basis of interview responses. It was estimated, from the interviews, that it takes six shifts to change all the movable parts of the cigarette maker All the other labor requirements were estimated proportionally to the value of movable parts to be replaced. The number of shifts needed

to modify the cigarette packers to effect changes in cigarette length was estimated as two shifts, in accordance with the literature,[8] and these requirements were used to adjust the number of shifts required for the packers. Average wage rates of $1584 per hour as of June 1986 (from BLS sources) and overhead rates of 60 percent were used to estimate labor costs in Tables 13 and 14. The costs of these modifications need to be annualized or ammortized over the service lives of the equipment

8 Tobacco International. April 4, 1986, page 52

Costs of Idle Equipment

The costs of idle equipment have been estimated as the interest on the value of idle equipment and the foregone profits from cigarette manufacturing. The formula for the estimation of the interest costs of each idle equipment is.

$$\left(\begin{array}{c}\text{Interest}\\\text{Costs of}\\\text{Idle}\\\text{Equipment}\end{array}\right) = \left(\begin{array}{c}\text{Hours}\\\text{Idle}\end{array}\right) = \left(\begin{array}{c}\text{Replacement}\\\text{Value of}\\\text{Equipment}\end{array}\right) = \left(\frac{\text{Annual Interest Rate}}{\text{Annual Manufacturing}}\right.$$

Table 12. Costs of Parts in Equipment Modifications of Cigarette Packers
(Per Cigarette Packer)

	Circumference Changes	
	From 25mm to 23mm	From 25mm to 22-20mm
Percent Process Parts Changes	0%	0%
Percent Movable Parts Changed	55%	90%
Cost of Movable Parts as Percent of Machine Costs	30%	30%
Part Costs in Modifications:		
Performance: 8,000 Cigarettes per Minute	$ 99,000	$162,000

Source: Interviews with selected equipment manufacturers.

The annual manufacturing hours were estimated as 6,000 hours (250 days x 24 hours per day) Interest rates of eight percent annual rates were used to estimate these costs The hours the equipment is idle corresponds to the labor requirements or shifts required to modify the equipment These costs should be amortized over the service life of the equipment

Costs of Extra Machines

The other costs associated with having idle equipment, concern the need for extra equipment to maintain production while the equipment in the production line is being modified. Thus, rather than estimate foregone profits while the existing equipment is being worked on, it is assumed that the cigarette manufacturers will maintain existing production figures through the installation of extra machinery The extra machinery requirements are estimated as follows:

$$\left(\begin{array}{c}\text{Extra Machines Required}\\ \text{During Repair Period}\end{array}\right) = \left(\begin{array}{c}\text{Repair}\\ \text{Shifts}\end{array}\right)$$

$$\left(\begin{array}{c}\text{No of Machines}\\ \text{to be Repaired}\end{array}\right) \div \left(\begin{array}{c}\text{Shifts Per Machine}\\ \text{Per Year}\end{array}\right)$$

Assuming 750 shifts per machine per year and 438 machines are to be modified, the number of extra machines needed to maintain production are six makeriplug combinations and eight packers. Taking into account the installation times of new equipment which is roughly seven shifts for the makeriplug and ten shifts for the packer, increases the machine requirements to seven makeriplug combinations and nine cigarette packer machines. The costs of the extra machinery should be amortized during their period of service life, which is generally seven years. Tables 13 and 14 present the cost of idle equipment for the makeriplug; combination and the cigarette packer respectively.

Equipment Replacement Needs

This section estimates the equipment replacement and/or modification needs of the U S cigarette manufacturing

Table 13. Costs of Labor and Idle Equipment in Modifications of Cigarette Makers/Plug Makers — 1986 (Per Machine Combination)

	Circumference Changes From 25mm to 23mm	Circumference Changes From 25mm to 22-20mm
Labor Requirements		
Cigarette Maker	4 shifts	6 shifts
Plug Maker	3 shifts	4 shifts
Total	7 shifts	10 shifts
Labor Costs		
2 Repairmen @ $15.84/hour[a]	$1,774	$2,534
Manufacturing overhead 60%[b]	1,064	1,520
Total Labor Costs	$2,838	$4,054
Interest on Idle Machines[c]		
Performance: 8,000 cigarettes per minute	$ 508	$ 720
Performance: 5,000 cigarettes per minute	$ 392	$ 560
Extra Machine Costs to Maintain Production While Idle		
Performance: 8,000 cigarettes per minute	$9,247	$10,788
Performance: 5,000 cigarettes per minute	$7,192	$ 8,390

[a] Average wage in cigarette manufacturing during June 1986 according to the Bureau of Labor Statistics Employment and Earnings, December 1986.

[b] Estimated from Table 2-1.

[c] Estimated at eight percent interest rate.

Table 14. Costs of Labor and Idle Equipment in Modifications of Cigarette Packers – 1986

(Per Cigarette Packer Machine)

	Circumference Changes	
	From 25mm to 23mm	From 25mm to 22-2omm
Labor Reauirements	9 shifts	13 shifts
Labor Costs		
2 Repairmen @ $15.84/hour[a]	$ 2,281	$ 3,295
Manufacturing overhead 60%[b]	1,369	1,977
Total Labor Costs	$ 3,650	$ 5,272
Interest on Idle Machines[c]		
Performance: 8,000 cigarettes per minute	$ 704	$ 1,023
Extra Machine Costs to Maintain Production While Idle:		
Performance: 8,000 cigarettes per minute	$ 9,589	$12,329

[a] Average wage in cigarette manufacturing during June 1986 according to the Bureau of Labor Statistics Employment and Earnings, December 1986.

[b] Estimated from Table 2-1

[c] Estimated at eight percent interest rate.

industry and the average age of equipment. The section begins by analyzing the improvement in equipment performance since the mid-sixties, which is shown in Table 15. As shown in Table 15 new improved equipment is introduced on the average every 3-4 years.[9]

The average age of equipment is estimated from the data on capital expenditures over the period 1974-1985; data which is presented in Table 16. Focusing on the 7-year capital replacement period which characterizes the industry. the following capital vintage (shown in Table 17) is estimated from the capital expenditure figures presented in Table 16.

The average age of equipment in the industry is estimated as 2½ years old, denoting the fact that the equipment in place has 4½ years of remaining value. In terms of residual value of the equipment in place, the residual value of the equipment is 65 percent of the original investment. However, to reflect concerns that the market for large numbers of used machines may be limited. the residual value of the equipment has been lowered to 40 percent.

[9] *Hauni claims that it took five years to create Protos from scratch See Tobacco International December 22 1978 p 31*

Table 15. Innovation in Cigarette Manufacturing Equipment Performance

Cigarette Makers			Cigarette Packers		
Year	Make	Performance (Cigarettes per Minute)	Year	Make	Performance (Packs per Minute)
1963	Garant 1b	2,250	1964	Hauni KDW II	250
1972	Garant 4	3,000	1972	Neipman 50	325
1976	Mollins Mark 9/N	4,000	1975	Schemermund ES	350
1978	Protos	5,000	1977	Schemermund NB	400
	Mollins Mark 9/5	5,000	1982	Mollins HCP 5	425
1982	Protos 1	6,000	1983	Neipman 50	450
1984	Protos 2	8,000		Mollins SP1	350
	Mollins Mark 10	8,000			

Source: E. Rittershaus. "Modern Aspects of Production in the Cigarette Industry." Tobacco Journal International, May 1984, p. 422.

Equipment Modifications vs. New Equipment Replacement Strategies

Equipment-related strategies for changes in cigarette circumference consist of either modifying the cigarette manufacturing equipment or purchasing new equipment if the modification costs are prohibitive. This section estimates the costs of equipment replacement or modification under two alternative implementation scenarios. In the first scenario the implementation is instantaneous and the manulacturers either modify the existing equipment or replace the existing equipment within the first year of implementation. In a second scenario, a 4-year grace period is allowed, so that manufacturers replace the equipment in the fifth year.

Since cigarette manufacturing machines are replaced over a 7-year period It is estimated from Table 16 that the average cigarette maker in operation in 1986 is capable of performance at 6 000 cigarettes per minute[10] On the basis of this average performance the equipment replacement needs may be estimated for the 1985 production level as follows

	1985
Production level (billions of cigarettes)	662 0
Average Performance of Cigarette Maker/Plug Maker (cigarettes per minute)	6000 0
Annual Hours (3 shifts per day @ 8 hoursishift @ 250 days)	6000 0
Manfacturing efficiency rate (%)[11]	70
Number of Cigarette Makersiplug Makers	438

[10] 6,000 cigarettes per minute correspond to the average performance of cigarette making machines during the period 1978-1985, according to the figures presented in Table 15

[11] The efficiency rate comes from Max Samfield "Effect on Mahrng Machine and Process Variables on the Filling Power of Tobacco Part I" Tobacco Journal International, April, 1980. p 356

Table 16. Capital Expenditures In New Plant and Equipment in the Cigarette Manufacturing Industry — 1974-1986

	Capital Expenditures (millions of current dollars)	Real Capital Expenditures (millions of 1972 dollars)
1974	$ 147.3	$ 127.9
1975	102.3	81.3
1976	98.3	74.3
1977	118.0	84.2
1978	166.9	110.9
1979	194.2	118.8
1980	326.0	182.7
1981	578.9	295.9
1982	(D)	198.5p
1983	570.0	264.7
1984	---	312.3p
1985	---	367.9p

Note: (D) represents information not available because of disclosure problems.

p denotes projected real capital expenditures.

Source: The capital expenditures in current dollars come from the U.S. Census of Manufacturers. The real capital expenditures represent current capital expenditures deflated to 1972 dollars with the GNP Implicit Price Deflator. Years 1982, 1984, and 1985 were projected from past trends.

Table 17. Age of Equipment in the Cigarette Industry – 1979-1985

Year	Percent of Real Capital Expenditures 1979-1985	Cumulative
1979	6.9	6.9
1980	10.5	17.4
1981	17.0	34.4
1982	11.4	45.8
1983	15.2	61.0
1984	17.9	78.9
1985	21.1	100.0
	100.0	

Table 18 compares the costs of equipment modifications, (annualized over the 4½ years of their remaining service lives) and the costs of new equipment (annualized over the seven years of equipment life of new equipment) for the instantaneous implementation scenario. Since the capital costs of equipment modifications and/or new equipment purchases are one-time non-recurrent costs, these costs need to be annualized over the remaining lives of the equipment. This is accomplished by multiplying the capital costs of equipment modifications by their respective capital recovery factors

The capital recovery factors, which are conventional to engineering economy analysis, are a procedure used to annualize capital costs. The capital recovery factors when multiplied by the capital investment (minus its residual value) results in the annual end of year depreciation and interest expenses corresponding to the capital expenditure. Capital Recovery Factors (CRFs) corresponding to eight percent interest rates are used throughout this study.[12]

The original equipment. whose average vintage appears to be 2½ years (see Table 17) is assumed to hold a 40 percent residual value. implying that there is an overseas market for the current equipment. For the sake of conservativism, cost estimates which assume no residual value of equipment are also presented in Table 18. In any case. the optimal instantaneous strategy is to modify the equipment. conclusion reinforced by the fact that the costs of the new equipment do not include the costs of installation which as mentioned earlier include labor during seven shifts per machine type Installation costs are not included in Table 18 because they are superfluous to the conclusion that the optimal implementation option in the short run is to modify the existing equipment

Equipment Costs During the 4-Year Grace Period

If a grace period of 4 years is allowed to the cigarette manufacturers the equipment replacement strategy is presented in Table 19 Normal replacement is estimated by dividing the equipment replacement needs of 438 machines into the seven years of service lives The incremental costs of equipment replacement are the replacement costs in excess of normal replacement The replacement costs under a 4 year grace period are smaller than the costs of instantaneous implementation as shown in Table 19

Equipment Costs Under Instantaneous Implementation

Under the scenario of instantaneous implementation of regulations for reducing cigarette ignition propensity, the strategy assumed is one of modifying the equipment during the first year of implementation. saving the equipment replaced under normal replacement policy during that year. The results are shown in Table 19.

[12] *The formula for the estimation of the capital recovery factors is given by*

$$CRF = \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

where i = *annual interest rates*
n = *interest rates econonmic lives of equipment (in years)*

Table 18. Costs of New Machines Vs. Costs of Equipment Modifications Under Instantaneous Implementation — 1986
(Per Machine)

	Cigarette Maker/Plug Maker Circumference Changes:		Cigarette Packers Circumference Changes:	
	From 25mm to 23mm	From 25m to 22-20mm	From 25mm to 23mm	From 25mm to 22-20mm
Strategy A: Equipnent Modifications				
A.l Capital Costs of:				
Parts	$ 89,100	$135,000	$ 99,000	$162.000
Labor	2,838	4,052	3,650	5.272
Interest on Idle Machines	508	720	704	1,023
Extra Machines	9,247	10,788	9,589	12,329
	$101,693	$150,560	$112,943	$180.624
A.2 Annualized Costs[b]	$ 27.792	$ 41,148	$ 30.867	$ 49,364
A.3 Annualized Costs per 1.000 Cigarettes	$ 0.018	$ 0.027	$ 0.020	$ 0.033
Strategy B: Purchase of New Machines				
B.1 Capital Costs				
Assuming no residual value of original equipnent	$675,000	$675,000	$600,000	$600,000
Assuming 40% residual[a] value of original equipment	405,000	405,000	360,000	360,000
B.2 Annualized Costs[c]				
Assusing no residual value of original equipment	$129,647	$129,647	$115,242	$115,242
Assuming 40% residual value of original equipment	77,788	77,788	69,145	69,145
B.2 Annualized Costs per 1,000 Cigarettes				
Assuming no residual value of original equipment	$0.086	$0. 086	$0.076	$0.076
Assuming 40% residual value of original equipment	$0.051	$0.051	$0.046	$0.046

[a] Estimated as: $\begin{pmatrix}\text{New}\\\text{Equipment}\\\text{Cost}\end{pmatrix} - \left[(\text{Proportional Residual Value})\begin{pmatrix}\text{Original}\\\text{Equipment}\\\text{Cost}\end{pmatrix}\right]$

[b] Annualized at CRFs of i = 8 psecent, n = 4 1/2 years (CRF = 0.2733)

[c] Annualized at CRFs of i = 6 percent, n = 7 years (CRF = 0.19207)

Total Costs of Circumference Changes

The total incremental costs of circumference changes are presented in Table 20. In this table, the increased costs of equipment are compensated by the reduction in tobacco and paper costs, with the net result being reductions in cigarette costs as the circumference is decreased. The costs of circumference changes are driven by the tobacco requirements presented in Table 9. Table 21 summarizes the costs of circumference changes in terms of the cost components used in the economic impact model developed by the National Bureau of Standards,

Table 19. Incremental Costs of Replacing Cigarette Packers, Cigarette Makers and Plug Makers – 1986

		4-Year Grace Period			Instantaneous Implementation		
		No. of Cigarette Packers and Maker/Plug Machines to be Replaced			No. of Cigarette Packers and Maker/Plug Machines to be Replaced or Modified (M)		
Year		Under 4-Year Grass Period	Under Normal Replacement	Increments	Under Instantaneous Implementation	Under Normal Replacement	Increments
1		63	63	0	438(M)	63	375
2		63	63	0	63	63	0
3		63	63	0	63	63	0
4		63	63	0	63	63	0
5		438	63	375	63	63	0
6		0	63	-63	63	63	0
7		0	63	-63	63	63	0
8		0	63	-63	63	63	0
9		0	63	-63	63	63	0
10		0	63	-63	63	63	0
11		0	63	-63	63	63	0
12		0	63	-63	63	63	0
Present Value of Replacement/Modification Costs[a] (millions of 1986 dollars)	Maker/Plug Combination	$362.555	$336.125	$ 26.430	$359.545	$336.125	$ 23.420
	Packer	$322.270	$298.776	$ 23.492	$339.091	$298.776	$ 40.313
Present Value of Replacement Costs per 1,000 Cigarettes[b] (1986 dollars)	Maker/Plug Combination	$ 0.045	$ 0.042	$ 0.003	$ 0.045	$ 0.042	$ 0.003
	Packer	$ 0.041	$ 0.038	$ 0.003	$ 0.043	$ 0.038	$ 0.005

[a] Estimated assuming replacement costs of $675,000 per cigarette maker/plug maker and $600.000 per cigarette packer and discount rates of 8 percent. Equipment modification Costs are presented in Table 18.

[b] Estimated by dividing the present value figures by the production of Cigarettes during the 12-year period (12 years x 663 billion cigarettes per year).

Table 20. Summary of Costs Associated with Changes in Circumference – 1986
(Per 1,000 Cigarettes)

			Annualized Costs of New Equipment Purchases or Modifications		Total	
Changes from 25mm to:	Tobacco costs	Paper Costs	Instantaneous Implementation	4-Year Grace Period	Instantaneous Implementation	4-Year Grace Period
21	$-0.950	$0.024	$+0.008	$+0.006	$-0.966	$-0.968

Source: Tables 10, 18, 19,

Table 21. Summary of Incremental Costs Associated With Changes to 21mm Circumference – 1986 (Per 1,000 Cigarettes)

	Instantaneous Implementation		4-Year Grace Period	
Cost Components	Costs	As Percentage of Component Costs	Costs	As Percentage of Component Costs
Domestic Tobacco Leaf	$-0.607	-29.4%'	$-0.607	-29.4%'
Paper	-0.024	-16.0%'	-0.024	-16.0%'
Federal Excise Tax	0	0%	0	0
Other Costs	$-0.335	$-1.4%	$-0.337	- 1.4%
Total Costs	$-0.966	-2.9%	$-0.968	- 2.9%

[a] Estimated from Table 10.

4. Option 2: Use of Chemical Additives

This option entails adding chemical additives to the blend. Because of the need to develop cost estimates for the test case, it has been necessary to analyze a specific product proposal which consists of adding silica gel to the blend The silica gel additive patented by the 3M company, will be marketed under the label of Expantrol. All the cost estimates presented in this section refer to the Expantrol silica gel additive, the only product available currently.

The silica gel additive may be used in amounts ranging from 150 to 200 grams to 1,000 cigarettes. to decrease the propensity of cigarettes to stay lit. A dose of 150 grams per 1,000 cigarettes (3 grams per pack of 20 cigarettes) is recommended for average cigarette sizes. While the additive can weigh up to a fourth of the weight of the tobacco in the cigarette, the manufacturer indicates that the extra weight and volume of the chemical additive should not cause any significant technical problems for the structure and design of the cigarette Since the additive is much more dense than tobacco, the volume of the tobacco mixture will not increase noticeably. and thus the cigarette length will not have to expand. According to the manufacturer. the extra weight should not affect the cigarette manufacturing process either.

The additive can be mixed directly into the tobacco or be mixed with the casing which is later applied to the tobacco. The silica gel does not necessarily have to dissolve in the casing mixture (although if soluble would lead to a more efficient manufacturing operation), since the casing mixture acts solely as a vehicle to disperse the additive throughout the tobacco. The other method is simply to mix the chemical additive with the dry tobacco. The discussion that follows assumes that the amount of tobacco in the cigarette remains constant as the silica gel additive is added during the manufacturing process.

Material Costs

3M has set a target price of $2 00 per pound ($440 per kilogram) for the silica gel additive So far the manufacturer has not attached any extra fees such as a licensing fee or installment fee for the use of the patented Expantrol Thus the $440 per kilogram should represent the full coat of the silica gel additive as currently envisioned by the 3M company

Cigarette Manufacturing Costs

As mentioned earlier, there are two alternative methods for incorporating the chemical additives into the cigarette manufacturing process: one method consists of adding the silica gel in the casing process, its alternative is to add it during the blending process.

The cost of either method of applying chemical additives will be minimal as long as the cigarette manufacturers can integrate the processes into their present tobacco handling. Both methods would only require adding in silica gel additives during other processses already used by the manufacturers. In the casing option, the manufacturers would add the chemical additives to the casing solution, and in the direct option, the manufacturers would add the additives to the tobacco during the blending process. The manufacturers might incur some minor labor costs in adding the chemical additives to the manufacturing process, and in maintaining quality of their tobacco blends. Table 22 presents the extra staffing required per plant for incorporating chemical additives into the manufacturing process

Table 22. Labor Requirements of Adding Chemical Additives to the Manufacturing Process – Per Plant

Staff	Function/Role	No. per Shift
Operator	Adds Expantrol to casing or blending	1
Quality Assurance	Measures Expantrol levels	1
Purchasing Staff	Purchases Expantrol	1/2
Inventory Staff	Keeps inventory	1/4
Quality Assurance	Measures effect on tar/nicotine for labelling purposes	1
Supervisor	Supervises all aspects of Expantrol	1/4
TOTAL		4

Source: Selected interviews with cigarette manufacturers

Table 23. Costs of the Chemical Additives Option – 1986 Dollars (Per 1,000 Cigarettes)

			Total costs		
	Expantrol -Product Coats[a]	Extra Labor Costs in Cigarette Manufacturing	Amount	As percent of the Manufacturing and Other Cigarette Costs[b]	As Percent of Cigarette Wholesale Price[c]
Expantrol Added to Casing Process or Blending Process	$0.66	0.007	$0.667	2.83%	1.98%

[a] Assuming 150 grams per 1,000 cigarettes and Expantrol price of $2.00 per lb.

[b] Excludes the costs of domestic leaf tobacco. paper and Federal exise tax.

[c] Assuming wholesale prices of $33.75 per 1,000 cigarettes.

Given 750 shifts per year per plant, and an annual cigarette production of 662.0 billion, the following expression estimates the cost of adding chemical additives per 1,000 cigarettes.

Increased Labor Manufacturing Costs per 1000 Cigarettes =

$$\begin{pmatrix}\text{Persons}\\\text{Per}\\\text{Shift}\end{pmatrix} \times \begin{pmatrix}\text{No. of}\\\text{Annual}\\\text{Shifts}\\\text{Per}\\\text{Plant}\end{pmatrix} \times \begin{pmatrix}\text{No.}\\\text{of}\\\text{Plants}\end{pmatrix}$$

$$\times \frac{\begin{pmatrix}\text{Hours}\\\text{Per}\\\text{Shift}\end{pmatrix} \times \begin{pmatrix}\text{Cigarette}\\\text{Manufacturing}\\\text{Hourly Wage}\end{pmatrix}}{\text{(Annual Cigarette Production) } 1{,}000}$$

$$= \frac{(4) \times (750) \times (13) \times (8) \times (15.84)}{662{,}000{,}000} = \$0.007$$

No overhead costs have been added since the staffing already included supervisory time The hourly wage in cigarette manufacturing comes from the Bureau of Labor Statistics and corresponds to June 1986 These relative small increases in cigarette manufacturing costs are added to the Expantrol product costs in Table 23

Total Costs

The total costs of the chemical additives option are presented in Table 24. Adding chemicals to the blend results in cost increases of approximately two percent of the wholesale cigarette price.

At the moment there appear to be technical problems with the incorporation of chemical additives. such as Expantrol into the blend. The granular particles of Expantrol do not stick to the tobacco and leave an acid or pungent taste on the cigarette smoker. Other efficiency-related problems surfaced in manufacturing trials at low manufacturing speeds. Our assumption in the analysis is that further refinement of the chemical additives option is possible, leading to lower granular sizes and mixing into soluble additives at negligible extra costs, Analysis of the taste and health consequence of chemical additives, such as Expantrol, are outside of our scope of work. The reader is reminded that the scope of this study does not include technical evaluations of the Expantrol product.

5. Option 3: Use of Expanded Tobacco

Background on Technology

The expanded tobacco option consists of greater use of industrial processes available for decreasing the density of tobacco. Dr. Max Samfield decribes the expanded tobacco processes as immersing the tobacco leaf in a highly volatile liquid and then subjecting this tobacco-liquid mixture to a zone of high temperature.[13] These processes. in commercial use since 1968, result in decreasing the density or increasing the filling power of the tobacco, thereby increasing the amount of cigarettes that may be produced from a given tobacco weight.

The use of expanded tobacco has been increasing in recent years spurred by the trend toward lower tar and nicotine cigarettes. Sarnfield claims[14] that the most usual amount of expanded tobacco found in American cigarettes is 20-25 percent. Indeed in some brands the weight of expanded tobacco is over 80-90 percent of the tobacco weight in the cigarette. The increased use of the expanded tobacco has resulted in improvements in the profit picture of the cigarette manufacturers, as less tobacco leaf is needed, and in reductions in tar and nicotine contents

The use of expanded tobacco processes is common occurrence in most plants. R.J. Reynolds Tobacco company has licensed about 25 plants in 11 countries to use its patented G-13 process. The Reynolds process uses a volatile organic liquid Freon 11 or trichloromonofluoromethane as the impregnant. Plants are available in the following sizes. 400, 1,000, 2,500, and 5,000 lbs/hour. In addition, a large 15,000 lb per hour facility was opened in Winston-Salem in 1984.[15]

Phillip Morris licenses a competing expanded tobacco process referred to as the "Dry Ice Expanded Tobacco! process or DIET. Approximately 15 DIET plants have been licensed ranging in size from 400 to 800 lbs per hour The DIET process involves the impregnation of tobacco with liquid carbon dioxide

[13] *Max Samfield "Improving Cigarette Yields with Expanded Tobacco" iobacco Journal International, May 1981, p 388*

[14] *Ibid, p 391*

[15] *See the discussion in Max Samfield "New Surge of Activity in Expanding Tobacco Research" Tobacco Journal International, March. 1986, p. 200*

Effect of Expanded Tobacco on Cigarette Yields

The cigarette yield will vary as a function of the degree of expansion of the tobacco blend component as well as the percent of that component in the blend

The filling power of a blend is the sum of the filling powers of the individual constituents time their weight fraction in the blend If the tobacco component to be expanded has initially the same filling power as the cigarette blend with which it will ultimately be mixed the following expression developed by Max Samfield[16] estimates the relative cigarette yields

Relative Yield =

$$\left[1 + \frac{E}{100}\right]\left(\frac{B}{100}\right) + \left[1 - \frac{B}{100}\right]$$

where

E = percent tobacco expansion

B = percent expanded tobacco in the blend

The above equation assigns a filling power of unity (Relative Yield = 1) to the initial blend This formula is used next to estimate the leaf tobacco requirements and costs

Costs of Expanded Tobacco

The incremental costs of using expanded tobacco include leaf costs along with increased investment and operating costs of the tobacco expansion process

[16] *Max Sarnfield Op Cit May 1981 p 390*

Table 24. Typical Blend Composltion

Individual Constituents	Weight Percent in Blend[a] (%)	Import Components in the Blend[b] (%)
Flue-cured Tobacco	34.92	20.9
Burley Tobacco	32.35	28.9
Reconstituted Tobacco	20.00	34.1
Oriental Maryland Tobacco	12.73	83.4
TOTAL	100.00	100.00

[a] Estimated by dividing the domestic tobacco weight presented in Table 6 by the proportion of domestic components in the blend. Reconstituted tobacco is assumed to be 20 percent.

[b] These figures come from the U.S. Department of Agriculture. Economic Research Service. Tobacco Outlook and Situation Report, Report TS-194, March, 1986, p. 14.

Tobacco Leaf Requirements

The tobacco leaf requirements are estimated from the relative yield formula, after specification of the percent of tobacco expansion and the proportion of expanded tobacco in the blend. The weight fraction of individual constituents in the blend assumed are shown in Table 24:

Two of the above components: reconstituted tobacco and oriental tobacco cannot be expanded. Flue-cured tobacco IS 100 percent expanded, and the resulting expanded flue-cured tobacco is mixed back in with other non-expanded flue-cured tobacco. The same is true of burley tobacco whose maximum expansion is 80 percent, but which is also mixed back in with other non-expanded burley.[17]

Since only flue-cured and burley tobacco can be expanded, the percent expansion of the expanded tobacco in the blend is estimated by weighing the percent expansion of the two constituents by their relatively proportions in the expanded blend. Table 25 estimates the leaf requirements of the expansion process for several levels of expanded tobacco in the blend In the results presented in Table 25. the relative weight proportions of the components in the blend are kept constant, that IS, the expanded tobacco IS mixed in with non-expanded flue cured and burley tobacco Following Samfield, the current average percentage of expanded tobacco in the blend is assumed to be 25 percent

Tobacco Leaf Costs

Tobacco leaf costs include the purchased leaf costs and the carrying, processing and storage costs (including stemming). These two cost items are kept separate because of the analytical needs of the economic impact model developed by the National Bureau of Standards.

The following formula is used to estimate the purchased leaf cost savings using the prices and weight relationships presented in Table 6.

[17] The source of these figures on expanded tobacco is the telephone conversation of February 20, 1987 with Dr. Alexander W. Spears ill. Executive Vice President for Operations and Research, Lorillard, inc.

Table 25. Relative Yields and Expanded Tobacco Used

(Weights expressed in lbs of unstemmed tobacco per 1,000 cigarettes)

			By Type of Expansion		By Component in the Blsnd			
Percent Expanded Tobacco In Blend[a] (B)	Relative Yield[a]	Total Weight	Expanded Tobacco	Un-Expanded Tobacco	Flue-cured	Burley	Reconstituted	Oriental and Maryland
0	1.0	2.084	a	2.084	0.728	0.674	0.417	0.265
25*	1.22	1.708	0.427	1.281	0.596	0.553	0.342	0.217
50	1.45	1.437	0.7185	0.7185	0.502	0.165	0.287	0.183

[a] Estimated from the relative yield equation.

[b] Represent current average conditions for the cigarette manufacturing Industry.

Table 26. Changes in Tobacco Leaf Costs from Doubling Expanded Tobacco Use"

(Per 1,000 Cigarettes)

	Flue-Cured		Burley		Maryland/Oriental		Reconstituted			Total
	Domestic	Imports	Domestic	Imports			Domestic Leaf	Imported Leaf	Industrial Operations[b]	
Unstemmed Tobacco Changes (lbs)	-0 074	-0 020	-0 063	-0 025	-0 006	-0 028	-0 036	-0 019	-0 055	-0 271
Farm Sales Weight / Unstemmed Processing Weight	-1.119	1.0	1.122	1.0	1.0	1.0	1.115	1.0	1.0	Not Applicable
Leaf Prices Paid and Costs Incurred[c]	$1.719	$1.03	$1.594	$0.90	$1.320	$1.54	$1.649	$1.48	$0.348	Not Applicable
Cost Changes	$-0.142	$-0.021	$-0.113	$-0.023	$-0.008	$-0.043	$-0.066	$-0.028	$-0.019	$-0.463

[a] This scenario corresponds to a doubling of the percentage of expanded tobacco in the blend from 25 to 50 percent

[b] Estimated by dividing the reconstituted tobacco costs presented in Table 4 by the reconstituted tobacco quantities presented in Table 24.

[c] Leaf prices for imports come from Tobacco Outlook and Situation Report. Report IS-192. September 1985, p. 14. The domestic prices come from Table 6

(Changes in Purchased Leaf costs) = (Changes in Unstemmed Processing Weight From Expanded Tobacco) x (Farm Sales Weight/Unstemmed Processing Weight Ratio) x (Leaf Paid to Farmers/ Importers)

Table 27. Capital Costs for Expanded Tobacco Processes – 1986
(facility, equipment, and installation costs)

Capacity lbs. per Hour	Type of Plant	Total Capital Costs	Annual Capital Costs per lb. of Expanded Tobacco[c]
1,500	Integrated[a]	$ 8,000,000	$0.129
6,000	Integrated[a]	15,000,000	0.061
6,000	Free standing[b]	41,000,000	0.166

[a] Integrated plants denote those that use tobacco filler produced elsewhere in the processing lines within the same manufacturing facility.

[b] Free standing plants denote those that use the tobacco leaf as inputs and must produce tobacco filler as the input into the tobacco expansion, with their expanded tobacco output transported to cigarette manufacturing plants.

[c] Estimated using capital recovery factors corresponding to 20-year lives and eight percent interest rates (CRF = 0.10185), and manufacturing efficiency rates of 70 percent.

Source: Selected interviews with industry representatives.

The purchased leaf cost savings generated by the use of expanded tobacco are presented in Table 26. There is scant information available in the literature on the costs of reconstituted tobacco. Moshy[18] estimates costs of reconstituted tobacco as $0.15–$0.20 per lb. in 1965. The cost figures presented in Table 26 presume a doubling of these costs.

Capital Costs of Expanded Tobacco

As discussed by Samfield,[19] the use of expanded tobacco is widespread throughout the industry. facilitated by the numerous plant sizes available. Since 1986, R.J. Reynolds has licensed a 400 lbs. per hour compact version of their G-13 process which can be made portable to suit the needs of manufacturers with low volume productions. In view of the modular characteristics of expanded tobacco process and its widespread use, only incremental additions to capacity are costed.

Table 27 presents the capital costs, including facility and equipment costs and installation costs, for several types of plants and capacities. For the ease of the analysis to be conducted, the costs analyzed are those of integrated plants, not an unreasonable assumption considering the modularity and ease of adapting plant capacities for manufacturing expanded tobacco.

[18] Raymond J. Moshy "The Technology and Economics of Reconstituted Tobacco Leaf. Part II" Tobacco, Vol. 160, No. 2, January 8, 1976, p. 16

[19] Max Samfield, Op. Cit. May, 1981, p. 391

Table 28. License Fees for Tobacco Expansion Processes

Patent Holder	Process	License Fees
Philip Morris	DIET	$0.10 per lb. for under 20 million lbs. of expanded tobacco
		$0.05 per lb. above 20 million lbs. of expanded tobacco
R.J. Reynolds	G-13	$0.12 per lb. for under 15 million lbs. of expanded tobacco
		$0.09 per lb. for under 15 million lbs. of expanded tobacco

Source: Selected interviews with cigarette manufacturers.

Licensing Fees

The two main industrial processes in use: the DIET and G-13, are licensed at several plant sizes. The licensing fees presented in Table 28 depend on total output and not on individual plant sizes. Given that the task at hand is to estimate incremental costs, the marginal licensing fees are estimated at between $0.05-$0.09 per lb. range, that is, in the lower rate step function. The reason for this is that the U.S. production of expanded tobacco exceeds the limits for the break in the licensing rates. An average of $0.07 per lb. has been used to estimated licensing costs.

In addition to these licensing fees, the patent holders for the processes also offer a training/technical assistance package of $0.5 million. These costs have not been considered since these packages are purchased mostly overseas. Given the widespread use of expanded tobacco in the U S. there appears no need to include these costs.

Labor Requirements and Costs

Labor requirements vary depending on the nature and capacity of the expanded tobacco plant These labor requirements are presented in Table 29 The labor costs per lb of expanded tobacco are also presented in Table 29

The labor costs use average hourly wages of $15 84 per hour as of June 1986 and 6,000 hours of plant operation per year Again manufacturing efficiency rates of 70 percent are assumed following Dr Max Samfield's writings [20]

Other Operating Costs

In addition to the labor and licensing costs, other operating costs include electricity and oil heat costs. The requirements of electricity range from 0.09-0.155 kilowatt hours per kilogram of tobacco saved, while residual oil No 5 for heating purposes was estimated as ranging from 0.085-0 15 liters of residual or/per kilogram of tobacco saved

These costs have been evaluated in Table 30 at September. 1986 prices of 4.99 cents per kilowatt hours and 28.1 cents per gallon for the wholesale price of residual oil No. 5 [21] The resulting costs of electricity and residual oil are 1.89 cents per kg. of tobacco saved.

[20] Max Samfield 'Effecl of Making Machine and Process Variables on the Filling Power of Tobacco Part I " Tobacco Journal International, April, 1980, p 356

[21] U.S Department of Energy. Monthly Energy Review Selected ISssues. 1986

Table 29. Labor Requirements and Costs for Tobacco Expansion Processes

Type of Plants	Integrated	Integrated	Free Standing
Capacity (lbs. per hour)	1,500	6,000	6,000
Staff Type:	Number of Staff per Shift		
Manager	0	1/3	1/3
Superintendents	2/3	1	1
Supervisors	2	2	3
Trained Operators	4	4	7
Substitute Operators	4	4	7
General Labor	2	3	5
Cleaners	3	6	6
Drivers	0	2/3	2
Back-up Drivers	0	0	2/3
TOTAL	15 2/3	21	32
Labor Costs per lb. of Expanded Tobacco	$0.236	$0.079	$0.120

Source: Selected interviews with cigarette manufacturers.

Cost Summary

The total incremental costs associated with the use of expanded tobacco are presented in Table 31. As a consequence of the increased use of expanded tobacco costs, decreases in costs amounting to 1.0 percent of the cigarette wholesale price are realized. While the use of expanded tobacco affects the taste of cigarettes, these effects are outside the scope of this study

A final comment concerns the impact of the compliance period for effecting the required changes to reduce cigarette ignition propensity. The lack of industrial capacity available for doubling the rate of use of expanded tobacco makes it impossible to effect these changes in the short run. A grace period of 3-4 years is required for this option.

Table 30. Incremental Costs of Expanded Tobacco — 1986
(per *1,000* Cigarettes)

Percent Expanded Tobacco in Blend (B)	Incremental in Costs Over the Current 25 Percent Expanded Tobacco in Blend						
	Purchased Leaf Costs		Capital Costs of Facility and Equipment	Licensing Fees	Labor costs	Electricity and Residual Oil Costs	Total
	Domestic Leaf costs	Other Tobacco costs					
25	--		--	--	--	--	
50	-0.263	-0.200	+0.018	+0,020	+0.023	+0.002	-0.400

* Represents current conditions in the industry

Table 31. Summary of Incremental Cost Changes of Expanded Tobacco — 1986
(per 1,000 Cigarettes)

	Incremental Costs from Doubling the Current 25 Percent Expanded Tobacco in Blend	
Cost Components	costs	As Percentage of Component Costs
Domestic Leaf Costs	$-0.263	-12.73%
Paper	0.0	0.0
Federal Excise Tax	0.0	0.0
All Other Costs	$–0.137	–0.65%
TOTAL	$–0.400	-1.16%

6. Option 4: Increase Paper Thickness

Cigarette Paper and Its Manufacturing

Paper use in cigarette manufacturing comes in 24-26 grams/m^2 basis weight with tensile strength of 3 kg. Its permeability varies substantially from 12 to 72 cm/min. cbar Coresta depending on cigarette design specifications. The cigarette paper is produced in bobbins of 24.5-28mm width and 6.000-9.000 meters length. Nearly 100,000 cigarettes are manufactured per bobbin of cigarette paper.

Samfield[22] provides the description of the manufacturing process described next. The basic raw material in the production of cigarette paper is flax straw, or fibers that are a by-product of the linen seed harvested for linseed oil. The flax straw passes through the following industrial operations at the paper plant: 1) decortication, 2) pulping, 3) bleaching, 4) beating and refining. 5) paper forming, 6) drying and impregnation and 7) slitting. Decortication involves the removal of the inner portion of the stalk and the flax plants, called shive flax. Pulping involves removal of lignin. pectin and hemicelluloses which are hound together with the flax. Pulp for cigarette paper uses the kraft system, which involves beating the tow with sodium hydroxide and sodium sulfide for several hours at temperatures exceeding 140°C. The bleaching process uses an aqueous solution of chlorine followed by sodium hydroxide and sodium hypochlorite.

After bleaching. the aqueous suspension of pulp is beaten for several hours in a Holland beater, a rotating cylinder studded with metal bars. After beating, calcium carbonate is added to achieve opacity and porosity, and next the fiber web is formed in the paper forming process by filtering the suspension of fiber and filler through wire screens. Next, the paper is dried through rotating steam-heated cylinders, after which alkali metal citrates are added *to* control the burning rate of the cigarette. The impregnated paper is then molded into rolls after being dried and next is cut into bobbins of finished paper

[22] *Max Samfield "cigarette Paper is an important ingredient." Tobacco Journal International, May, 1972, p. 390*

Methods Controlling for Porosity and Permeability

To achieve the desired porosity. calcium carbonate is added to the cellulose fibers after the beating and refining process. The calcium carbonate particles constitute 21-38 percent of the weight of the final paper. The permeability of the paper is controlled by adjusting the amount of calcium carbonate among other methods.

If an extreme degree of permeability is required. the cigarette paper is perforated by means of an electric spark at high voltages. The perforated holes have 20-50 microns of diameter, and their spacing and diameter determine the degree of permeability.

Raw Material Components

The raw material components of the cigarette paper are the flax fiber, the calcium carbonate and the alkali metal citrates among others Their relative proportions of the weight of the cigarette paper are as follows

	as Percent of Weight of Cigarette Paper	
Component	Range	Mean
Flax Fiber	62% – 72	67¼
Calcium Carbonate	21 – 38	29½
Alkali Metal Citrates	05 – 20	125
Miscellaneous	2	2

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Paper Thickness Options

The paper options *to* be costed include increasing the basis weight of the cigarette paper from the conventional basis weight of 24 grams/m² to basis weights corresponding to a doubling of cigarette paper thickness. Since a doubling of the cigarette paper results in an 8-fold increase in stiffness (with its concommitant manufacturing problems), the following equation, from Ecusta sources,[23] was used to develop specifications of heavy weight paper comparable to doubling paper thickness:

$$T = A\,(BW) + b$$

where

T = cigarette paper thickness (mm)
BW = basis weight (g/m²)
A = .00136mm m²/g (experimentally determined)
b = .00176mm (experimentally determined)

According *to* the above formula, a doubling of paper thickness would correspond to basis weight of 49 grams/m². However, given that Ecusta has developed heavyweight paper of 45 grams/m², it was decided to take advantage of this opportunity and analyze heavyweight paper of 45 and 32 grams/m².[24]

Ecusta claims that its heavyweight cigarette paper comprised of flax and calcium carbonate can obtain equal desired puff counts and ashing characteristics as conventional basis cigarette paper after addition of burning chemicals. In addition, the firms claims that "heavyweight cigarette papers offer improved quality parameters. including enhanced opacity, appearance, tensile, and puncture resistance. Additionally, cigarettes exhibit improved rod firmness at equivalent rod weights. The increased thickness and stiffness of heavyweight cigarette paper can lead to significant cost reductions by decreasing tobacco weight and/or increasing utilization of expanded tobacco."[25] These two heavyweight paper sizes are costed out next.

[23] *Ecusta. "Ecusta Heavyweight Cigarette Papers." Pisgah Forest, North Carolina, April, 1976.*

[24] *The 32grams/m² paper corresponds roughly* to *one of the Kimberly Clark models (KC-1) currently under testing at the National Bureau of Standards. A second Kimberly-Clark model (KC-2) which uses 6mm wide strips of dense non-pourous paper spaced 36mm apart along the cigarette's length, has been termed by the Kimberly-Clark* to *be non-manufacturable in the near and medium term.*

[25] *Ecusta, Op.* Cit.. *page 2*

Incremental Cost *of* Increased Paper Thickness

The costs associated with changes in paper thickness include changes in paper manufacturing costs (including costs for adjusting porosity/permeability) and cigarette manufacturing costs including requirements for increased adhesives, and paper bobbin changes, among others. At the outset, it should be recognized that no changes in tobacco weight are contemplated in the change in paper thickness. At the same time, it is desired to hold constant other factors that influence taste.

Cost Structure

The manufacture of cigarette paper is highly specialized; only a small number of paper mills devote themselves to this paper manufacturing endeavor. A detailed cost structure similar to the one developed for cigarette manufacturing in Chapter 2 is unavailable due to the small number of cigarette paper manufacturers and the confidentiality of the industry.

Instead, the cost analysis of the paper thickness options relies on some basic cost facts about the paper industry published in the literature26 and summarized in Table 32. One important fact is the assumption that 59.3 percent of the supply price of paper products corresponds to variable operating costs, with capital costs accounting for 32.2 percent of the supply price. These assumptions regarding the relative proportions of operating and capital costs are used in the cost analysis presented in this chapter,

Paper Manufacturing Costs

The cigarette paper manufacturing costs include both operating and capital costs. At present increases in paper thickness cannot be accommodated without significant increases in the capacity of the cigarette paper industry. Cigarette manufacturing peaked in 1981. when 736.5 billion cigarettes were manufactured for domestic consumption and export. As of June 30, 1986, the cigarette production was 89.3 percent of peak 1981 production rate,[27] denoting a 10.7 percent available capacity for accommodating increases in paper requirements due to increases in cigarette paper thickness. The extra capacity requirements of increased paper thickness are presented in Table 33.

[26] *These proportions of capital and operating costs come from both Barry Bosworth "Activity Creation in Basic-Materials Industries." Brookings Papers on Economic Activity, Vol. 2: 1976, and from Brookhaven National laboratory. A Process Model of the U.S. Pulp and Paper Industry, long Island, New York, April, 1980.*

[27] *The cigarette production figures come from the U.S Department of Agriculture. Economic Research Service. Tobacco: Situation* ***and*** *Outlook Report, TS-195, June, 1986.*

Table 32. Relative Cost Structure of Pulp and Paper Industry - 1975

Operatine Costs	59.3%
Fiber	14.8%
Other Raw Materials	13.8%
Direct Labor	7.6%
Energy	3.6%
Overheads	8.3%
Environmental and OSHA Expenses	1.9%
General Sales and Administrative Expenses	9.3%
Capital Costs	32.2%
Plant Facility and Equipment	27.6%
OSHA-related Equipment	0.7%
Pollution Abatement Equipment	3.9%
Interest on Working Capital	2.0%
Net Incomes	6.5%
	100.0%

Sources: Energy and raw materials costs come from Brookhaven National Laboratory. A Process Model of the U.S. Pulp and Paper Industry. Prepared for the U.S. Department of Energy, April, 1980.

The net income proportions come from the Internal Revenue Service. Statistics of Income. Corporation Income Tax Returns, 1981.

All other costs come from Barry Bosworth "Capacity Creation in Basic Material Industries." Brookings Papers on Economic Activity, Vol. 2, 1976, p. 320.

Operating Costs

The estimation of the operating costs relies on the assump tion documented in Table 32, that 593 percent of the supply price of cigarette paper are operating costs If the increases in operating costs are assumed to be proportional to the basis weight of paper then the changes in basic manufacturing costs of cigarette paper may be estimated as

Table 33. Changes in Cigarette Paper Industry Capacity Requirements – 1986

Changes in Basis Weight to (1)	Increased Paper Production Requirements (2)	Available Industrial Capacity (3)	Incremental Capacity Requirements (4) = (2) - (3)
32 grams/m^2	33.3%	10.7%	22.6%
45 grams/m^2	87.5%	10.7%	76.8%

[a] Estimated in reference to the 1981 peak of cigarette paper production level.

$$\left(\begin{array}{c}\text{Incremental Operating Costs}\\ \text{of Cigarette Paper}\\ \text{per 1,000 Cigarettes}\end{array}\right) =$$

$$\left(\frac{\Delta BW}{BW_o}\right) \times \left(\begin{array}{c}\text{Proportion}\\ \text{Operation}\\ \text{Costs}\end{array}\right) \times \left(\begin{array}{c}\text{Costs of}\\ \text{Paper per}\\ \text{1,000 Cigarettes}\end{array}\right)$$

where:

$$\left(\frac{\Delta BW}{BW_o}\right) = \text{ratio of increase in basis weight to the conventinal basis weight of 24 grams/m}^2$$

At paper costs of $0 17 per 1,000 cigarettes (see Table 5), the incremental basis costs of manufacturing cigarette paper are $0 04 (for the 32 grams/$m^2$ heavyweight paper) and $0 105 (for the 45 grams/$m^2$) These basic costs must be modified by the specialized processes for increasing the porosity/ permeability of the heavyweight paper

Capacity Costs

As estimated earlier in Table 33, increases in capacity ranging from 22 6 to 76 8 percent are required by the paper thickness options analyzed The following formula is used to estimate the capital costs

$$\left(\begin{array}{c}\text{Incremental Capital Costs}\\ \text{of Cigarette Paper}\\ \text{per 1,000 Cigarettes}\end{array}\right) =$$

$$\left(\begin{array}{c}\text{Proportion}\\ \text{Incremental}\\ \text{Capacity}\\ \text{Requirements}\end{array}\right) \times \left(\begin{array}{c}\text{Proportion}\\ \text{Capital}\\ \text{Costs}\end{array}\right) \times \left(\begin{array}{c}\text{Costs of}\\ \text{Paper per}\\ \text{1,000}\\ \text{Cigarettes}\end{array}\right)$$

At capital cost proportions of 0.322 (see Table 32) and paper costs of $0.17 per 1,000 cigarettes, the incremental capital costs due to increased capacity are $0.012 per 1,000 cigarettes for the paper with 32 grams/m^2 basis weight and $0.042 per 1,000 cigarettes for the heavier paper with 45 grams/m^2 basis weight.

An Alternative Approach

Ecustas marketing materials. already referred to present a cost formula for estimating the cost changes due to increasing the basis weight of cigarette paper The Ecusta formula is [28]

$$\left(\begin{array}{c}\text{Cost Change}\\ \text{per}\\ \text{Billion Cigarettes}\end{array}\right) = 2.2046\,(\Delta BS)(L)(W)(C_p)$$

where.

ABW = $(BW_h - BW_l)$ or difference in cigarette paper basis weight in grams/m²
L length of cigarette paper (or tobacco column, in rnm
W width of paper bobbin. in mm.
C_p cost of paper per lb.

Assuming conventional values of 65mm paper length, paper width of 27.5mm and cigarette paper costs of $1.75 per lb.. increases in basis weight from the conventional 24 grams/m² to 32 and 45 grams/m² result in cost increases of $0.055 and $0.145 respectively per 1,000 cigarettes. That is. the Ecusta marketing materials assume cost increases proportional to the basis weight of the cigarette paper.

Adjustments for Porosity

To the earlier basic cigarette paper manufacturing costs. we must add the cost of special adjustments for porosity. One adjustment would involve doubling the amount of calcium carbonate in the paper, amount which now constitutes 29% percent of the weight of the paper.

Assuming a basis weight of 24 grams/m² for the cigarette paper, and length and widths of 65mm and 27.5mm respectively, the weight of the cigarette paper is estimated as 0.09438 lbs. per 1,000 cigarettes.[29] The increased costs of doubling the calcium carbonate in the paper to increase porosity is estimated from the following equation.

$$\left(\begin{array}{c}\text{Increase in Calcium}\\ \text{Carbonate Costs per}\\ \text{1,000 Cigarettes}\end{array}\right) = \left(\begin{array}{c}\text{Weight of}\\ \text{Cigarette}\\ \text{Paper in lbs.}\\ \text{per 1,000}\\ \text{Cigarettes}\end{array}\right) \times \left(\begin{array}{c}\text{Proportion}\\ \text{Calcium}\\ \text{Carbonate}\\ \text{Cigarette}\\ \text{Paper Weight}\end{array}\right) \times \left(\begin{array}{c}\text{\% increase in}\\ \text{Calcium Carbonate}\\ \text{1,000 Cigarettes}\\ \hline 100\end{array}\right) \times \left(\begin{array}{c}\text{Price}\\ \text{Calcium}\\ \text{Carbonate}\\ \text{per lb.}\end{array}\right)$$

Assuming 100 percent increases in calcium carbonate and a price of $0 50 per lb the following cost increment per 1 000 cigarettes results

$$\left(\begin{array}{c}\text{Increase in Calcium}\\ \text{Carbonate Costs per}\\ \text{1,000 Cigarettes}\end{array}\right) = (0.09438)(0.295)\left(\frac{100}{100}\right)(0.50) = \$0.0139$$

In addition to the adjustment in calcium carbonate, another possible adjustment in permeability concerns the use of electrostatic or microlaser perforating equipment to achieve high degrees of permeability in excess of 70 Coresta. Comparisons of the costs of cigarette paper reveals a premium of $3.00 per bobbin of highly permeable paper [30] This permeability premium gets translated into an extra cost of $0.03 per 1,000 cigarettes (assuming 100,000 cigarettes per bobbin)

In conclusion. adjustments for permeability/porosity will increase the costs of cigarette paper by $0.014 to $0.03 per 1,000 cigarettes depending on the method chosen to make the necessary adjustments for porosity/permeability

Cigarette Manufacturing Cost Changes

In addition to the costs of cigarette paper increases in paper thickness creates some unique manufacturing prob

[28] *Ecusta, Op Cit , page 2*
[29] *See the formula presented in Table 5*

[30] *We owe this observation to Dr William Selke formerly Vice President Group R&D of the Kimberly Clark Corporation*

lems with their concommitant increases in manufacturing costs These manufacturing problems concern the need for increased amounts of adhesives more frequent changes in paper bobbins increases in flavoring and finally the possible slowing down of cigarette manufacturing equipment speeds

Increased Amount of Adhesives

The heavier or thicker the paper the greater the need for adhesives. Table 5 presents the current cost of adhesives. Doubling the amount of adhesives will add 0.043 per 1,000 cigarettes.

Interview responses with equipment manufacturers revealed the use of different practices regarding paper bobbin changes. Equipment manufacturers claim a waste loss of 20 cigarettes per bobbin change, but they also claimed that some machine operators slow down the equipment to half the operating speeds during ten second periods for the purpose of effecting bobbin changes. Each of these alternatives is costed out next

Assuming current production levels of 662.0 billion cigarettes and bobbin lengths corresponding to 100,000 cigarettes per bobbin, the number of bobbin changes per year amounts to 6.62 million times. At a rate of 20 cigarettes lost per bobbin change, nearly 132.4 million cigarettes are lost each year during bobbin changes, resulting in an increase in manufacturing costs of 5185,360 annually at manufacturing costs of $1.40 per 1,000 cigarettes (as shown in Table 4). The costs per bobbin change amounted to 50.029 in 1986 dollars.

The increase costs due to manufacturing cigarettes with cigarette paper of basis weight greater than 24 grams/m² is estimated as follows:

$$\left(\begin{array}{c}\text{Increased Costs}\\ \text{due to Paper}\\ \text{Bobbin Changes}\end{array}\right) = \left(\frac{BW_h}{BW_o}\right) \times \left(\frac{\text{Current Cigarette Production}}{\text{Cigarettes per Paper Bobbin}}\right) \times \left(\begin{array}{c}\text{Operating Cost}\\ \text{Per Bobbin}\\ \text{Change}\end{array}\right)$$

For new basis weights of cigarette paper of 32 and 45 grams/m², the increased costs per 1,000 cigarettes due to bobbin changes correspond to 50 0004 and $0 0005 respectively

If the machines are slowed down to half speeds during ten seconds each bobbin change, the costs per bobbin change are 23⅓ greater than the figures above (assuming 0.70 manufacturing efficiency rates) or incremental costs due to bobbin changes of $0.0093 and $0.012 for cigarette paper of 32 and 45 grams/m² basis weight respectively.

Increases in Flavoring

Given the increased thickness of the paper, it will be necessary to add flavoring to overcome the taste induced by the increased paper. While it is generally easier and less costlier to add the flavor to the paper in the cigarette paper manufacturing stage, the lack of detailed information on the cost structure of paper manufacturers precludes the estimation of these costs at the paper manufacturing stage.

Instead. the extra flavor has been costed as if added during the casing process of cigarette manufacturing. a doubling of the flavoring costs are estimated to be required to overcome the taste of the extra paper. These flavoring costs were earlier presented in Table 5.

Effect on Performance Speeds of Equipment and Their Relationship to Implementation Periods

There are other manufacturing problems associated with increases in cigarette paper thickness It appears that for the thicker paper to be used in today's cigarette maker machines, these machines would have to be slowed considerably. In the case of doubling the paper thickness. the cigarette maker machines would have to be slowed down to approximately half their performance speeds Two cases are discussed next: the effects on manufacturing speeds of a 4-year grace period versus the effects of instantaneous implementation of regulations on cigarette ignition propensity.

Effects of a 4-Year Grace Period.
Under a 4-year grace period, it is assumed that the cigarette manufacturers will continue normal replacement procedures during the first four years of the grace period and will replace all the cigarette making equipment in the fifth year, that is. in the first year of operation under the new regulations.

Earlier in Chapter 3, the equipment replacement requirements of the cigarette manufacturing industry were estimated at 438 cigarette maker/plug makers and 438 cigarette packers. A seven-year depreciation period has been assumed in accordance with the selected interviews conducted with equipment manufacturers, even though there are circumstances of new equipment replacing equipment which was only 2½ years old. Assuming a seven-year replacement period, the normal replacement rate was assumed to be 63 cigarette maker machines annually.[31] At the outset, it was determined that the performance speeds

[31] *The scant data available on the aye vintage of the equipment and the confidential nature of this data prevented the use of more sophisticated analysis on this issue*

of the cigarette maker machines would be the equipment most affected by the use of heavier paper Table 34 presents the annual equipment replacement flows of cigarette inakers under the 4-year grace period and under normal replacement.

Given the adverse effect of heavier paper on the performance speeds of cigarette maker machines. it is reasonable to assume that the cigarette maker machines will be modified in the intervening period to accept the heavier paper without having to slow down the performance speeds. Given that the R&D gestation periods in the cigarette industry average 3-4 years, the 4-year grace period is long enough to enable new cigarette maker machines to be developed

Costs of Modification of Cigarette Maker Machines. Earlier in Chapter 3, the costs of current cigarette makeriplug maker combinations was estimated as 5675,000. The cigarette maker itself is priced around $550,000 although some models run into $600,000. The task of this section is to estimate the costs of the modified cigarette maker machines to be installed after the grace period is ends.

The estimates of the cost of the new equipment rely on information on the pay-out period of R&D expenditures on machinery. Based on the annual McGraw-Hill surveys of plans for investments in plant and equipment, Edwin Mansfield shows that 51 percent of the U.S. manufacturers of machinery expect pay-out periods for their R&D outlays of three years or less.[32] This short pay-out period provides. as noted by Mansfield,[33] evidence that most R&D expenditures are geared towards improvements or moderate changes in existing products.

The R&D costs of equipment modifications are then estimated from the following formula

$$\begin{pmatrix} \text{R\&D} \\ \text{Costs} \end{pmatrix} = \begin{pmatrix} \text{R\&D} \\ \text{Pay-Out} \\ \text{Years} \end{pmatrix} \times \begin{pmatrix} \text{Net} \\ \text{Income/} \\ \text{Sales} \\ \text{Ratio} \end{pmatrix} \times \begin{pmatrix} \text{No. of} \\ \text{Annual} \\ \text{Machines} \\ \text{Sold} \end{pmatrix} \times \begin{pmatrix} \text{Sales} \\ \text{Price} \\ \text{per} \\ \text{Machine} \end{pmatrix}$$

[32]*Edwin Mansiield. et ai, Research and Innovation in the Modern Corporation. W W Norton. 1971, page 7*

[33]*Ibid, page 8.*

The number of annual cigarette maker machines sold annually under normal replacement is estimated as 63 machines (assuming 7 years as average life of cigarette manufacturing equipment) The net income after taxes for specialized machinery is estimated as 4 5 percent of sales from Internal Revenue Service sources[34] Assuming average pay out periods of three years and sales prices of $550 000 per cigarette maker the R&D costs of these equipment combinations are estimated as

$$\frac{\text{R\&D}}{\text{costs}} = (3)(0.045)(63)(550{,}000) = \$4{,}677{,}750$$

or $10.680 per equipment combination assuming total replacement needs of 438 machines These R&D costs constitute 1 9 percent of the original costs of the cigarette maker machine

However, the equipment manufacturers will also incur costs other than R&D in developing the equipment innovations required. The most accepted R&D definition is that of the National Science Foundation (NSF), which specifies R&D as including "the development of designs for special manufacturing and tools but excluding tool making and tool tryouts."[35] The NSF definition of R&D includes applied research, development of specifications and prototypes. but excludes tooling and manufacturing facilities, manufacturing start-up and marketing start-up costs R&D costs as a percentage of the total costs of innovation range from 51.6 percent in machinery to 50 7 percent in electronics.[36] Thus. R&D costs constitute approximately half of the total costs of the innovation.

In light of this discussion. it may be concluded that the total costs of the requried innovation may constitute 3.8 percent of the original machine costs, which equals $21.360 per machine. The costs of the new cigarette makers are estimated to be $571.360 per machine Thus. it is estimated that the R&D program costs would result in maintaining the high performance levels of the current cigarette maker machines. The incremental costs of replacing the cigarette maker machines at the conclusion of the grace period are presented in Table 34. The incremental costs are estimated as the present values of replacement requirements over the normal replacement needs of the cigarette manufacturing industry.[37]

[34]*Internal Revenue Service. Corporation Income Tax Returns. Statistics of Income. Government Printing Office, Washington, D C . Selected Issues 1978-1981*

[35]*Quoted in E Mansfield, et ai, Op Cit, page 122-123*

[36]*Ibid, page 123*

[37]*The installation costs of new machines versus normal replacement of cigarette maker machines are assumed to cancei each other*

Table 34. Costs of Replacing Cigarette Makers Under a 4-Year Grace Period – 1986

	No. of Ciaarette Maker Machines to be Replaced		
Year	Under 4-Year Grace Period	Under Normal Replacement	Increments
1	63	63	0
2	63	63	0
3	63	63	0
4	63	63	0
5	438	63	375
6	0	63	-63
7	0	63	-63
8	0	63	-63
9	0	63	-63
10	0	63	-63
11	0	63	-63
12	0	63	-63
Present Value of Replacement Costs (millions of 1986 dollars)	$302.118[a]	$273.880[b]	$28.838
Present Value of Replacement Costs per 1,000 Cigarettes[c] (1986 dollars)	$ 0.038	$ 0.034	$ 0.004

Notes:

a Estimated assuming cigarette maker costs of $550,000 for the first four years and $571,360 for the equipment modification of Year 5, and discount rates of 8 percent.

b Estimated assuming cigarette maker costs of $550,000, that Is, assuming no need to modify equipment, and 8 percent discount rates.

c Estimated by dividing the present value figures by the production of cigarettes during the 12-year period (12 years x 663 billion cigarettes per year).

Table 35. Incremental Costs Associated with Paper Thickness Under 4-Year Grace Period Implementation — 1986
(per 1,000 cigarettes)

	Basis Weight of Cigarette Paper	
	32 grams/m²	45 grams/m²
Increments in Basis Weight (%)	33 1/3	a7 1/2%
Paper Costs		
Manufacturing Capital Costs	$0.012	$0.042
Manufacturing Operating Costs	$0.04	$0.105
Adjustments for Porosity	$0.014 - $0.03	$0.014 - $0.03
Cigarette Manufacturing Costs		
Increased Use of Adhesives	$0.043	$0.043
Increased Bobbin Changes	$0.0004 - $0.0093	$0.0005 - $0.012
Increased Flavor Additives	$0.016	$0.016
Incremental Costs of New Equipment	$0.004	$0.004
Total	$0.129 - $0.154	$0.225 - $0.252
As Percent of Cigarette Wholesale Price	0.4% - 0.5%	0.7% - $0.8%

Instantaneous Implementation of Regulations

As shown earlier in this chapter, the cigarette paper industry does not possess the capacity required to implement instantaneously the option of doubling paper thickness. In spite of this major impediment to the instantaneous implementation of the option, some cost estimates are presented next on the costs to be incurred if no grace period is allowed under the self~extinguishing cigarette regulations.

Under the current equipment configurations doubling the paper thickness (i.e., 45 grams/m² basis weight) will require slowing down the cigarette maker machines to half their performance speeds, while the effect of using the 32 grams/m² basis weight paper will slow down the machines to 75 percent of their performance speeds. One major complication is that the industry does not have extra machines to substitute for the slow down in their performance speeds. For example, slowing down the machines by 50 percent would require doubling the number of cigarette maker machines, requirements that far exceed the inventory of equipment.

Assuming that the shortage in machines can be overcome by purchasing new machines, the costs atfected by the slowdown in machines are cigarette maker labor and equipment depreciation. which amount to $0 468 per 1,000 cigarettes (see Table 4). Doubling the paper thickness will require $0.468 extra of labor and depreciation during the first four years before the new cigarette maker machines become available. Increasing the paper thickness by using paper with 32 grams/m² of basis weight will increase labor and depreciation cost by $0.234 per 1,000 cigarettes during the first four years. The present value of these costs are $0.127 per 1,000 cigarettes for the 45 grams/m² basis weight paper and $0.064 per 1,000 cigarettes for the 32 grams/m² of basis weight paper.[38] To these labor and

[38] Amortized over the 12-year period shown in Table 34 a! eight percrn! discount.

depreciation costs must be added the new equipment costs of 50.004 per 1,000 cigarettes presented in Table 34. However, it is unrealistic to expect that an instantaneous implementation IS possible. Neither does the cigarette paper industry have the required capacity, nor does the cigarette manufacturing industry have the extra cigarette maker machinery necessary to substitute for the slowing down of the performance speeds of the current machines.

Cost Summary

Table 35 presents the summary of incremental costs associated with paper thickness options, while Table 36 presents a cost summary that interfaces with the National Bureau of Standards' economic impact model requirements Mos! of the costs are associated with the manufacturing of heavyweight cigarette paper.

Table 36. Summary of Incremental Costs Associated With Paper Thickness Under 4-Year Grace Period Implementation – 1986
(per 1,000 Cigarettes)

	Basis Weight of Cigarette Paper			
	32 grams/m^2		45 grams/m2	
Cost Components	costs	AS Percentage of Component costs	costs	AS Percentage of Component costs
Domestic Tobacco Leaf	0	0%	0	0%
Paper	$0.066-$0.082	38.8%-48.2%	$0.161-$0.177	94.7%-104.1%
Federal Excise Tax	0	0%	0	0%
Other Costs	$0.063-$0.072	0.3%-0.3%	$0.064-$0.075	0.3%-0.3%
Total Costs	$0.129-$0.154	0.4%-0.5%	$0.225-$0.252	0.7%-0.8%

Economic
Sector Data
for Modeling
the Impact
of Less
Ignition-Prone
Cigarettes

Section 4

Estimates of the Economic and Non-Economic Health Consequences of Smoking, Smoking Cessation, and Reductions in the Amount Smoked

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List of Tables

1. Introduction

In this report, we present our estimates of the economic and noneconomic health consequences of smoking and changes in smoking habits, and describe the methods that we used to calculate: (1) losses related to smoking (Tables 1 and 2); (2) benefits related to smoking cessation (Tables 3 and 4); and (3) benefits related to reductions in the amount smoked (Tables 5 and 6). These losses and benefits are measured in terms of changes in individuals' expected lifetime costs for the medical treatment of smoking-related diseases, and changes in years of life expectancy Estimates of changes in medical care costs have *not* been adjusted to reflect the fact that smokers as a group, because of their shorter life expectancies, may incur lower costs over a lifetime for the treatment of diseases unrelated to smoking.

All estimates were calculated separately for men and women between the ages of 35 and 79 in 5-year age increments. Estimates of losses related to smoking and benefits related *to* smoking cessation were calculated separately for men and women who were light (1-19 cigarettes per day), moderate (20-39 cigarettes per day), and heavy (40 or more cigarettes per day) smokers. Estimates of benefits related to reductions in the amount smoked were calculated separately for changes in smoking from moderate to light. and from heavy to moderate.

Losses and benefits were tallied separately at annual discount rates of 0 percent, 2.5 percent. 5 percent, and 10 percent. Future medical care costs (used in the calculation of changes in expected lifetime costs for the treatment of smoking-related diseases), and future annual probabilities of survival (used in the calculation of changes in life expectancy) were both discounted. Estimates of the present value of changes in expected lifetime medical care costs are expressed in 1986 dollars.

Estimates of changes in expected lifetime medical care costs for the treatment of smoking-related diseases were calculated using methods similar to those described in [1] Estimates of changes in life expectancy due to smoking. smoking cessation. and reductions in the amount smoked were calculated using methods similar to those described in [2]. Where the calculation techniques used in this report have been identical to those used in these earlier studies, we have provided only a brief overview of methods. We present a more detailed description when these techniques were significantly modified, or when new techniques were used

2. Losses Attributable to Smoking

Increases in Costs for the Medical Treatment of Smoking-Related Diseases

Estimates of the economic loss attributable to smoking (measured in terms of additional lifetime costs for the treatment of smoking~related diseases) are presented in Table 1.

We calculated the additional expected lifetime medical care costs for the treatment of smoking~related diseases by combining age-and-sex specific estimates of the incidence-based costs of the major three such diseases (lung cancer, coronary hear disease, and emphysema) with estimates of smokers' increased likelihood (i.e., excess risk) of developing them in each remaining year of life. Using these estimates. we calculated the expected lifetime costs of treating these diseases for smokers and for nonsmokers respectively. The difference in these costs (i.e., between smokers and nonsmokers) represents the economic loss attributable to smoking. The methods and data used in these calculations are described in detail in [1]

Reductions in Life Expectancy

Reductions in life expectancy as a result of cigarette smoking are presented in Table 2 To calculate these estimates we combined unpublished annual mortality rates for smokers and nonsmokers between the ages of 35 and 105 years from the American Cancer Society (ACS) 25 State Cancer Prevention Study, with relative mortality rates for male light, moderate, and heavy smokers in the ACS study population [3] to calculate life expectancies for light smokers, moderate smokers, heavy smokers, and nonsmokers.

Results reported in [3] indicate that the mean number of cigarettes smoked per day among smokers in the ACS study population was slightly more than 20 per day. We assumed, therefore, that the mortality rates for smokers presented in the unpublished ACS data represent the experience of moderate smokers. We calculated average relative mortality rates for light and heavy male smokers. compared to moderate male smokers, across all ages, using results reported in [3]. We assumed that relative mortality rates for light and heavy female smokers were the same as those of corresponding male smokers. We multiplied these relative mortality rates by age-and-sex-specific mortality rates for moderate smokers to calculate annual mortality rates for male and female light and heavy smokers of every age between 35 and 79 years.

We then calculated life expectancies for light. moderate, and heavy smokers of every age between 35 and 79 years, and for nonsmokers at each of these ages, using annual probabilities of survival derived from corresponding annual mortality rates. The difference, at any given age, between the life expectancies of smokers and nonsmokers, represents the losses related to smoking measured in terms of the reduction in life expectancy.

Table 1. Additional Expected Lifetime Medical Care Costs for the Treatment of Smoking-Related Diseases Due to Smoking for Light (L), Moderate (M), and Heavy (H) Smokers, by Discount Rate, Sex and Age.

	Additional Expected Lifetime Hedical Care Costs for the Treatment of Smoking-Related Diseases											
	Discounted at 0 Percent			Discounted at 2.5 Percent			Discounted at 5 Percent			Discounted at 10 Percent		
Age/Sex Group	L	M	H	L	M	H	L	M	H	L	M	H
Men												
35-39	$6,305	$10,785	$16,944	$2,760	$4,720	$7,416	$1,332	$2,278	$3,579	$ 412	$ 705	$1,107
40-44	6,209	10,590	16,502	3,012	5,136	8,004	1,594	2,718	4,236	567	967	1,507
45-49	6,006	10,167	15,700	3,205	5,425	8,337	1,844	3,122	4,821	746	1,262	1,949
50-54	5,612	9,360	14,235	3,264	6,443	8,278	2,014	3,359	5,108	909	1,516	2,305
55-59	5,154	8,479	12,727	3,247	5,341	8,017	2,154	3,543	5,318	1,082	1,780	2,672
60-64	4,612	7,483	11,139	3,138	5,092	7,580	2,227	3,614	5,379	1,249	2,026	3,016
65-69	3,980	6,374	9,462	2,907	4.657	6,912	2,180	3,493	5,184	1,346	2,157	3,201
70-74	3,226	5,158	7,684	2,500	3,996	5,953	1.989	3.180	4,738	1,339	2,141	3,189
75-79	2,383	3,798	5,699	1,952	3,111	4,669	1,629	2,596	3,896	1,185	1,888	2,833
Women												
35-39	$3,187	$ 5,774	$12,063	$1,286	$2,330	$4,869	$ 574	$1,039	$2,171	$ 156	$ 282	$ 589
40-44	3,138	5,621	11,320	1,413	2,531	5,097	698	1,251	2,519	222	397	800
45-49	3,204	5,745	11,279	1,593	2,857	5,609	859	1,539	3,022	310	555	1,091
50-54	3,081	5,512	10,832	1,687	3,018	5,932	981	1,755	3,449	403	722	1,418
55-59	2,924	5,201	10,267	1,747	3,107	6,133	1,100	1,957	3,863	512	910	1,796
60-64	2,720	4,771	9,501	1,762	3,090	6,154	1,195	2,096	4,175	618	1,084	2,159
65-69	2,401	4,156	8,371	1,685	2,917	5,075	1,234	2.135	4.301	716	1,239	2,496
70-74	1,872	3,208	6,561	1,410	2,416	4,941	1,086	1,862	3,807	705	1,208	2,471
75-79	1,365	2,325	4,802	1,097	1,869	3,859	893	1,521	3,141	625	1,065	2,199

Note: All costs are expressed in 1986 dollars. See text for definitions of light, moderate, and heavy smokers.

Table 2. Reductions in Years of Life Expectancy Due to Smoking for Light (L), Moderate (M), and Heavy (H) Smokers, by Discount Rate, Sex and Age.

Age/Sex Group	Reductions in Years of Life Expectancy: Discounted at 0 Percent			Discounted at 2.5 Percent			Discounted at 5 Percent			Discounted at 10 Percent		
	L	M	H	L	M	H	L	M	H	L	M	H
Men												
35-39	4.69	6.58	8.16	2.07	2.88	3.58	1.01	1.39	1.74	.31	.43	.54
40-44	4.51	6.35	7.88	2.22	3.08	3.83	1.19	1.63	2.03	.43	.58	.73
45-49	4.20	5.96	7.41	2.27	3.18	3.96	1.31	1.83	2.28	.54	.74	.92
50-54	3.77	5.43	6.80	2.22	3.16	3.96	3.96	1.38	1.95	.63	.88	1.11
55-59	3.26	4.81	6.07	2.08	3.03	3.84	1.39	2.01	2.55	.71	1.01	1.29
60-64	2.69	4.10	5.24	1.85	2.79	3.57	1.33	1.98	2.54	.75	1.11	1.42
65-69	2.07	3.34	4.35	1.54	2.44	3.17	1.17	1.83	2.39	.73	1.13	1.47
70-74	1.41	2.53	3.40	1.12	1.96	2.64	.91	1.56	2.10	.62	1.05	1.41
75-79	.82	1.77	2.52	.69	1.45	2.06	.59	1.21	1.21	.45	.88	1.24
Women												
35-39	2.04	3.89	5.45	.88	1.57	2.18	.41	.70	.97	.11	.19	.26
40-44	2.01	3.82	5.34	.97	1.72	2.38	.50	.85	1.17	.17	.27	.37
45-49	1.87	3.62	5.09	1.00	1.80	2.50	.56	.97	1.33	.22	.35	.48
50-54	1.68	3.36	4.76	.99	1.84	2.57	.61	1.07	1.48	.27	.44	.60
55-59	1.44	3.03	4.35	.93	1.81	2.56	.62	1.14	1.60	.31	.53	.J3
60-64	1.15	2.64	3.86	.81	1.71	2.47	.59	1.16	1.66	.33	.60	.84
65-69	.82	2.18	3.29	.64	1.53	2.28	.50	1.17	1.64	.32	.65	.94
70-74	.39	1.62	2.60	.35	1.22	1.94	.31	.94	1.48	.24	.61	.93
75-79	-.01	1.07	1.92	.05	.86	1.52	.07	.70	1.22	.09	.49	.84

Note: See text for definitions of light, moderate, and heavy smokers.

3. Benefits Attributable to Smoking Cessation

Reductions in Costs for the Medical Treatment of Smoking-Related Diseases

The benefits of smoking cessation for light. moderate, and heavy smokers, measured in terms of changes in lifetime costs for the treatment of smoking~related diseases, are presented in Table 3

By combining incidence-based estimates of lifetime treatment costs for smoking~related diseases (lung cancer, coronary heart disease, and emphysema) with estimates of exsmokers' probabilities of developing them, we calculated expected costs of medical treatment for smoking-related disease for exsmokers who were previously light. moderate, and heavy smokers. Techniques of disease costing are described above; the estimation of relative disease risk for exsmokers is described in detail in [1]. The difference between the expected lifetime costs of treatment of smokers and exsmokers at any given level of pre-cessation cigarette consumption represents the economic benefit attributable to smoking cessation.

Note that, for any given discount rate, amount smoked, sex and age, the benefits of smoking cessation are always less the costs of smoking. since the elimination of marginal disease risk due to smoking cessation is not instantaneous.

Increases in Life Expectancy

Estimates of the increase in life expectancy due to smoking cessation are presented in Table 4. They were calculated using mortality rates for light smokers, moderate smokers, heavy smokers, and nonsmokers derived from ACS data, and estimates of the relative decline in excess mortality for exsmokers in the years after quitting from [4]. We assumed that the relative decline in excess mortality for exsmokers in the years after quitting is the same for all exsmokers. regardless of cigarette consumption prior to quitting. For every age between 35 and 105 years, we calculated mortality rates for exsmokers who were previously light, moderate, and heavy smokers.

Life expectancies were then calculated for exsmokers who were previously light, moderate and heavy smokers, for every age between 35 and 79 years, using annual probabilities of survival derived from annual mortality rates The difference, at any given age, between the life expectancy of smokers and exsmokers represents the added years of life expectancy attributable to smoking cessation. Note that among light smokers, added years of life expectancy are in some instances negative; this is probably a result of selection bias.

Table 3. Reductions in Expected Lifetime Medical Care Costs for the Treatment of Smoking-Related Diseases Due to Smoking Cessation for Light (L), Moderate (M), and Heavy (H) Smokers, by Discount Rate, Sex and Age.

	Reductions in Expected Lifetime Medical Care Costs for the Treatment of Smoking-Related Diseases											
	Discounted at 0 Percent			Discounted at 2.5 Percent			Discounted at 5 Percent			Discounted at 10 Percent		
Age/Sex Group	L	M	H	L	M	H	L	M	H	L	M	H
Men												
35-39	$ 4,825	$ 8,622	$13,419	$ 2,042	$ 3,649	$ 5,679	$ 940	$ 1,680	$ 2,615	$ 256	$ 458	$ 713
40-44	4,615	7,984	12,233	2,141	3,714	5,691	1,074	1.857	2.846	331	573	878
45-49	4,240	7,056	10,743	2,152	2,581	5,452	1,166	1,940	2,954	413	688	1,047
50-54	3,748	5,944	9,079	2,066	3,276	5,004	1,208	1,916	2,926	474	752	1,149
55-59	3,118	4.710	7,358	1,859	2,808	4,386	1,163	1,757	2,745	528	797	1,245
60-64	2,471	3,597	5,869	1,600	2,328	3,800	1,079	1,571	2,564	546	795	1,297
65-69	1,844	2,643	4,477	1,285	1,842	3,120	922	1,321	2,238	517	741	1,255
70-74	1.256	1,811	3,182	950	1,369	2.406	720	1.038	1.824	460	663	1.164
75-79	805	1.188	2,156	657	970	1,760	526	776	1,408	378	558	1,012
Women												
35-39	$ 2,150	$ 4,301	$ 8,849	$ 845	$ 1,691	$ 3,478	$ 365	$ 730	$ 1,503	$ 88	$ 176	$ 362
40-44	2,071	4,047	8,290	895	1,748	3,581	423	826	1,692	120	234	479
45-49	2,095	4,037	8,196	1,000	1,927	3,912	508	979	1,987	159	306	621
50-54	1,917	3,598	7.383	1,000	1,878	3,853	546	1,026	2,105	193	363	745
55-59	1,686	3,064	6,529	957	1,739	3,706	574	1,043	2,224	228	414	882
60-64	1,418	2,550	5.748	871	1,566	3,531	567	1,020	2,299	263	474	1,067
65-69	1,111	2,013	4,707	744	1,349	3,154	515	934	2,184	275	498	1,165
70-74	828	1,514	3,625	603	1,104	2,642	449	821	1,966	266	488	1,167
75-79	553	1,009	2,454	435	795	1,934	352	642	1,562	234	428	1,041

Note: All costs are expressed in 1986 dollars. See text for definitions of light, moderate, and heavy smokers,

Table 4. Increases in Years of Life Expectancy Due to Smoking for Light (L), Moderate (M), and Heavy (H) Smokers, by Discount Rate, Sex and Age.

Age/Sex Group	Increases in Years of Life Expectancy											
	Discounted at 0 Percent			Discounted at 2.5 Percent			Discounted at 5 Percent			Discounted at 10 Percent		
	L	M	H	L	M	H	L	M	H	L	M	H
Men												
35-39	3.64	5.08	6.21	1.56	2.15	2.64	.72	.99	1.22	.20	.27	.34
40-44	3.27	4.60	5.62	1.53	2.14	2.62	.78	1.07	1.32	.24	.33	.41
45-49	2.81	4.00	4.90	1.44	2.03	2.49	.79	1.10	1.35	.28	.39	.48
50-54	2.28	3.32	4.07	1.28	1.83	2.25	.75	1.07	1.32	.30	.42	.53
55-59	1.74	2.60	3.20	1.05	1.55	1.92	.67	.97	1.21	.30	.44	.54
60-64	1.22	1.90	2.36	.80	1.23	1.53	.55	.83	1.03	.28	.42	.52
65-69	.78	1.32	1.65	.56	.92	1.15	.41	.66	.83	.24	.37	.47
70-74	.41	.82	1.06	.33	.62	.80	.26	.47	.61	.17	.30	.39
75-79	.17	.49	.67	.16	.40	.54	.14	.32	.44	.11	.23	.34
Women												
35-39	1.65	3.18	4.41	.69	1.25	1.71	.31	.54	.73	.08	.13	.18
40-44	1.50	2.94	4.10	.70	1.27	1.76	.35	.60	.82	.10	.17	.23
45-49	1.29	2.64	3.71	.66	1.26	1.74	.36	.64	.88	.12	.20	.27
50-54	1.05	2.28	3.25	.59	1.19	1.67	.35	.65	.91	.14	.23	.32
55-59	.75	1.85	2.69	.48	1.05	1.51	.31	.63	.89	.14	.25	.36
60-64	.46	1.40	2.10	.33	.86	1.27	.24	.56	.81	.13	.26	.37
65-69	.19	.97	1.52	.17	.65	1.00	.15	.45	.69	.10	.24	.35
70-74	-.03	.59	1.01	.02	.43	.71	.04	.32	.52	.05	.19	.30
75-79	-.14	.33	.63	-.08	.26	.48	-.04	.21	.38	0.00	.14	.24

Note: See text for definitions of light, moderate, and heavy smokers.

4. Benefits Attributable to Reductions in the Amount Smoked

Reductions in Costs for the Medical Treatment of Smoking-Related Diseases

The benefits of a reduction in the amount smoked from moderate to light and from heavy to moderate measured in terms of changes in expected lifetime medical care costs are presented in Table 5 We calculated these benefits by subtracting the reductions in expected lifetime costs of treating smoking related diseases experienced by light smokers who quit from the reductions in expected lifetime costs of treatment for moderate smokers who quit

Increases in Life Expectancy

Increases in years of life expectancy due to reductions in the amount smoked from moderate to light and from heavy to moderate are presented in Table 6 We calculated these esti mates by subtracting the increase in years of life expectancy due to smoking cessation for light (moderate) smokers from the increase in life expectancy due to smoking cessation for moderate (heavy) smokers

Table 5. Reductions in Expected Lifetime Medical Care Costs for the Treatment of Smoking-Related Diseases Due to Reductions in the Amount Smoked from Moderate to Light Smoking (M–L), and from Heavy to Moderate Smoking (H–M), by Discount Rate, Sex and Age

	Reductions in Expected Lifetime Medical Care Costs for the Treatment of Smoking-Related Diseases							
	Discounted at 0 Percent		Discounted at 2.5 Percent		Discounted at 5 Percent		Discounted at 10 Percent	
Age/Sex Group	M - L	H - M	M - L	H - M	M - L	H - M	M - L	H - M
Men								
35-39	$3,797	$4,797	$1,607	$2,030	$ 740	$ 935	$ 202	$ 255
40-44	3,369	4,249	1,567	1,977	783	989	242	305
45-49	2,816	3,687	1,429	1,871	774	1,014	275	359
50-54	2,196	3,135	1,210	1,728	708	1,010	278	397
55-59	1,592	2,648	949	1,578	594	988	269	448
60-64	1.126	2,272	728	1,472	492	993	249	502
65-69	799	1,834	557	1,278	399	917	224	514
70-74	555	1,371	419	1,037	318	786	203	501
15-79	383	968	313	790	250	632	180	454

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Table 5. (continued)

Women								
35-39	$2,151	$4,548	$ 846	$1,787	$ 365	$ 773	$ 88	$ 186
40-44	1,976	4,243	853	1,833	403	866	114	245
45-49	1,942	4,159	927	1.985	471	1,008	147	315
50-54	1.681	3,685	878	1,975	480	1,079	170	382
55-59	1,378	3,465	782	1,967	469	1,181	186	468
60-64	1,132	3,198	695	1,965	453	1.279	211	593
65-69	902	2.694	605	1,805	419	1.250	223	bb7
70-74	686	21111	501	1,538	372	1,145	222	679
75-79	456	1,445	360	1.139	290	920	194	613

Note: *All* costs are expressed in *1986* dollars. See text for definitions of light, moderate, and heavy smokers.

Table 6. Increases in Years of Life Expectancy Due to Reductions in the Amount Smoked from Moderate to Light Smoking (M–L), and from Heavy to Moderate Smoking (H–M), by Discount Rate, Sex and Age

	Increases in Years of Life Expectancy							
	Discounted at 0 Percent		Discounted at 2.5 Percent		Discounted at 5 Percent		Discounted at 10 Percent	
Age/Sex Group	M - L	H - M	M - L	H - M	M - L	H - M	M - L	H - M
Men								
35-39	1.44	1.13	.59	.49	.27	.23	.07	.07
40-44	1.33	1.02	.61	.48	.29	.25	.09	.08
45-49	1.19	.90	.59	.46	.31	.25	.ll	.09
50-54	1.04	.75	.55	.42	.32	.25	.12	.11
55-59	.86	.60	.50	.37	.30	.24	.14	.10
60-64	.68	.46	.43	.30	.28	.20	.14	.10
65-69	.54	.33	.36	.23	.25	.17	.13	.10
70-74	.41	.24	.29	.18	.21	.14	.13	.09
75-79	.32	.18	.24	.14	.18	.12	.12	.07
Women								
35-39	1.53	1.23	.56	.46	.23	.19	.05	.05
40-44	1.44	1.16	.57	.49	.25	.22	.07	.06
45-49	1.35	1.07	.60	.48	.28	.24	.08	.07
50-54	1.23	.97	.60	.48	.30	.26	.09	.09
55-59	1.10	.84	.57	.46	.32	.26	.11	.11
60-64	.94	.70	.53	.41	.32	.25	.13	.11
65-69	.78	.55	.48	.35	.30	.24	.14	.11
70-74	.62	.42	.41	.28	.28	.20	.14	.ll
75-79	.47	.30	.34	.22	.25	.17	.14	.10

Note: Sea text for definitions of light, moderate. and heaw smokers

5. References

[1] Oster. G.. Colditz, G.A.. Kelly, N.L.: The economic costs of smoking and benefits of quitting for individual smokers. Prev. Med., 1984; 13:377-389.

[2] Oster, G.. Huse. D.M., Delea, T.E., Colditr, G.A.. Cost-effectiveness of nicotine gum as an adjunct to physician's advice against cigarette smoking. JAMA 1986; 256:1315-1318.

[3] Hammond, E.C.: Srnoking in relation to the death rates of one million men and women. In: Haensrel. W. (ed). Epidemiological Approaches to the Study of Cancer and Other Chronic Diseases. National Cancer Institute Monograph 19. Bethesda, MD: U.S. Department of Health, Education and Welfare, Public Health Service. National Cancer Institute. January 1966.

[4] Doll. R., Peto, R.: Mortality in relation to smoking: twenty years of observation on male British doctors Br Med. J., 1976; 2:1525-1536.

Economic Sector Data for Modeling the Impact of Less Ignition-Prone Cigarettes

Section 5

The Costs and Benefits to Smokers of Reduced Flammability Cigarettes

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List of Tables

1. Introduction and Summary

A. Purposes and Methods

This report is part of a large effort to assess the costs and benefits of introducing new cigarettes that are less likely to cause accidental fires. The Cigarette Safety Act of 1984[1] created an Interagency Committee on Cigarette and Little Cigar Fire Safety, which is charged with addressing the feasibility and consequences of developing cigarettes and little cigars with a minimum propensity to ignite upholstered furniture and mattresses. That group created a Technical Study Group, which in turn contracted with the Applied Economics Group in the Mathematical Analysis Division of the National Bureau of Standards (NBS) for a cost-benefit study on cigarettes with reduced "ignition propensity.' The NBS group divided the task into distinct but overlapping parts: reduced fire losses, changed health care and productivity costs, net benefits to smokers (changed consumer6 surplus), changed produce6 profits, changed employment and wages, and changed farm income. The present report addresses changes in consumers' surplus, that is. net benefits (exclusive of health and fire effects) to smokers of reduced flammability cigarettes.

A note *on* terminology is necessary. We shall use the term "reduced flammability," rather than "reduced ignition propensity:' when referring to cigarettes that are less likely to cause fires. We reserve the terms "self~extinguishing' and "reduced ignition propensity" to refer to two different types of reduced flammability cigarettes.

This report is on changed consumer surplus, that is, the net gain or loss incurred by smokers themselves as a result of smoking reduced flammability cigarettes. exclusive of health and fire effects, which are dealt with in other reports. Net benefits for smokers depend on both the nature of reduced flammability cigarettes and the manner in which consumers and the rest of the market (especially manufacturers) react to the changed cigarettes and to each other. Thus our analysis focusses on consumer behavior and the adjustments of buyers and sellers in competitive markets.

Some elements in our analysis necessarily impinge upon other parts of this project For example, smokers may adjust their smoking behavior *to* compensate for changes in taste. burning characteristics. and perhaps tar and nicotine content. We shall also look at socio-economic differences in smoking behavior and propensity to start fires. the regulatory choice between performance standards versus input standards. mandated changes versus information campaigns. and so on. All these could affect estimates of both fire prevention and health consequences of changed cigarettes

We outline here some principles that shaped our analysis. Where data are available, we have tried to use it Examples are the section on the confluences of smoking and fires, and the value that smokers attach to cigarette taste. Usually, available data do not address the specific topics we deal with. The main problem is lack of information on how reduced flammability cigarettes will differ from existing brands. how the differences would affect other factors such as taste and tar and nicotine yield, and how smokers value these changes. The best we have been able to achieve is to make reasonable conjectures of possible changes, or to produce illustrative calculations that seem to include the range of likely changes.

We have paid particular attention to demographic differences among smokers and to the role of competitive forces in the cigarette market We did this because we found the demographic differences to be substantial, and because past events in the cigarette market have demonstrated that market forces are potent determinants of pattern of smoking behaviors that emerge from regulation and other changes Because of this history and the frequently disappointing experience with interventions in other markets, we also gave some attention to various ways of implementing reduced flammability cigarettes, noting the likely differences requiring changes as opposed to letting the market implement new technologies

[1] *Public Law 98 567 section 4(W) (October 1984)*

Findings and Conclusions

1. There are substantial demographic differences in the confluences of smoking and fires. For example, the heaviest smokers are in the 25-44 age group, whereas the greatest relative concentration of fire victims is in the over 64 age group.

2. Because of lack of specific data on reduced flammability cigarettes, and on smoker reactions to likely changes, our conclusions on net costs and benefits are almost entirely qualitative in nature, supplemented by illustrative calculations. Ne! changes in costs and benefits to smokers from price changes alone will probably be "moderate." Changes in net benefits from adverse changes in smoking characteristics – poorer taste and the necessity to relight cigarettes frequently – are impossible to estimate with present data, but the changes could be substantial.

3. Different methods for constructing reduced flammability cigarettes may have markedly different effects on changes in net benefits to smokers (due to different changes in taste and other smoking characteristics).

4. Tar and nicotine yield could change substantially as a result of reductions in flammability, with possibly substantial adverse health consequences, Much of the change could escape detection by Federal Trade Commission (FTC) ratings, since the changes would come from smoker 'tompensation" that is no! taken into account by the FTC machines. Moreover, different types reduced flammability cigarettes may have markedly different effects on tar and nicotine yield.

5. Voluntary implementation of reduced flammability cigarettes merit serious consideration, in view of the significant possibility of adverse effects of requiring reduced flammability cigarettes, and the uncertainties associated with an intervention.

6. If reduced flammability cigarettes are mandated, mandates expressed as performance standards rather than design standards offer considerable advantages in terms of reducing the likelihood of adverse consequences of intervention.

7 If the government requires that cigarettes be constructed a certain way to reduce flammability. or that cigarettes achieve a certain level of flammability, the new market is unlikely to be simply the old market with fewer fires started by cigarettes. Smokers will change brands and smoking techniques, and manufacturers will adjust tar and nicotine content and other aspects of cigarette construction. These adjustments could affect the health consequences of smoking and the predicted reductions in fires.

2. Cigarettes and Fires

[redacted]

The demographics of cigarette use and of fires are of interest for three reasons. First, if reduced flammability cigarettes are introduced by means of market forces rather than through regulation. sales of the new cigarettes will depend partly on the degree to which specific groups would see or expect benefits from them. In particular, we note that if the benefits are concentrated in a few groups, those persons might find the advantages outweigh the disadvantages. and thus sales might be significant in exactly the places where it would do the most good. On the other hand, if benefits trom reduced flammability cigarettes are evenly spread among the population of smokers, and if there is a significant cost in terms of smoking pleasure, sales might be insignificant because no one would find the modified cigarettes worth their cost.

Second, regardless of whether reduced flammability cigarettes are required by regulation. consumer trade-offs between safety and other characteristics such as smoking quality and tar and nicotine content will vary according to the perceived benefits of preventing fires, and this will affect changes in net benefits to smokers and overall market adjustments to new cigarettes.

A final reason for looking at the demographics on smoking and fires is that these results will be important lor other parts of the reduced flammability cigarette project. such as predicted effects on fires and health.

Data and Methods

We work with two distinct sets of data one on smoking behavior (who smokes how much etc) and one on the victims of fires started by cigarettes [2] Data on smoking behavior are quite comprehensive and easily obtainable although they are not broken down exactly as we would wish The primary source is the National Center for Health Statistics whose data were supplemented by data from other souces on teenage smoking

There is almost no data available on the characteristics of those who start fires with cigarettes The most comprehensive source of data about fire deaths injuries and losses is contained in the five editions of *Fire in the United States* published by the United States Fire Administration [3] These data however contain no demographic information on the victims of fires caused by cigarettes Additional sources of information about those who are involved in fires have come from studies done of specific locales or states [4] These studies also provide little in the way of useful demographic data about those killed or injured in smoking caused fires The most thorough analysis of the demographic characteristics of those who die in fires started by cigarettes [6] is contained in the United States Fire Administration report

[2] *Data on who starts* hies *wrth cigarettes are nearly non existent*

[3] *Fire* in the *United States has* **been** *published lor the years 1977 1978, 7980, 1981 and 1983 The data from the National I* **ire** *Incident Reporting System, (NFIRS). and horn a survey completed* **by** *the National Fire Protection Association In the latest edition of* Fire *in the United States. the NFIRS dafa were drawn Irom lire deparfments in 34* states plus *the District of* Columbia *From ten* to *59 percenf of the fire departments* in *a* state *participated in NFIRS The national estimates for civilian deaths reported in Fire in the* Unifed *States were based on a* National *Fire Protection Association survey* of *fire departments (Fire in the United States, 1982. page 9) We have no information about the details* of *the survey* it is *our impression fhal the dafa published in Fire* in *the Unifed States are generally considered reliable As noted below however, the estimates of fire* deaths *contained in lhat publication are between fifty and one hundred percent higher than lhose which come Irom the Hall and Helzer (1983) study*

[4] *See lor example. fhe studies of Syracuse (Karter and Donner 1978) and Toledo (Gunther 1981) and fhe Maryland (Berl and Halpin 1979, Birky et al 1979) study.*

[5] *For example,* the *Maryland study provided information about the age, race and sex distribution of 463 fire fatalities in Maryland horn 1972-1977 These dafa were not broken down separately for smoking caused and other caused hies (Berl and Halpin, 1979) Nationally, it is estimated* fhat *slightly less than one-quarter of* all *fire deafhs are the results of cigarette caused* ***Ires,*** *although Berl and Halpin estimated the percentage at 444 percent for thea data* (at *p 11) The Toledo study concluded that there was an inverse correlation between smoking caused* fire *and income, but no detailed findings were reported for other demographic variables (Gunther, 1981, p 56).*

[6] *Cigarettes were known to have started 788 percent* of *the hres started by smoking materials in the years 1977-1978 Pipes. cigars* arid *other* items *account* for *3 6 percent and the cause of the remaining 176 percent was unknown.* (Fire *in the United Slates, Second* Edition, *1982, p. 46) For the purposes of lhis report. smoking caused fires can be interpreted as cigarette caused fires*

"Civilian Residential Fire Fatality Rates: Six High-rate States Versus Six Low-rate States:' (Hail and Helzer, 1983) which used data from the 1978-1979 time period to calculate the death rate per million for population groups jointly categorized by age, race and sex.[7] The most striking finding from the Hall and Helzer was that black males 45 years and older in high fire rates states had approximately twenty times the smoking caused fire death rates of white children under five in both high and low fire rate states[8] (Hall and Helzer, p. 16). For our purposes, the Hall and Helzer data provided a starting point for comparing the characteristics of firestarters to smokers.[9]

Our methodology can be described as follows. Hall and Helzer provided estimates of smoking caused deaths per million by age, sex and race categories for high and low fire-rate states for 1978-1979.[10] The actual deaths in each category were estimated by multiplying the total population in these categories in the six high and six low fire-rate states by the deaths per million incidents. The population estimates by age, race and sex were obtained from 1980 census data.[11] The result of this calculation was an estimate of the number of people who died by age, sex and race from smoking caused fires in the six high and six low fire-rate states.

The next step was to combine the estimates for the two groups of states into an overall weighted average. This was done by weighting the number of estimated deaths in each age, race and sex category for the high-fire rate states and the low fire-rate states by the percentage of the population in each category of states. For example, the percentage of black males between 25 and 44 in high fire rate states, was estimated by dividing the number of black males in that age category by the total number of black males in that age category in all twelve states. Comparable calculations were completed for the low fire-rate states. Comparable calculations were completed for the low fire-rate states. The resulting estimates were summed within the age, race, sex categories across high and low fire-rate states to produce a weighted average of deaths by age, sex. and race across the twelve states. The weighted approach was necessary because the high-fire rate states had twice the relative death rates but only half the population of the low fire-rate states. Thus, a simple average would have been inappropriate.[12]

The method for estimating the distribution of smokers was much more stratightforward since the National Center for Health Statistics, (NCHS), supplies such data for smokers aged twenty and above and by agem race and sex. The only complicating factor was the fact that the incidence of teeenage smoking is not estimated in the NCHS data and

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[7] *The data in lhis study should be reasonably reliable Since records were gathered lor every non-motor vehicle lire fatality for a one year period in the tweive states. Although the reporting periods differed (July to June or January to December (due to reporting differences in some of the states. there is no reason to expect that this would bias the results. The high fire rate states were Alabama. Arkansas, Georgia, Mississippi, Oklahoma and Tennessee The low lire rate states were California, Connecticut, Delaware, Florrda, Utah, and Wisconsin Subsequent analysis shows that in 1981, lour of the* **six** *high rate states ranked above the median in fire incidents and that four of the* **six** *iow fire rate states ranked below the median on the same measure (FUS, 1981, A42) Apparently the fire ranks are not entirely stable from year to year*

[8] *Hall and Helzer warn that age, sex and race crosstabulations should be treated with caution since the incidence of death calculations were based on small numbers of cases. This note of caution is worth bearing in mind, Since the calculations we perform rely on this data. In our defense, we aggregate the data lrom the high and low fire rate slates by calculating weighted averages based on 1980 census population count of each state. Thus. the small sample size problem occurring in Some cells* **is** *diminished somewhat*

[9] *Since Hall and Helzer examined those who died in cigarette caused Ires as opposed to those who started and died in cigarette caused fires, it can be argued that the data are not completely reliable regarding the characteristics of firestarters. Haii and Helzer state however. "smoking fire death rates tend to grow steadily with age. This suggests that most of the people dyrng in smoking-related Ires are the smokers whose cigarattes ignited the tires. and so the young-child peak is eliminated by the fact that the young children do not smoke" (p 14.) This conclusion may have to be tempered somewhat because. in the study of deaths from fires completed in Maryland, Berl and Halpin (1979) presented data that showed 135 smoking caused tires resulted in 184 deaths, an average of 1.36 deaths per fire. This data indicates that there is a substantial chance that the smoker is not the oniy person who will die in a fire. What really may be going on in multiple death smoking caused* **fires. 6** *that those who die generally include the smoker and his or her family We were not able to locate data on the percentage of smoking caused Ires that are single death fires.*

Because these are the only data on the age, race and **sex** *of those killed in smoking caused fires, they were treated as if all of those who died were smokers. While being able to remove non-smoking victims of smoking caused fires would change the size of our estimates. it should have no effect on the estimates of the differences between groups of smokers regarding their chances of dying in smoking caused fires (This assumes, 01 course, that the population of non-smoking victims of smoking caused hres is similar to that of the smoker victims)*

[10] *The Hall and Helzer data consisted of five age group categories. (<5, 5-24, 25-44, 45-64, and >64); two race categores (black and all other). two sex categories. Thus, 20 (i.e., 5×2×2) discrete categories existed lor the high and low hie-rate states.*

[11] *This creates an inaccuracy of unknown, but presumably small, size. Hall and Halzer estimated the population in the twelve states at 61.2 million, split 66.3 percent in low (ire rate states and 33.4 percent in high-/Ne-rate states (at p. 3) Using the 1980 census estimates. the population of the tweive states is estimated at 64.8 million, split 66.3 percent in high-rate states and 334 percent in low fire-rate states.*

[12] *It is interesting to note that when the resulting weighted incidence rate is generalized to the national population it is estimated that slightly less than 1,000 people will dre in cigarette caused fires Since the most common estimates are that between 1.500 and 2,000 people die each year in smoking related hies it is apparent that the sample of twelve states is not representative of all 50 states or that the data reporting system is not valid We believe the Hail and Helzer data set was compiled very carefully*

had to be estimated form other data sources.[13] After combining data on teenage smoking with the NCHS data, we developed the joint probability distribution of smokers by age, race and sex.

Before the distribution of firestarters could be compared to that of smokers, one final manipulation of the data was done. This involved an adjustment of the age breakdown data for the less than five year-olds and the five to 24 year-olds age groups. Since the smokers data used age groups starting with seventeen year-olds, we attempted to estimate fire deaths in those less than seventeen and those from seventeen to twenty-four. NFIRS data on cigarette fire caused deaths from 1983 and 1984 was available by age and sex for single year intervals. Based on two years data we were able to estimate the split in deaths between those sixteen years and younger and those seventeen to twenty-four and adjust the Hall and Helzer data.[14] This adjustment provided similar data for the distribution of smokers and the distribution of firestarters.

Main *Results: Smokers and Firestarters*

Table 1 shows the distribution of deaths from fires caused by smoking the distribution of smokers by age race and sex and a ratio that compares these two distributions for each demographic group That table suggests there are strong demographic differences in fire starting with cigarettes as well as in smoking behavior The largest group of smokers is in the 25 44 year old age category White males and females account for over 87 percent of all smokers Black only represent one out of every eight smokers, (12.5 percent), which is quite consistent with their representation in the population. The marginal percentages show that white males account for slightly over one-half (i.e., 53.7 percent) of all deaths from smoking fires and that white females represent almost 30 percent of the victims. Less than eight percent of the victims are sixteen years or younger (and although not shown here, only three percent are less than five years old), The data indicate quite clearly that most victims of cigarette caused fires are adults, and in fact, 63 percent are 45 years or older.

The lowest section of Table 1 shows, for each category. how the ratio of deaths to smokers compares to the ratio for the average category. An entry greater than one indicates a category of smokers with a greater than average change of dying in a smoking caused fire, while a ratio of less than one indicates the opposite. We see disproportionately high entries for smokers 45 years and older, this age group accounts for 35 percent of the smokers and 63 percent of the deaths from smoking caused fires. Black males, black females and white males over 64 also seem particularly likely to benefit from a reduction in ignition propensity, since these three groups represent approximately four percent of the smokers but account for nineteen percent of the victims of smoking caused fires.[15] Among those older smokers black-males have a particularly high ratio (6.43) while white-females exhibit the lowest death to smoker ratio among that age group.[16]

In contrast are the smokers under age 45. As a group. these smokers exhibit a ratio of less than one, i.e., less than the average for all smokers. Especially notable are those between 25 and 44. They are the heaviest smokers (e.g., approximately 30 percent of this group smoke 25 or more cigarettes per day),** but have the lowest comparative ratio of deaths from smoking caused fires to smoking prevalence (.45). The ratios are also particularly low for women smokers under 45 as non of the ratios for white and black females in

[13]*At approximately age seventeen, apprecrable percentages of teenagers begin smoking The data for white-males, black-males. white-females and black-females aged 17-19* is *quite sketchy or old (This is important because smoking patterns in this age group are changing fairly rapidly. For example, 1978 data indicated that 33.4 percen: of males and 30.9 percen: of females aged 17-24 were regular smokers (Advancedata, No. 52 p. 4j Data from the National Institute of Education for 1979, estimated that 193 percent of males and 26.2 percent of females aged 1718 smoked NCHS estimated that among high school students in 1984. 160 percent of males and 205* **percent** *of females "smoked cigarettes daily in the last thirty days." (NCHS, mimeo, Table 3) The data indicated that blacks smoking rate are less than whrtes For example, Remington e: al, (1985) reported that* the *smoking participation rate lor white males aged 18-29 was 34.0 percen:, versus 23 7 percent for* **black** *males in that age group. For white iemales and black females aged 18-29, the corresponding percentages were 349 percent and* 21.1 *percent. respectively It seems clear that while appreciable percentages of 17-19 year-olds* smoke, *the percentages are somewhat smaller than for the 20 24 year-olds It also* seems *clear that a lower percentage of young blacks smoke than do young whites For purposes of this analysis the participation rates of 17-19 year old smokers were estimated at three percent less than comparable percentages for 20-24 year-olds. While admittedly arbitrary this approach results* in *estimates that are consistent with :he smoking patterns lor even younger smokers and with the patterns observed for while-males. black-males, white-females and black-females Thus, although the estimates are arbitrary, they are probably reasonable ?be estimated percentages of teenage smokers by age race and sex are multiplied by 1985 census data to obtain an estimate of the number of* **smokers** *in each* category *This was added to* **the** *estimate of the number of smokers 20-24 to calculate* the *number of smokers between fhe ages of 17 and 24 by race and sex Using this procedure the total number of smokers in the United States* in *1986 is estimated at 51.8 million*

**Since *data were not available by race, we assumed that the incidence rates were equivalent for blacks and whites*

[15]*Older smokeis consume fewer cigarettes per day than do younger smokers,* re *380 percen: smoke fewer than 15 cigarettes per day and 194 percent smoke 25 or more* a *day. On average 308 percent of smokers consume less than 15 and 272 percent smoke* 25 *or more cigarettes per day (NCHS. Health, 86 preliminary data. July 17, 1986) Thus, older* smokers *participate* in *fewer smoking occasions than other smokers and still are involved* in *more fires*

[16]*Although black male smokers 65 and over have the highest death to smoking ratio they account for relatively few deaths per year For example, if there are 2,000 smoking* hie *caused deaths in the United States, approximately sixty elderly* **black** *men would be estimated to die for that cause,* (i *e , 2.000* x *.02943 = 59) This* is *due to the relatively small incidence of* **elderly** *black smokers By contrast, using that same death estimate, 275 white males between 45 and 64 would be estimated to die in smoking caused fires (2,000 × 187419 =5 375) Their death to smoker ratio is much less. (160), but them are so many more while males* in *the population that the absolute number of deaths* is *much greater*

***NCHS1986b*

Table 1. Relative Chances of Smokers Dying In Smoking Caused Fires"

Percent Distribution of Deaths from Smoking Caused Fires

Age	White Male	Black Male	White Female	Black Female	Totals
<16	2.3 %	1.2	3.0	0.9	7.5
17-24	5.6	0.4	2.0	0.3	8.3
25-44	12.4	3.4	3.9	1.3	21.0
45-64	18.7	3.6	13.4	0.9	36.6

Percent Distribution of Smokers

White Age	Black Male	White Male	Black Female	Female	Totals
17-24	7.6010	1.0	8.2	1.1	18.0
25-44	22.0	3.1	18.9	3.2	47.2
45-64	11.7	1.7	11.6	1.6	26.6
>64	3.6	0.5	3.7	0.4	8.2
Totals	45.0	6.3	42.4	6.3	100.0

Ratio of Deaths to Smokers**

Age	White Male	Black Male	White Female	Black Female	Totals
17-24	0.74	0.40	0.24	0.27	0.46
25-44	0.56	1.11	0.21	0.42	0.45
45-64	1.60	2.13	1.15	0.58	1.38
>64	4.00	6.45	1.95	4.82	3.24
Total ratio	1.19	1.85	0.70	0.82	1.00

*Cell entries may not sum to column and row totals due to rounding.

**Each entry in this portion of the table is the ratio of the corresponding entries in the two other portions of the table: e.g., the entry of 1.15 for white females of ages 45-64 is the ratio of 13.4 to 11.6, which are the other two entries for white females of ages 45-64.

these age groups is greater than 1. Thus younger smokers will apparently benefit the least (at present) from reduced flammability cigarettes.[18]

Unfortunately, little is known about those who are involved in both smoking and fires, beyond age, sex, and race. Very little hard data exists about other demographic or socieco-monic characteristics of those who actually start fires with cigarettes. Since smoking participation rates vary inversely with education and income,[19] it can be hypothesized that a relatively greater percentage of those who smoke, and thus, of those who start fires are in lower socioeconomic groups. In the Toledo study, Gunther found an inverse relationship between median household income and smoking fires.[20] Karter and Donner (1978) found that in Newark, Phoenix and Toledo the percentage of persons below the poverty level in a census tract was directly related to the number of fires started. These data were not restricted to smoking caused fires, however.** Therefore. although there is some evidence that firestarters are relatively less educated and less wealthy, the extant data are by no means conclusive.

[18] *The fact that the 25-44 year old group represents the largest category of smokers is due primarily to the 'baby boom" cohort rather than lo increased smoking participation rates. Although a larger percenlage of members of lhis age group smoke (35 percent of lhose belween 25 and 44 are smokers, versus slightly over 30 percent of all lhose 20 years and older), lhe fact thal 44 percent of the population over twenty years old is in this age group is a much more important reason why 47 percent of all smokers are between 25 and 44.*

This may indicate thal in the nexl ten or twenty years the number of deaths caused by smoking Ires will increase substantially as these baby boomers enter the prime firestarter years. For example, given the same death rates per million lor those 45 and over in lhe year 2.000 as exist at presenl. it would be expected that approximately 1.200, (95 7 million x 13.5/million death rate) smokers aged 45 and older would die in smoking caused fires as compared to 950 at present (These calculations assume that 1.500 people annually die in smoking caused Ires: if the lrue number is higher or lower lhe projected numbers would change accordingly It is also assumed tha! lhere are no changes in smoking participation rales. use of smoke defectors and so on Population forecasts for year 2.000 by age group are contained in American Demographics, January 1986, p 58)

[19] *Remington et al. 1985. Health – United States, 1982; Advancedata 1986, no. 118.*

[20] *Gunther (1981) at p. 56*

[21] *Karter and Donner (1978) at pps. 62-64.*

3. Reduced Flammability Cigarettes

In this section we are concerned with the ways in which cigarettes might be changed to reduce their propensity to cause fires, and how these changes would affect smoking behavior. Unfortunately. almost nothing is known about what the nature of future reduced flammability cigarettes. Current publicly available research is apparently limited to that prompted by the Cigarette Safety Act of 1984. National Bureau of Standards test results using current brands suggests that at least five characteristics may significantly affect flammability:

(a) Lower density tobacco
(b) Smaller diameter
(c) Lower paper porosity
(d) increased burley tobacco
(e) Use of filters.

In addition, we understand there is some possibility that adding a silica gel to the tobacco in cigarettes may reduce ignition propensity, perhaps without requiring substantial changes in the above attributes.

The extent to which reduced flammability cigarettes would involve changes in these factors is unknown at the present time. There are no specific new cigarettes. such that we can take into account their attributes so as to predict smoker behavior and market adjustments. What we can provide is qualitative analysis, enhanced by some purely illustrative quantitative examples. We shall concentrate on the expected kinds of changes in smoking characteristics of cigarettes, and their effects on smoking behavior and levels of satisfaction. In a later section, the findings on consumer behavior will be used to predict overall market effects.

Before describing specific changes, however, we wish to emphasize a general point about markets. Market forces often transform regulatory initiatives into something other than what was intended by regulators. There is a difference between the kinds of cigarettes one has in mind when describing the best means for constructing reduced flammability cigarettes. and the kinds of cigarettes that will eventually emerge from the varied forces that shape the cigarette market. Adjustments by manufacturers and, particularly, by consumers, could result in the market producing a mix of cigarettes quite different from what a regulator might have in mind at the beginning. For example, even if regulations specified exactly the minimum construction requirements to insure a given less of flammability, sellers can be expected to adjust other, unregulated aspects so as to maintain taste and tar and nicotine yield. New tar and nicotine ratings would be provided by the Federal Trade Commission (FTC), and smokers would switch brands in accordance to their own preferences for taste and tar and nicotine yield. Thus average cigarette flammability might be as intended, but other characteristics could be quite different. To the extent that the regulations specified design standards rather than the flammability standards,[22] even flammability might end up being quite different than envisioned.

It is useful to think in terms of two basic techniques for reducing the flammability of cigarettes, One is to ensure that unattended cigarettes do not burn long enough to start a fire when left on an inflammable surface. Cigarettes with this property are "self-extinguishing" cigarettes. The second method is to reduce the propensity to start a fire while the cigarette is burning. Such cigarettes have "reduced ignition propensities." The two kinds have somewhat implications for consumer behavior and satisfaction.

'Self-Extinguishing" Cigarettes

The effect of self~extinguishing cigarettes on smoker behavior depends primarily on four factors: price, taste, smoking characteristics (especially, the time allowed between puffs) and changes in the ingestion of health-related ingredients such as tar, nicotine and carbon monoxide. Price changes are dealt with elsewhere. Taste changes are impossible to assess without more information; it is possible that taste will not be appreciably worse in these cigarettes than in current varieties, perhaps because of the addition of new flavor enhancers. Smoking characteristics and health~related ingredients remain to be considered. The two aspects are interrelated, because the manner in which smokers change smoking habits to counteract the tendency to self-extinguish may affect how much tar, nicotine and carbon monoxide are ingested.

[22] See later section on these two approaches to regulating flammability.

The essential feature of self-extinguishing cigarettes is a tendency to go out if left unpuffed for a modest period of time. Available data on puff frequency, duration and volume indicate that smokers puff approximately every 40 to 60 seconds,[23] that there is a wide variation within and across smokers,[24] that the average puff duration is between two and three seconds,[25] and that smokers take between nine and twelve puffs on average per cigarette.[26] Thus if new cigarettes self-extinguish within. say, 60 seconds, many smokers would either puff more frequently or relight occasionally.

It seems likely that smokers will increase puff frequency to avoid the annoyance of a cigarette that self-extinguishes, just as smokers now puff more frequently to compensate for reduced tar and nicotine. If so, more smoke would go into the lungs of the smoker, and less into the ambient environment. Thus self-extinguishing cigarettes could dramatically increase tar and nicotine consumption. For example, Kozlowski (1981) estimated that increasing puff frequency increases tar delivery by 58 percent or more.[27]

Changes in cigarette construction or ingredients are another possible cause of increased tar and nicotine ingestion. We understand that self-extinguishing cigarettes are likely to have reduced paper porosity and/or increased tobacco density.[28] Less porous paper will cause less dilution of the smoke with air, and will therefore increase the extent to which smokers inhale undiluted smoke. The effect could be substantial. Kozlowski estimates that an ultra low tar cigarette (i.e., 1 mg of tar) is designed (although not necessarily smoked) so that as much as 80 percent of the smoke in each puff consists of diluting air.[29] In addition. more densely packed cigarettes exhibit a slower burn rate and this. too. may result in increased tar levels.

To some extent, changes in cigarette characteristics will be reflected in FTC tar and nicotine ratings. But the effects of such changes in smoking behavior as puff frequency and puff duration are unlikely to be captured by the FTC rating system The FTCs system has not been altered in twenty years since its inception, despite the well-documented existence of compensatory smoking behavior that sometimes makes FTC ratings inaccurate, and it is unclear whether changes will arrive soon.[30] These problems with the FTC system could be compounded by self~extinguishing cigarettes could even render ultra-low tar cigarettes (those yielding roughly 1 to 5 mg of tar) obsolete. These cigarettes use extremely porous paper (and filters), and contain 'kxpanded tobacco that is "puffed to reduce density. Requiring that tobacco be denser and that wrapping paper be less porous may therefore remove the least harmful type of cigarette from the market.[31] Thus requiring that cigarettes self-extinguish could result in smokers ingesting more tar. As we shall note below in the discussion in section 5 of likely changes in tar and nicotine yield, the health effects of increased tar yield would probably be substantial.

Reduced Ignition Propensity Cigarettes

Reduced ignition propensity cigarettes will probably be thinner, faster burning, longer, covered with thicker and more porous paper, and made of expanded tobacco. We understand cigarette tobacco may also be coated with a neutral tasting silica gel so as to create a cigarette that does not self-extinguish while being smoked but does if placed on a substrate. Such a design could *may* curtail the need for the other modifications.[32] Since little is known about this product at this time. including its performance taste and carcinogenic properties, this analysis concentrates on other changes designed to reduce ignition propensity.

To the extent that these cigarettes burn faster, without an offsetting increase in length, smokers may tend to puff more frequently. as has happened with low-tar cigarettes that burn faster.[33] This would perhaps not affect actual ingestion of tar and nicotine, but it could affect FTC measurements, since the FTCs machines smoke at a constant pace.[34]

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[23] *Creighton and Lewis 7977 p. 292; Comer and Creighton 1977, p. 79, Guillerm and Radziszewski 1977, Rawbone, Murphy Tate and Kane 1977 p. 187*

[24] *Guillerm and Radziszewski (1977) found that the* time *between puffs ranges from 23 to 115 seconds (with* a mean *puff frequency* of *40 seconds).* in *a study of eight smokers conducted over a seven day period.*

[25] *Creighton and Lewis 1972*

[27] *Altering puff frequency is one* of ***a*** *number* of *ways* in *which smokers "compensate" for changes in cigareite content and construction. The general problem* of *compensation is discussed briefly below* in *section 5,* in *the subsection on changes in tar and nicotine yield*

[28] *We consider the possibility of a cigarette using silica* ***gel*** *later* in *the Section on reduced ignitron propensity cigarettes*

[29] *Kozlowski, n.d , p. 8.*

[30] *Calfee 1987*

[31] *See e g.. Benowitz 1986 on the apparent effectiveness of "ultra low" tar brands*

[32] *See Ruegg, Weber and Lippiatt, "Crgarette Ignition Propensity:* ***A*** *benefit-cost study, Second progress report." National Bureau of Standards, July 31, 1986* **As** *noted above, little* is *known about the silica gel additive From the smokers' perspective, the effects* of *the additive on taste and on tar and nicotine content of the cigarette are obviously important, as are any harmful proprrties of the gel itself when consumed in the form* of *smoke. Since we know* so *little about this additive, it would be* unwise *for us to speculate about its effects on consumer demand, other than* to state *thai it is obvious thai if the silica gel changes the taste of the product dramatically or has adverse health consequences. consumer satisfaction will be drminrshed.*

[33] *Kozlowski (1981)*

[34] *Kozlowski (1981)*

The primary factor of concern (other than increased costs which are discussed elsewhere). involves changes in cigarette construction and/or ingredients. especially the increased use of expanded tobacco. Expanded tobacco is used today in a large proportion of cigarettes manufacturered, including most low tar brands which account for well over fifty percent of the total cigarette market [35] Increasing use of expanded tobacco would tend to further decrease average tar and nicotine content. which is just the opposite effect from what is expected from self-extinguishing cigarettes We note, however, that the ppractical effect could be small. or could be concentrated in only a few segments of the market This is because some brands may already contain the necessary amount of expanded tobacco. and other brands may alter other ingredients so as to offset the tar-reducing tendencies of expanded tobacco.

The major design change (besides the silica gel) that could adversely influence cigarette taste is increased paper thickness. We understand that taste is also influenced by the amount of paper being burned relative to the amount of tobacco To the extent flavorings can be used to mask the paper taste. which is possible to some extent, then cigarette taste will be relatively unaffected.[36] Tar yield is relatively unaffected.[37] Finally. costs may go down, because less tobacco is required.

[35] *Maxwell Report 1981 Apparently most if not all low tar cigarettes use expanded tobacco We are not aware of the percentage of total cigarette Sales that employ expanded tobacco*

[36] *Lago 1986*

[37] *We have not located any literature on whether cigarette paper itself contributes noticeably to the tar delivered by cigarettes We suspect it does not But if it does or if tobacco is used in the cigarette wrapping then increasing paper thickness could have an effect on tar and nicotine content*

4. Ways to Implement New Cigarettes

The effects of reduced fire propensity cigarettes on net benefits to smokers, number of fires. and other factors depend strongly on the manner in which the changed cigarettes make their way into the market. Mandated changes will work differently from "voluntary" ones. Moreover, if the government is to require changes, there are quite different methods for doing so.

We analyze briefly here both mandatory and "voluntary" approaches, concentrating on the aspects that will impinge upon estimation of net benefits to smokers.

Mandated Changes

The nature of changed cigarettes is discussed elsewhere. Here, we concentrate on the interactions between the manner in which changes are implemented and the incentives of producers. It is clear that the more in accord are regulation and market incentives, the more likely the regulations will be followed. Less obvious is the fact that some kinds of regulation are much more compatible with incentives than others, and that taking this into account can improve the degree to which regulatory goals are achieved.[38]

In the present context, there would be a choice between requiring that cigarettes be made a certain way (paper thickness, tobacco weight, and so on), as opposed to requiring the cigarettes perform in a certain manner (for example, extinguish within forty seconds of being placed on a standard textile surface.) This first approach may be referred to as design or input standards, and the second, performance standards.

Performance standards offer considerable advantages. Chief among these are that this method more thoroughly harnesses competitive market forces in support of the purposes of introducing the new cigarettes. Firms would be free to achieve the same effects using new methods that could reduce costs, improve the trade-offs between flammability and other features such as tar content, or even improve upon flammability itself. Also competitive forces could easily be superior to regulatory action in dealing with the effects of consumer preferences among the new and old cigarette attributes; these preferences are essentially unknown and could produce unanticipated results from regulation

A disadvantage of the performance standard approach is inherent in its main advantage. The market may eventually compete so exclusively on the exact attributes of the performance standards that the results could be perverse, although the adverse effects may be slow to emerge. For example, product development could concentrate on techniques that work well with the particular textiles used in tests but work poorly with other surfaces. The experience with the Federal Trade Commission's tar and nicotine measurement service has shown that this could happen.[39] If new cigarettes are required and performance standards are used, the problem of competing for the favors of the testing machines should be kept in mind.

'Voluntary" Changes

Cigarettes may become less prone to cause fires even if no regulations are promulgated Methods for manufacturing safer cigarettes may arise from federal efforts or indepen dently and the new cigarettes may find a place in the market We discuss here some of the factors (besides the nature of the cigarettes themselves) that will determine how the market adjusts to the availability of reduced flammability cigarettes

The role of advertising and information

Consumers will choose among old and new cigarettes on the basis of what they know about the alternatives available Information on new cigarettes can come from three sources: from government, from third parties such as health authorities. the news media, or consumer magazines. and from sellers themselves through advertising. All these sources can be important. but we think that advertising can play the most important role in providing information on new cigarettes. Reduced flammability cigarettes will offer sellers an opportu-

[38] *This point is elaborated in Rubin and Cohen (1985)*

[39] *Calfee (1987).*

nity to gain market share. This is typically achieved through advertising. In the past, competitive instincts have frequently led smaller firms to try to gain market share by agressively promoting new cigarettes.

Moreover, the cigarette market has a long history of using health concerns in advertising as a competitive tool. History has also shown that market shares can change very rapidly when new health information is reflected in advertising. This happened in the 1950s, when advertising helped shape consumers' reactions to information of cancer dangers and the importance of reducing tar content.[40] It is likely to happen again in connection with reduced flammability cigarettes, since the new cigarettes will have little advantage other than in connection with fires. Under the "voluntary" approach, individual brands would have an incentive to make smokers aware of fire danger, in order to sell reduced flammability cigarettes. This incentive would not exist if all cigarettes were required to be reduced in flammability. Also, the advertising could be targeted at high fire-risk smokers.

Substantiation of advertising claims about fire safety

Cigarette advertising has traditionally been closely regulated by the FTC and by legislation. Advertising claims must be substantiated, i.e., the advertiser must rely upon a reasonable basis for the claim.[41] The level of substantiation that would be required for a claim that a cigarette is less likely to cause fires is uncertain, although presumably a finding to this effect by the National Bureau of Standards would be sufficient. Where problems would arise is with cigarettes that are new and relatively untried, perhaps because they incorporate new techniques for reducing flammability while avoiding increases in tar and nicotine yield. Regular testing by the NBS. somewhat analogous to testing of tar and nicotine now conducted by the FTC, could provide a convenient benchmark for all reduced flammability advertising. To require that manufacturers use only the government standard could be counter-productive, however, in view of the distortions that have arisen in use of the FTCs tar and nicotine tests.[42]

[40] *See Calfee (1985) describing the sales drop of 1953 54 when cigarette companies engaged in "fear advertising" during the "cancer scare," and the rapid improvement in filter cigarettes during heavily advertised "tar derby" of 1957-59.*

[41] *See Ford and Calfee, 1986.*

[42] *See Calfee. forthcoming 1987*

Mandated Versus Voluntary" Standards

The advantages of mandated standards

The main advantage of requiring reduced flammability cigarettes, rather than simply allowing such cigarettes to find their natural place in the market, is to reduce the costs of fires caused by smokers who do not bear or take into account the full costs of the fires. The extent to which fire dangers of smoking are a significant negative externality of this sort is not known. Nonetheless, if smokers do impose substantial fire costs on others, mandatory standards would have the desirable effect of reducing those costs to others, while raising overall costs of smoking for smokers as a group.

Certain other potential advantages of mandated standards are less obvious. If smokers are poorly informed on the risks of fires. mandatory flammatory standards could force smokers to make approximately the choices they would have made if they had known the risks. This by itself is not a compelling argument in favor of mandatory standards, however. A simpler solution would be to provide the information to smokers, and let those smokers at greatest risk choose accordingly.

Another potential advantage of mandatory standards is more subtle. If smokers who are most at risk from fires — i.e., those who tend to smoke in bed or fall asleep when smoking — learn that the cigarettes they smoke are less flammable than before, they will tend to be less careful. Assuming that even the improved cigarettes involve some fire risk, this adjustment by risky smokers would tend to reduce the advantages of the new cigarettes. If reduced flammability cigarettes were required, rather than left to the market, this undesirable adjustment by smokers might be attenuated. There would be no need for an informational campaign to make smokers aware of fire dangers, and cigarette companies would have little reason to advertise reduced flammability, On the other hand, some publicity on flammability would undoubtedly accompany the switch in cigarettes, and there is no reason to think smokers would long remain ignorant of the convenient fact that the Cigarettes were safer in certain situations.

The advantages of voluntary standards

The potential advantages of using market forces to determine the flammability of cigarettes fall roughly into two categories: greater freedom for consumers and greater incentives for producers to create the best mix of cigarette types. We have seen that smokers vary considerably by age, race and sex in their apparent risk of dying in smoke-related fires. This suggests that reduced flammability cigarettes would be far more valuable to some consumers than to others. Market forces would tend to direct improved cigarettes at these persons, and avoid imposing the costs of reduced flammability cigarettes on all smokers, even those with little fire risk.

Perhaps more important would be market adjustments to tar and nicotine content. It seems likely that reduced flammability will involve increases in tar, nicotine, and other health-related ingredients. Thus the new cigarettes may involve a trade-off between fire risks and health risks For some persons, such as relatively young smokers who are at little risk from fires, the appropriate trade-off might be in favor of minimal tar and nicotine, while for others. such as the elderly, the best trade-off might be an increase in tar and nicotine accompanied by reduced fire danger

These considerations suggest that the voluntary approach would have several advantages Smokers would be able to choose their preferred mix of fire safety and other dangers Producers would have an incentive to develop and market an appropriate variety of such cigarettes. Moreover, the process of marketing the new reduced flammability cigarettes would probably involve providing useful information to smokers on fire dangers and other topics.

Finally changing the market by means of competitive forces rather than by regulation offers the great advantage of allowing consumers to reveal their valuation of the changes If the new cigarettes do not sell or sell well only in a restricted market the reason could be that they offer little of value to most persons Perhaps the cigarettes would be less effective in fire prevention than anticipated Perhaps the cost in terms of tar and nicotine would be greater than expected In a relatively free market a flawed experiment with reduced flammability cigarettes would be naturally self limiting On the other hand if the cigarettes are required vested interests in required product attributes could arise and these interests may be difficult to dislodge even when something better comes along

5. Expected Market Changes

The market effects of reduced flammability cigarettes may include changes in prices, sales, tar and nicotine yield of cigarettes. the manner in which smokers smoke and the extent to which smokers take precautions against starting fires. In discussing these potential changes, we pay particular attention to the distinction between directly observable market changes, such as sales and measured tar and nicotine yield, and unobservable changes, such as variations in the manner of smoking and in precautions against setting fires.

We cannot predict in quantitative terms any of these changes. We lack data on the nature of the new cigarettes, and even if we had such data, we lack information on how smokers are likely to react to the changes in cigarettes. What we can do is point out some of the likely changes in qualitative terms, and describe some factors that will help determine what happens.

Before discussing specific factors, we note a general point. The cigarette market has a long history of rapid change in the face of new circumstances. The taste of cigarettes, for example, has evolved greatly, beginning with the development of the blend that first made Camel brand successful after World War I, and continuing to the present day, as flavor is modified to offset reductions in tar and nicotine. Some modifications have apparently been made in response to changes in consumer preferences, as when cigarettes increased in length from 70 to 85 millimeters after World War II, and later, from 85 to 100 mm or more. More striking were the events of the 1950s when spontaneous health~related advertising and "tar derbies" permanently altered the mix of cigarettes available.[43] Thus we know that competitive forces can being rapid changes in the cigarette market.

The rapidity with which competition will bring change, and the final results, will depend on a number of factors. These include the factors already discussed: the nature of the cigarettes (self-extinguishing, reduced ignition propensity, changes in burning characteristics, changes in taste and in tar and nicotine content), the exact manner in which new cigarettes are introduced (design standards, performance standards, no mandatory standards), the nature of consumer information about changes in flammability and tar/nicotine yield, and cost increases. These factors will naturally interact over time. For example, the relations between flammability, tar and nicotine yield, and cost increases. These factors will naturally interact over time. For example, the relations between flammability, tar and nicotine yield. and taste may change in response to new technology and market demand. In addition. market forces will be affected by changes in consumer behavior, and vice versa, so the factors discussed in this section, on observable market changes, depend partly on those described in the next section. which is on smoker behavior.

Since we lack information on many of these specific factors, as well as reliable predictions of how they interact. we can do no more than suggest how the market will look after reduced flammability cigarettes are introduced.

Price Changes

An increase in the costs of cigarette production. due to reduced flammability requirements. would operate very much like an increased cigarette tax. Recent analyses of the response of the cigarette market to past tax increases have generally concluded that prices adjust by about the amount of the tax increase, which is what one would expect in a market that is roughly competitive.[44] We think it likely, therefore, that cigarette prices would increase by the full amount of any increase in costs, but no more.

Changes In Overall Market Demand

Estimating overall demand for reduced flammability cigarettes is difficult because we know so little about the cigarettes themselves. Demand will be influenced by price. smoking characteristics (such as need to relight. strength of

[43] *See Calfee (1985)*

[44] *For example, Barzel found a tax elasticity of price of +1.065, which he ascribed io unmeasured qualify changes rather than non-marginal cost pricing [Porter at p 456.] Also see Sumner (1981), and the review in Porter,* 1986, a! *pp 456-458*

"draw" necessary to pull smoke through the filter, and so on), taste and potency of cigarette smoke (determined by tar. nicotine, flavorings, and degree of dilution with air), perceived flammability, and perceived changes in health-related ingredients such as tar and nicotine.

Of these factors, only the influence of price is straightforward. A number of studies have attempted to assess the price elasticity of demand for igarettes. The findings generally range from around −0.22 to about −1.20. with a cluster at roughly −0.50.[45] This suggests that a two percent increase in price would cause about a one percent decrease in overall sales. This prediction should be treated with caution. For one thing, some investigators have found that response to price changes varies substantially among socio-economic groups, and overall changes in demand consists partly of changes in the decistion to take up smoking or quit, especially among youths.[46] Thus response to pride changes may be concentrated in certain groups, and long-run effects may differ from short-run effects.

We can assume that changes in cigarette taste and smoking characteristics will also tend to reduce demand. The question is the magnitude of effects. Unfortunately, we know neither the likely changes in cigarettes, nor how smokers are likely to react to these changes.[47] In theory, reductions in smoking quality can be treated as equivalent to price increases. the price increase being roughly what one would have to pay a smoker to smoke the reduced flammability brand instead of his old brand – or, somewhat equivalently, what the smoker would pay for the privilege of sticking with the old brand.[48]

One thing that seems clear is that self-extinguishing cigarettes are likely to dampen demand more than reduced ignition types. Self-extinguishing brands would be more inconvenient to smoke, would tend to produce larger tar and nicotine ratings because of the way they are constructed and the kinds of tobacco they would contain, and would tend to yield even more tar and nicotine because of the faster puffing that would be encouraged.

It is most difficult to guess the magnitude of these effects on demand. On one extreme would be a cigarette that is virtually unchanged from current varieties except for a special coating that reduces ignition propensity. Then most of the effect on demand would come through higher price, which is likely to be a small change in view of the fact that most of the price of current cigarettes reflect factors other than direct manufacturing costs. If costs were to increase by, say, two percent (about two cents per package), demand would decline by roughly half that (assuming a price elasticity of −0.5), or one percent. At the other extreme would be a cigarette that costs more to produce, is distasteful, yields more tar and nicotine, and is inconvenient to deal with (because of self-extinguishing.)One could easily imagine that if all cigarettes were changed in this manner, sales would decline substantially.

If reduced flammability cigarettes are introduced voluntarily rather than through mandated standards, there seems little reason to expect substantial decreases in demand. The fact that the new cigarettes are safer to smoke in bed, would tend to cause a slight increase in demand. There seems no reason, however, to think this effect (which would operate regardless of whether standards are mandatory or voluntary) would be substantial.

Changes in Tar, Nicotine, and Other Health-Related Ingredients

The effect of reduced flammability cigarettes on tar and nicotine yield can be broken into two parts: changes in measured yield, as documented by the FTCs smoking machines. and additional changes – uncaptured by the FTCs measurement methods – that occur as a result of smokers' 'tompensation," i.e., adjustments in smoking behavior in response to changed characteristics of cigarettes. We begin with changes in measured yield.

Again we must emphasize that we lack data not only on the construction of reduced flammability cigarettes, but also on exactly how changes in construction would affect measured tar and nicotine yield. A few points are relatively clear, however. Self-extinguishing cigarettes (those which are designed to go out if not puffed frequently) could increase tar and nicotine yield substantially, because such cigarettes would probably employ reduced paper porosity and/or increased tobacco density. As we noted in section 3, both these techniques tend to reverse changes that have been used to reduce tar and nicotine in smoke.

On the other hand, reduced ignition cigarettes (those designed to avoid starting fires when placed on a substrate) would tend to work in the opposite direction. These cigarettes would probably be faster burning and therfore yield fewer puffs per unit length. If the cigarettes were not lengthened proportionately, they would probably produce improved tar and nicotine ratings since FTCs smoking

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[45] *For example Lyon and Simon (1968) estimated a price elasticity of −0,511. Vernon, Rives, and Naylor (1969), looking tobacco prices estimated a price elasticity of −0.43. Ippolito, Murphy and Sant (1979) found a value of −0.81. and Ippolito and ippoiito (1984), −0.48 Schneider, Benjamin and Murphy (1981) found a iarger value of around −1.22. whereas Porter (1986) found much smaller values of around −0.25.*

[46] *Lewitt and Coate, 1982.*

[47] *The demand for new products can be forecast by collecting empirical data about likely consumer acceptance through a variety of methods including focus groups, experiments, surveys and other means or through using information about the demand for other similar products We were not aware of any available empirical data that could be used to help forecast the demand for reduced ignition propensity or self-extinguishing cigarettes, nor did we have the funds to gather our own. Similarly, we were not able to identify any products. services or situations that were similar enough to this product to help us forecast demand.*

[48] *Cf. the approach in Ippolito and Ippolito (1984).*

machines puff at a constant rate. It is well known that many current low-tar brands achieve their low ratings partly because of fewer puffs on the FTCs machines.[49]

Changes that affect the yield of individual brands will not be translated directly into changes in yield for cigarettes in the aggregated, however. Smokers are aware of the health hazards of smoking,[50] and take these hazards into account in their decisions on how much to smoke and what type of cigarette to smoke.[51] Smokers will switch brands in response to changes in yield (as well as changes in taste and smoking characteristics.) Thus if, for example, all brands were required to make changes that increased yield. smokers would presumably switch to brands that resembled what they had previously smoked, or brands would alter other aspects of cigarette construction to reach their former ratings. Thus the main effect of changes that tend to increase yield would probably be on the lower range of existing yields As we noted earlier, the primary effect of implementing self-extinguishing cigarettes would be to eliminate the very lowest yield brands (the "ultra-low" brands[52]) while leaving other brands relatively unaffected.

Smoker 'tompensation" – i.e, changes in smoking behavior that occur in response to changed cigarettes but may not be captured by the FTCs smoking machines – can be as great or greater than the changes already discussed. Both kinds of cigarettes – self-extinguishing and reduced ignition – could be affected substantially, since both types would encourage smokers to puff more rapidly than the FTC smoking machines. These and other types of unrecorded compensatory behavior could easily distort measured ratings of tar and nicotine yield[53] The degradation in self-extinguishing cigarettes could be worse than suggested by ratings. and the improvements in reduced ignition types could be illusory. On the other hand, if the method of treating tobacco with a silica gel so as to promote self-extinguishing on a substrate but not an ashtray proves to be successful. many of these problems would not occur.

Methods of implementing reduced flammability cigarettes would also make an important difference. If new cigarettes are mandated, using performance standards instead of design standards would allow more freedom to adjust tar and nicotine along with flammability, and might prevent some adverse developments If standards are voluntary instead of required, smokers who are relatively more at risk from fires than from long-term health effects of smoking (for example. elderly persons who smoke only moderately) may choose different cigarettes from those with opposite concerns

Finally, we note that increases in tar yield, whether intended or not, could have health consequences equal to or greater than those associated with fires started by cigarettes. Epidemiological studies strongly indicate that past reductions in tar yield substantially reduced the incidence of lung cancer.[54] Given the relatively small number of deaths associated with fires started by cigarettes. and the apparently large number of lung cancer deaths associated with smoking. even a modest increase in lung cancer rates could offset a dramatic reduction in fire deaths

Changes in Taking Precautions Against Fires

Smokers who knowingly smoke reduced flammability cigarettes may alter their behavior toward fire prevention. Smokers presumably choose a level of precaution that balances the risks of fires reduced, many persons may smoke in situations where formerly they avoided smoking – in bed. for example, or when about to fall asleep in a chair One effect would be simply an increase in overall cigarette consumption. although this effect seems likely to be slight

More important. perhaps, is the potential impact *on* fire prevention. To the extent that people become less careful, the deffect of safer cigarettes will be diluted – unless the cigarettes are completely safe, of course, which seems unlikely. In theory. there could actually be a net increase in fires (presumably offset by a great increase in the conveniences of smoking), rather than the intended decrease We see no reason to expect such a drastic effect. however But it is possible that the net effect of reduced flammability cigarettes on fires could be less than predicted because of changes in consumer behavior

[49] *Kozlowski (1981)*

[50] *Recent National Institutes of Health survey data indicate fhat the following proportions of the population are aware fhal smoking increases risk for these drseases lung cancer, 95%, emphysema, 92%, heart disease, 91%. cancer of fhe larynx. 88%, chronic bronchitis. 87% cancer of the esophagus. 80%, low birth weight of newborn. 80% miscarriage in pregnancy 74% National Center for Health Statistics (1985), pp. 7-8.*

[51] *Jhe most authoritative recent study, which takes into account smokers' taste lor tar and nicotine as well as health concerns. estimated fhat between 1953 and 1980. smokers reduced total per capita nicotine intake by about two-thirds Ippolito and Ippolito (1984). p 62, Table 1*

[52] *Benowitz, et al (1986)*

[53] *The literature on compensation is extensive and somewhat mixed in its assessment of overall effects on what actually reaches smokers' lungs Some of this research is summarized in US Public Health Service 1984, chapter 6, and more recently in Calfee (1986) at n 119, and Calfee (1987)*

[54] *Lee and Garfinkel (1981). Lubin, et al (1984), Participants in the Fourth Scarborough Conference on Preventive Medicine (1985), Peto (1985)*

6. Changes in Net Benefits to Smokers (Consumer Surplus)

"Consumers' surplus" is a technical term that refers to the value that consumers obtain from a product, beyond what they pay for the product. It is roughly the difference between what is actually paid and what individuals would have paid for the product. Competitive markets, in which all consumers pay the same price regardless of how much the desire the product, can produce large amounts of consumer surplus. This can be usual downward-sloping demand curve. Regulatory policies are commonly judged partly by their effects on consumer surplus, since consumer surplus represents net costs and benefits to the consumer of the product in question.

Consumer surplus is affected by changes in price or shifts in the demand curve itself. The introduction of reduced flammability cigarettes would raise prices and would tend to shift the demand curve as the result of three factors: perceived effects of fire safety, perceived effects on health (from changed tar and nicotine), and changes in taste and smoking characteristics. In principle, the changes in consumer surplus for all these factors, plus whatever costs are not taken into account by smokers, would tell us the net benefits or costs of introducing the new cigarettes. Two of these factors. fire costs and health effects, are being dealt with in other reports on reduced flammability cigarettes. Thus we are directly conserned with the effects on consumer surplus of changes in price and smoking characteristics.

Since we do not know how the new cigarettes would be different, nor do we have any data on how smokers would react to the kinds of changes under consideration, we cannot make reliable predictions of the magnitude of changes in consumer surplus. What we can do is perform some hypothetical calculations. This is more easily done for price changes. We assume a price elasticity of –0.5 or –1.00 (which approximates most empirical estimates), and an adult population of about 180 million. The small proportion of consumer income involved allows simple estimates of consumer surplus.[55] In these conditions. a price increase of two percent would reduce consumer surplus by about one percent of current revenues, or about $627 million (If population or prices are changed, the results would change proportionally.)

For changes in cigarette taste or smoking characteristics such as the necessity *to* relight occasionally, all consumer surplus estimates are speculative The only work we are aware that attempts to estimate smokers' value of the taste of cigarettes is the study by Ippolito and Ippolito (1984.) They found that abstracting from health consequences, the average smoker in the year 1980 placed a negative value of approximately fifteen cents per pack on the approximately one-third reduction in nicotine content that had taken place since 1953. Although this result is suggestive, it may reflect primarily the value that smokers place on the psychological and physiological properties of nicotine. These are quite different from the changes in flavoring, draw and other smoking characteristics that might accompany reduced flammability cigarettes. We can offer no more than illustrative calculations. based on the notion that degradation in smoking characteristics could be valued by smokers as equivalent to an increase in price. In that case, Table 1 provides estimates of changes in consumer surplus associated with various perceived price increases.

For similar reasons, the Ippolito and Ippolito study cannot be used to deal with one of the most striking aspects of reduced flammability cigarettes, the possible inconvenience of having to relight occasionally. The most we can say is that it seems plausible that smokers would pay significant amounts to avoid such an inconvenience. Thus again. one can think of the negative aspects of self-extinguishing cigarettes as being roughly equivalent to price increases.

Two other points merit emphasis. One is that our calculations do not take into account changes in either fire occurrence or health aspects of smoking. both of which are dealt with in other reports. Increases in tar yield would shift the demand curve downward, perhaps sharply downward, and this could result in much larger changes in consumer surplus: the effects of reducing the risk of fires would tend in the opposite direction. Finally the use of voluntary rather than mandated standards, could reduce the estimated losses in consumer surplus dramatically by concentrating charged cigarettes in certain socio-economic segments, while leaving the rest of the market relatively unchanged.

[55] *See Willig (1976)*

Table 2. Changes in Consumer Surplus from Price Changes

Table 2. Changes in Consumer Surplus from Price Changes

% change in price	elasticity of demand	price peak	annual consump. per adult	adult pop. in millions	change in consumer surplus" (in mill. $)
1	-0.50	$1.00	175	180	-314
2	-0.50	$1.00	175	180	-627
3	-0.50	$1.00	175	180	-938
4	-0.50	$1.00	175	180	-1247
5	-0.50	$1.00	175	180	-1555
1	-1.00	$1.00	175	180	-313
2	-1.00	$1.00	175	180	-624
3	-1.00	$1.00	175	180	-931
4	-1.00	$1.00	175	180	-1235
5	-1.00	$1.00	175	180	-1536
6	-0.50	$1.00	175	180	-1862
7	-0.50	$1.00	175	180	-2166
8	-0.50	$1.00	175	180	-2470
9	-0.50	$1.00	175	180	-2771
10	-0.50	$1.00	175	180	-3071
12	-0.50	$1.00	175	180	-3667
14	-0.50	$1.00	175	180	-4256
16	-0.50	$1.00	175	180	-4838
18	-0.50	$1.00	175	180	-5415
20	-0.50	$1.00	175	180	-5985
20	-2.00	$1.00	175	180	-5040

* Approximation, assuming linear demand curve and no income effect.[56]

[56] See Willig (1976)

7. Appendix: The Demographic and Socioeconomic Characteristics of Smokers

[redacted]

The National Center for Health Statistics (1986) estimates that over 48 million persons over twenty are current smokers and that almost 40 million more are former smokers.[57] Thus, well over fifty percent of the adult population has at some time been or still is a smoker, undoubtedly making smoking one of the most commonly engaged in behaviors in American society. But despite being one of the most ubiguitous of American activities. fairly large differences exist among various subgroups of the population in terms of the percentages who smoke, the amount smoked and in the kinds of cigarettes that are smoked. This section describes who smokes and who does not, who is quitting and who is starting. Our purpose is to provide a rough description of the characteristics of the future smoking population.

Characteristics of Smokers

As alluded to above and as shown in more detail in Table 3 approximately 53 percent of the U S population were or currently are smokers[58] Overall 62 percent of white males and 56 percent of black males were or are smokers Less than half of all females have tried smoking and as was the pattern for males a greater percentage of white females have smoked than have black females

Table 3. Distribution of U.S. Population by Age, Race, and Sex, July 1, 1985 Ratio of Smokers and Former Smokers to Total

	Males		Females		Totals
Age	White	Black	White	Black	
20-24	0.387	0.294	0.434	0.287	0393
25-34	0.544	0.511	0484	0.427	0508
35-44	0.667	0.612	0.504	0.538	0.584
45-64	0735	0.773	0.509	0.495	0.618
>65	0.697	0.602	0.319	0297	0.466
Totals	0.622	0.560	0.455	0.425	0.530

Examination of the marginal percentages for age reveals that a monotonically increasing percentage of the population has been or currently is a smoker until the 65 or older age cate gory Slightly less than 40 percent of those 20 24 are or were smokers compared to over fifty percent of those aged 25 34 The percentage of those who have smoked or are smokers begins to level off at close to sixty percent for those between 35 and 64 years of age Less than fifty percent of those 65 or older have been or are smokers[59] The individual cells of Table 3 indicate that white females have the highest former or current smoking participation rates of the 20 24 age group From age 25 to 44 a larger

[57] *As noted in the main text if teenagers who are regular Smokers are included !he total number of smokers is closer to 52 million*

[58] *The dafa in the analyses that follow were derived from two sources NCHS smoking dafa lor 1986 whrch will be incorporated into Health 86 and Population estimates derived from the Bureau of Census Since the census estimates are for July 1 1985 and the smoking data are for 1986 the data are slightly inaccurate We do not expect this to represent any major weaknesses in our analysis however. We have limited our analysis to those aged twenty and above*

[59] *The reason there is such a large drop in the percenfages of those 65 and over who arc or were smokers at some time is probably due to the higher mortality rates for smokers than nonsmokers Essentially, nonsmokers live longer than smokers arid this is reflected most dramatically in the mortality rates of those who are at least 65 years old. See, generally Smoking and Health (1979), Table 1. p 2-11 and Table 2, p. 2-12*

percentage of white males have smoked or do smoke than do black males or both groups of females. In the 45-64 age group over three-quarters of black males are or were smokers, as are 73 percent of white males.

The data summarized in Table 3 represents merely a cross-section, albeit based on the most recent information, of the percentage of smokers and former smokers in the population. Longitudinal analysis reveals that for the males the percentage of current smokers has been declining rather steadily since 1955, while simultaneously the percentage of former smokers has been increasing quite steadily. For example, in 1955 the percentage of males who were current smokers was approximately 52 percent and the percentage of former smokers was three percent. By 1975 these percentages became approximately, 40 and 28 percent, respectively.[60] In 1986, the percentage of male current smokers was 33.2 percent while the former smokers were 31.9 percent.[61] If these trends continue, by 1990 for the first time in history, more males will be classified as former smokers than as current smokers.

The data for female smokers follows a similar if less dramatic pattern.[62] This is due, apparently, to two conflicting factors. First, smoking participation rates of women have lagged the smoking patterns of men by 20 to 30 years.[63] In 1955, for example, less than 25 percent of women were current smokers, while by 1965 this percentage had increased to 35 percent, which was just about the peak smoking participation rate for women.[64] Second, just as the smoking participation rates of women were increasing, the first Surgeon General's report on smoking was published (in 1964) and concerns about smoking and adverse health consequences grew. This information apparently influenced decisions to start and stop smoking, with the net result that by 1975 approximately 30 percent of women were current smokers and 15 percent were former smokers.[65] By 1986, 279 percent of women were current smokers and 18.7 percent were former smokers.[66]

Those Who Are Stopping Smoking

To what extent have those who smoked continued or quit? Some data about this question is provided in Table 4, which shows the ratio of the percentage distribution of smokers by age, race, and sex to the percentage distribution of smokers and former smokers on the same variables. A ratio of greater than one indicates that a relatively greater percentage of members of a cell have continued to smoke than have quit.

Table 4. Distribution of U.S. Population by Age, Race, and Sex, July *1*, 1985 Ratio of Smokers and Former Smokers

Age	Males		Females		Totals
	White	Black	White	Black	
20-24	1.339	1.296	1.342	1.586	1.351
25-34	1.177	1.402	1.172	1.450	1.204
35-44	0.951	1.217	1.085	1.332	1.038
45-64	0.776	1.090	1.047	1.219	0.917
>65	0.472	0.789	0.693	0.826	0.580
Totals	0.897	1.185	1.067	1.308	1.000

The data in Table 4 indicates that as smokers age, relatively greater percentages quit than continue. For example, the ratios of the percentages of smokers to the total of current and former smokers are well over 1.0 for those between 20 and 34 and decline monotonically by age group. This indicates that relatively few of those in their twenties who have

[60] *Shopland and Brown (1985.)*
[61] *NCHS (1986.)*
[62] *In a study of smoking initiation and cessation rates lor age cohorts by sex, Harris concludes, "Recent smokrng cessation rates among women thus appear to fail below those of men for age cohort." (Harris, 1983, p. 477)*
[63] *Harris (1983); Loeb, Ernster Warner Abbolls, and Lazlo (1984); Horm and Kessler (1986) at p. 426.*
[64] *Shopland and Brown (1985.)*
[65] *Shopland and Brown (1985.)*

[66] *NCHS (1986) For males smoking participation fates are inversely related lo socioeconomic status. This is especially true for males, as for exampie, in 1981 almost fifty-eight percenl of males with a grade school education were smokers versus less lhan twenty percenl of males wilh a graduate degree (Remington et ai., 1985). Similar findings were reported for occupational categories. i.e., according to lhe Surgeon General's report of 1985, 33 percenf of white collar workers are current smokers versus 47 percent of blue collar employees (Surgeon General 1985, p 25) and smoking participation rates decline monotonically as incomes increase. (NCHS, Supplement lo Advance Data No. 118, 1983, Table 6A.)*

The data for females are not nearly as clear cut. Although smoking participation rates decline as females' income increases, and a lower percentage of wornen with at least Some coiiege education smoke than do women wilh less education, women with less lhan hrgh school education smoke less than do women with a high schooi degree (NCHS, Supplement io Advance Data No. 118, Table 6B). Similarly, although 26.5 percent of women professionals are smokers, 38.3 percent of women managers smoke, compared to 333 percent of women sales workers, 38.1 percent of women blue collar workers and 33.0 percenl of homemakers (Surgeon General 1985, p. 25) Thus, the degree of consistency in smoking participation rates. evidenced by men are not found lor women tried smoking have decided to discontinue the practice. Conversely, relatively more of those 45 and over have decided to quit rather than continue.[67]

Among the race and sex groups, white males are the only group with a ratio of less than one, indicating that they are the only group with relatively higher percentages of quitters than smokers[68] Except for those 65 and older, black males who smoke, and black females in particular, are not quitting in the same rates as are whites

These data are consistent with trend data in other sources For example, the 1983 Surgeon General's report indicated that the percentage of white males who indicated they were current smokers declined steadily from 51 percent to 37 percent, while the percentages of those indicating they were former smokers increased steadily from 21 percent to 32 percent in surveys taken in 1965. 1976 and 1980. This same report also showed that although the percentage of black males who reported being current smokers declined over all three periods, from almost 60 percent to approximately 45 percent, it still remained much higher than for white male smokers. Also. the percentage of black male former smokers was substantially less at approximately 20 percent in 1980.[69]

The data for women indicate that the percentage of both white and black women smokers decreased only slightly from 1965 to 1980, as 34.5 percent of white women and 32.7 of black women smoked in 1965. In 1980 these data were 30 percent and 306 percent for white and black women, respectively.[70] These data also indicate that a smaller percentage of black women are quitting than are white women. In 1980, 16.3 percent of white women and 11.8 percent of black women were former smokers."

[67] These numbers are confounded by the mortality ratios of smokers and former smokers Since former smokers live longer than smokers, the ratios will show relatively more former smokers than would be the case if smokers and former smokers had similar mortality rates This confound is likely to be most pronounced in the oldest age group. in which the differences in mortality rates are most evident. Harrrs (1983, p 474). presents a method far correcting the differential mortality rates of smokers and nonsmokers.

[68] Of course, they are aiso the group with lhe highest percentage of members who have become smokers.

[69] United States Public Health Service (1983,) p 367

[70] United States Public Health (1983,) p 367

[71] United States Public Health Service (7983.) p 367 The Socioeconomic characteristics of those who are quitting smoking are for all intents and purposes the converse of those of smokers Males in higher socioeconomic groups have quit at hrgher rates lhan have males in lower socioeconomic groups when measured in terms of occupation. (Surgeon General 1985. pps 33 40;), and income (NCHS. 7986, Supplement to Advance Data No. 118, Table 6A)

Agarn. for women the data are less consistent By 7980, a greater percentage of women than men professionals smoked, because male professionals had a higher quit rate than did females (Surgeon General 7985, pps 5.38) Nonelheless. lhe percentage of while collar women who smoke decreased from 36 I percent in 1970 to 31 9 percenl in 1980, whrte the percentage of blue collar workers who smoke remained relatively constant over that lime period. and equalled 38 7 percent in 1980 Similarly, in 1980, 33.8 percent of while collar female workers and 24 9 percent of blue collar femaie emptoyees were classified as former smokers (Surgeon General 1985, p 34)

Those Who Are Starting to Smoke

The focus of the preceding discussion was to summarize what is known about the demographic and socioeconomic characteristics of those who smoke and of those who are quitting. To perform a comprehensive analysis of the characteristics of the future smoking population, we require similar information about those who might be described as beginning or new smokers. Unfortunately, we have not been as successful in locating comparable information about new smokers. Specifically, although some information exists about the age, race and sex of teenage and other beginning smokers, little information exists about their socioeconomic characteristics.

One way by which to answer the question of who are the new smokers is to analyze smoking participation rates by age, race and sex in order to learn whether people tend to start smoking when they are teenagers or whether any such findings vary by race and sex. Examination of this data indicates that by age 35 the percentage of current smokers levels off or egins to decline for white males and females Black males and females appear *to* begin smoking at a somewhat older age than do whites. continue adding smokers in larger percentages than whites as they age, and do not quit smoking at as high a rate as do whites. Consequently, their smoking participation rates do not decline until the 45-64 age group for females and 65 years and older group for males.

For whites, it appears that most smokers begin smoking (or begin experimenting with smoking) when they are teenagers or by the time they are twenty-four years old. For example, 31.6 percent of white males and 33.1 percent of white females in the 20 to 24 year old age group, are smokers.[72] Also, based on existing data it was estimated earlier in this report that smoking participation rates were only three percent less in the 17-19 age group than in the 20-24 age group. In contrast, for the 25 to 34 year olds, the percentages of current smokers are 37.3 percent and 32.0 percent for males and females, respectively.[73] Thus, among

[72] NCHS, Health 86. preliminary.

[73] As was noted earlier, white male smokers do not quite in large numbers until they are 35 years old and over For example, only 11 5 percent of white mates and 11 9 percenl of while females in the 20-24 age group are former smokers in the 25-34 age group the corresponding percentages are 20.5 for whrle males and 17.9 ior while iemales By age 44, the percenlage of white males who are former smokers has increased 10 33.6 percent and it increases steadily to over 54 percent of those 65 and older By conlrasl. only 21.1 percent of white females in the 25-34 year old age group are former smokers and this percentage reaches its iargest value of 22 1 in the 35.44 year old age group (NCHS, Heallh 86, preliminary).

Since as while males age, increasing percentages move into lhe former smoker category while the overall percentage of smokers remains relatively constant (at least until age 35) some white males are always moving irom the nonsmoker to the smoker category. For exampie, comparrng 20-24 white males with their 25-34 year old counterparts, the percentage of smokers increases ham 31 6 lo 373 percent, the former smokers increase from 11 5 to 20.5 percent and the nonsmokers decline from 56 9 lo 42 2 percent. Thus, although the 17 to 19 year old age group appears lo represent the age when the largest percentage of individuals begin smoking. people continually enter and exit the smoking category. For white males lhe decrease in lhe percentage of nonsmokers does not slop until the 45 and over age group [NCHS, Heallh 86, preliminary).

white male and female smokers the most substantial increases in the percentages of smokers occur between the ages of 17 and 24.

For blacks, the findings are similar but not as pronounced. In the 20-24 age group, 27.5 percent of black males and 28.3 percent of black females are smokers.[74] For black males, the percentage remains at about 45 percent from ages 25 to 64, while for females the percentage of smokers increases until it peaks at 40.4 percent in the 35-44 year old age group.[75] The percentage of former smokers among black males is a low 15.8 percent in those aged 20 to 44, while for black females the corresponding percentage is even smaller – 9.9.

What these statistics indicate is that although the largest percentage of new smokers is in 17-24 year old category, (and as will be shown in the next section, in the 17-19 year old age category in particular), significant percentages of blacks continue to start smoking as they age. For example, 27.5 percent of black males between the ages of 20 and 24 are smokers while the corresponding percentage for those between the agges of 25 and 34 is 45.5 percent. The percentages of former smokers in these two age groups are 11.2 and 13.8 for the 20-24 year olds and 25-34 year olds, respectively.

In sum. our analysis of those who are starting to smoke reveals that the largest increase in smokers occurs in the 17 *to* 24 year old age group and that this statistic holds regardless of the sex or race of the smoker. That said, it remains true that regardless of race or sex, in all age categories up to approximately 45, the percentage of new smokers is substantial since smoking participation rates do not fall dramatically even though some smokers are quitting. The former smoker statistics indicate that white smokers both quit smoking earlier and at higher rates than do black smokers. The most useful source of information about the demographic and socioeconomic characteristics of adolescent smokers that we located was the 1982 Surgeon General's report on smoking and health. The data in that report indicate that smoking behavior is inversely related to parental status, i. e., the lower the income and education of the parents, the higher the smoking prevalence." Consistent with this is the finding that scholastic achievement and aspiration are also inversely related to smoking prevalence. For example, one study found that 9.0 percent of boys and 12.0 percent of girls in college preparatory cources smoked compared to 18.3 percent of boys and 20.1 percent of in other curricula.'*

Of course the infiuence of peers and parents also is strongly related to smoking. 'Adolescents are more likely to smoke if either or both their parents smoke than if they do not."[79] Also, smoking prevalence is highly correlated with self-reports of having friends who smoke.[80] One National Institute of education study found that 87.6 percent of boys and 94.0 percent of girls who smoked reported that at least one of their four "best friends" smoked. In contrast, only 33.8 percent of the boys and 32.9 percent of the girls who were nonsmokers reported having at least one of their four best friends who were smokers.[81]

The data that exists about the demographic characteristics of teenage smokers was summarized earlier. We noted that approximately 4 percent of 12-14 year olds. thirteen percent of 15-16 year olds, and 19.6 percent of males and 27.0

[74] *As was the case with the 17-19 year old white males and females. the percentage of black 17-19 year olds that smoke was estimated at three percent iess lhan the percentage of 20-24 year old black males and females who smoke*

[75] *NCHS, Health 86, preliminary*

[76] *United States Public Health Service (1982.) Theie does not appear to be as much information available about adolescent smokers as there is about older smokers. "Strong correlations between smoking and a number of demographic and psychosocial variables have been reported, but casual connections have not been established. Neither has the set "predisposing factors" been often subjected io multivariate analysis. It is rare thai more than one or two variables have been tested simultaneously." United States Public Health Service (1982) p. 281.*

[77] *United States Public Health Service (1982), pp. 281-282.*

[78] *United States Public Health Service (1982). p. 286.*

[79] *United States Public Health Service (1982), pp. 282.*

[80] *"It has not been demonslrated, however, that is the behavior of friends rather than the inclinations of the adolescent whrch influences him or her to smoke." United States Public Health Service (1982), p. 284.*

[81] *United States Public Health Service (1982), p. 284.*

percent of females aged 1718 were smokers.[82] The smoking rates of 17-19 year olds were found to be slightly less than those for 20 24 year olds and were estimated at three percent less than the rates for 20 to 24 year old smokers for purposes of our calculations

The Age, Race and Sex Distribution of New Smokers

Even though the vast majority of smokers will continue to smoke from one year to the next, the smoking population is dynamic as some of its members die or quit as others begin to smoke. Therefore, we attempted to analyze age, face and sex characteristics of new smokers. Our methodology and results are described below.

Our estimates are based on three types of data: the percentage of smokers by age, race and sex as provided NCHS: the percentage of former smokers by age, race and sex from the same source; and the distribution of the population by age, race and sex as estimated by the Bureau of the Census. The methodology was as follows.

The NCHS data describes the probability that an individual of a certain age, race and sex will be a smoker, a former smoker or nonsmoker. Since these probabilities changes as the person ages, we can calculate the total percentage of new smokers within a given age category by adding the marginal increase (decrease) in current smokers from one age group to the next, to the marginal increase in the number of former smokers in that age group. The resulting total includes both the increase in the absolute number of smokers in that age group and the new smokers who took the place of those smokers who quit. For example, if among white males the percentage of 20-24 year olds who smoke is 31.6 percent and the percentage of smokers in the 25-34 age group is 37.3, then 5.7 percent are new smokers. In addition, if the percentage of former smokers among the 20-24 age group is 11.5 percent and among the 25-34 year old age group it is 20.5 percent, an additional 9.0 percent of whites in the 25-34 year old age group it is 205 percent, an additional 9.0 percent of white males in the 25-34 year old age group began to smoke. Thus, the total increase in smokers among the 25-34 year old white male age group from one year to the next can be estimated as 5.7 plus 9.0 or 147 percent.[83] If this percentage new increase is multiplied by the number of white males who were 24 years old the preceding year, a rough estimate of the percentage of new smokers in the 25-34 age group can be obtained.[84]

The results from using this methodology are shown in Table 5, which provides estimates both of the absolute number of new smokers in each age, race and sex category and of their percentage distribution.[85] Based on Table 5 we estimate that approximately 2.35 million people in the United States will begin smoking in 1986. Almost one million of these will be in 17-19 year old age category and approximately 500 thousand will be between 20 and 24 years old[86] As a group white males represent Slightly over half of all new smokers and white females account for an additional 33 percent.[87]

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[82] *United States Public Health Service (1982) p 277 These data are based on high school seniors and measured the percent who smoked at least one cigarette per day for lhe last thirty days Those who dropped out of high school before the survey was taken were not included For more details see Shopland and Brown 1985*

[83] *This approach assumes that when an age group cohort enters a higher age group, the members of thal cohort will immediately assume the mean smokmy participation and quit rates of thair new age category This, of course. is not what happens For example, if the mean smoking participation rate of while males in the 25-34 age category is 323 percent, 32 or 33 percent of those close to 25 years old may smoke and 39 or 40 percent of lhose close to 34 years old may smoke The simplifying assumption lhat we made should have little elfecl on lhe overall estimates lhat were developed, however since we are estimating the number of new smokers in a one year time frame*

[84] *This is a conservative estimate of the number of new smokers, because it ignores mortality Some percentage of smokers will die from disease, accidents, etc. Obviously, some of the new smokers fake the place of the deceased smokers. Since the vast majority of new smokers are 24 years of age or under. we do not expect that our estimates will be substantially biased by ignoring fhe effects of mortality.*

[85] *The NCHS dala fhat was used for the distribution of smokers was for 1986 (NCHS, Health 86, preliminary) and the Bureau of the Census dala was for 1985 Since the new smoker estimates were based on lhe numbers of individuals in a previous age category becoming one year older and moving into a new aye group, the estimates lhat have been developed are lor this number of new smokers in 1986 The number of new smokers in 1987 and succeeding years will be quite similar. Differences dspend on changes in start ratas and on the number of people in each age category*

[86] *Actually, many of these new smokers will be less than seventeen years old We have made fhe same simplifying assumption here lhat we made earlier i.e., that there are no regular smokers younger than seventeen years old. Of Course we realize that some individuals begin smoking earlier, but again. we do not have sufficient confidence in the existing estimates lo use them in our calculations. The estimate of the number of new smokers would not change very much because all that would happen is that Some of those who are estimated lo begin smoking at 17 would be estimated to Start at 13 lo 16, and the total number of I7 year old smokers would be the same as we have estimated It would be a srmple matter to calculate the number of 13-16 year old smokers if lhe Technrcal Study Group can agree on that percentage (and lo revise our estimates of 17-19 year old Smokers. also)*

[87] *Using the same methodology we estimated the number of people who quit smoking in 1986 at 124 million. As was the case wilh tho new smokers. white males account for over one-half of quitters (777,000) while white females represent an additional 350,000. We were not able to estimate the number of smokers who die each year It is estimated fhat 350,000 smokers die from smoking related diseases, but the number of smokers who die from any cause. e.g., accidents, old age, etc., was not located ti these numbers were available by age, race and sex, we could develop tables illustrating the dynamics of lhe smoking population in terms of new smokers, continuing smokers. quitters and smokers who die arid how lhis population is changmg over lime*

Table 5. Estimated Number of New Smokers in 1986

Age	Males White	Males Black	Females White	Females Black	Totals
17	433	64	432	66	966
19	238	41	226	21	526
24	281	63	91	39	474
34	204	18	34	25	281
44	58	12	0	0	70
65+	0	0	0	0	0
Totals	1215	197	783	151	2347

ercent Distribution **of New Smokers**

Age	Males White	Males Black	Females White	Females Black	Totals
17	185%	2 7	184	2 8	42.4
19	102	1 7	9 6	0 9	22.4
24	12.0	2.7	3.9	1.7	20.2
34	8.7	0.8	1.5	1.1	12.0
44	2.5	0.5	0.0	0.0	3.0
65	0.0	0.0	0.0	0.0	0 0
Totals	51.8%	8.4%	33.4%	6.4%	100.0%

Conclusions Regarding the Demographic and Socioeconomic Characteristics of the Smoking Population, Quitting Smokers and New Smokers

With over 50 million smokers, net changes in the overall characteristics of the smoking population will occur slowly, since yearly turnover only represents five percent of total smokers. Therefore, it can be expected that the total smoking population five years from now will look much like the current population in terms of age, race and sex. Since little is known about the socioeconomic characteristics of beginning smokers, it is difficult to draw conclusions about variables other than demographics. Were we to hazard a guess about this population, our guess would be that new smokers who continue to smoke would have similar socioeconomic characteristics to current smokers, That is, we expect that new smokers who continue to smoke would be drawn disproportionately from lower socioeconomic groups, while nonsmokers and new smokers who quit would be members of higher education, income and occupational status groups. Such a result would be a continuation of trends that are already well-established,

8. References

[1] Adams PI. (1977) "The Influence of Cigarette Smoke Yields on Smoking Habits," in Smoking Behavior, Physiological and Psychological Influences, Raymond E. Thornton. editor, Churchill Livingston: London, 349-360.

[2] Barrel, Yoram (1976) "An Alternative Approach to the Analysis of Taxation," J. of Political Economy, v. 84, pp 1177-1198.

[3] Bishop. John A., and H. Yoo (1985) "'Health Scare.' Excise taxes and Advertising Ban in the Cigarette Demand and Supply," 52 Southern Econ. Journal p 402-411

[4] Calfee, J.E. (1985) "Cigarette Advertising. Health Information and Regulation before 1970," Bureau of Economics. Federal Trade Commission, Working Paper No. 134 (December 1985.)

[5] ———— (1987) "Cigarette Advertising Regulation Today: Unintended Consequences and Missed Opportunities," forthcoming in Advances in Consumer Research, 14.

[6] Corner. A. Kay, and D.E. Creighton (1977). "The Effect of Experimental Conditions on Smoking Behavior: in Smoking Behavior; Physiological and Phychological Influences, Raymond E. Thornton. editor, Churchill Livingston: London, pp. 760-786.

[7] Creighton, D.E. and PE. Lewis (1977) "The Effect of Different Cigarettes on Human Smoking Patterns:' in Smoking Behavior, Physiological and Phychological Influences, Raymond E. Thornton. editor, Churchill Livingston: London, pp. 289-300.

[8] ———— (1977b) "The Effect of Smoking Pattern on Smoke Deliveries," in Smoking Behavior, Physiological and Phychological Influences, Raymond E. Thornton, editor. Churchill Livingston: London, pp. 301-314.

[9] Cumming, Gordon, Andrew R. Guyatt. and Michael A Holmes (1977) "The Absorption of Carbon Monoxide from the Airwaves of the Human Lung: in Smoking Behavior, Physiological and Psychological Influences, Raymond E. Thornton, editor, Churchill Livingston. London, pp. 68-170.

[10] Dunn. PJ , and E.R. Freiesleben. (1977) "The Effects of Nicotine Enhanced Cigarettes on Human Smoking Parameters and Alvoliar Carbon Monoxide Levels' in Smoking Behavior, Physiological and Psychological Influences, Raymond E Thornton. editor, Churchill Livingston: London. pp. 195-202.

[11] Federal Emergency Management Agency (FEMA) (1984). Fire in the United States, Fifth Edition, (FA 68) 60 pages.

[12] Ford, Gary T., and John E. Calfee (1986) "Recent Developments in FTC Policy on Deception.' 82 J of Marketing. pps. 82-103 (July 1986.)

[13] Guillerm, R. and E. Radriszewski (1977) "Analysis of Smoking Patterns Including Intake of Carbon Monoxide and Influences of Changes in Cigarette Design: in Smoking Behavior, Physiological and Physchological Influences, Raymond E. Thornton. editor, Churchill Livingston. London, pps. 361-370

[14] Gunther, Paul (1981) "Fire-Cause Patterns for Different Socioeconomic Neighborhoods in Toledo Ohio," Fire Journal, Vol. 75, No. 3, (May), pps. 52.58.

[15] Hall, John R. and Susan G Helrer (1983) "Civilian Residential Fire Fatality Rates: Six High-Rate States Versus Six Low-Rate States: Federal Emergency Management Agency, NBSIR 83-2754, 23 pages

[16] Harris, Jeffrey E. (1983) "Cigarette Smoking Among Successive Birth Cohorts of Men and Women in the United States During 1900-1980," Journal of the National Cancer Institute. Vol. 71. No. 3 (September), pps. 473-479.

[17] Horm, John W. and Larry G. Kessler (1986) "Falling Rates of Lung Cancer in Men in the United States," The Lancet, February 22, 1986, pp. 425-426.

[18] Ippolito. Richard A., R Dennis Murphy, and Donald Sant (1979) Staff Report on Consumer Responses to Cigarette Health Information. Bureau of Economics, Federal Trade Commission.

[19] Ippolito, PM.. and R.A. Ippolito (1984) "Measuring the Value of Life Saving from Consumer Reactions to New Information," 53-81

[20] Karter Jr., Michael J., and Allan Donner, (1978) "The Effect of Demographics on Fire Rates," Fire Journal, Vol. 72, No. 1, (January), pps. 53-65.

[21 Kozlowski. Lynn T. (1981) "Tar and Nicotine Delivery of Cigarettes: What a Difference a Puff Makes:' Journal of the American Medical Association 245, (Jan. 9). pps. 158-159.

[22] ——————, (no date) "Less-Hazardous Tobacco Use as a Treatment for the Smoking and Health Problem: unpublished manuscript, 50 pages.

[23] Lago, Armando (1986), "Notes on April 14 Meeting with Dr. John Krasny," (June 13), mimeo, 5 pages.

[24] Lee, P and Garfinkel. L. (1981) "Mortality and Type of Cigarette Smoked," Journal of Epidemiology and Community Health, Vol. 35, pps. 16-22.

[25] Lewit, Eugene M., Douglas Coate and Michael Grossman (1981) "The Effects of Government Regulation on Teenage Smoking:' Journal of Law and Economics, 24, pps. 545-570.

[26] Lewit, Eugene M. and Douglas Coate (1982) "The Potential for Using Excise Taxes to Reduce Smoking:' Journal of Health Economics, 1, pps. 121-145.

[27] Loeb. L.A.. V.L. Ernster, K.E. Warner, J. Abbotts and J. Lazlo, (1984), "Smoking and Lung Cancer: An Overview: Cancer Research, Vol 44 (December), pp. 5940-5958.

[28] Lubin, J., Blot, W., Berrino. F., Flamant. R., Gillis, C., Kunze, M., Schmahl, D., and Visco, G. (1984). "Patterns of Lung Cancer ?igarette Smoked," International Journal of Cancer, Vol. 33, pp. 169-176.

[29] Lyon, Herbert L., and Julian L. Simon (1968) "Price Elasticity *of* the Demand for Cigarettes in the United States" 50 American Journal of Agricultural Economics pps. **888-895** (November).

[30] Maxwell jr., John C. (1981) "The Maxwell Report" Advertising Age, (December 7).

[31] Moody, PM., R.B. Griffith, and J.H. Averitt (1972) "Smoking History and Puff Profiles of Hospital Patients. Report 3," Proceedings of the University of Kentucky, Tobacco and Health Research, Tobacco and Health Workshop Conference, Lexington, University of Kentucky, pps. 30-148.

[32] National Center for Health Statistics (1985) "Provisional Data from the Health Promotion and Disease Prevention Supplement to the Nat??5, 1985, U.S. Department of Health and Human Services.

[33] National Center for Health Statistics (1986a) "Trends in Smoking, Alcohol Consumption. and Other Health Practices Among U.S. Adults, 1977 and 1983:' Advance Data. No. 118, (June 30), U.S. Department of Health and Human Services.

[34] —————— (1986b) Health 86, preliminary data.

[35] Participants in the Fourth Scarborough Conference on Preventive Medicine (1985) "Is There a Future for Lower-Tar-Yield Cigarettes? The Lancet, November 16. 1985. pps. 1111-1114.

[36] Peto, Richard (1985), "Control of Tobacco-Related Disease: The Value of Preventive Medicine. Ciba Foundation Symposium 110.

[37] Porter, R. (1985), "The impact of government policy on U.S. Cigarette industry," an Ippolito. P and D. Scheffman. eds, Empirical Approaches to Consumer Protection Economics, Bureau of Economics Report, Federal Trade Commission, pps. 447-482.

[38] Rawbone. Roger, G.K. Murphy, M.E. Tate and S.J. Kane (1977). "The Analysis of Smoking Parameters. Inhalation and Absorption of Tobacco Smoke in Studies of Human Smoking Behavior," in Smoking Behavior, Physiological and Psychological Influences. Raymond E. Thornton, editor, Churchill Livingston: London, pps. 171-194.

[39] Remington, Patrick L., Michelle R. Forman, Eileen M. Gentry, James S. Marks, Gary C. Hogelin and Frederick L. Trowbridge (1985). "Current Smoking Trends in the United States," Journal of !he American Medical Association, Vol. 253, No. 20, (May 24-31), pps. 2975-2978.

[40] Rubin, Paul, and Mark Cohen (1985) "Private Enforcement of Government Regulation," Yale Journal of Regulation. 2.

[41] Ruegg. Roselie, Steven Weber and Barbara Lippiatt (1986) "Cigarette Ignition Propensity: A Benefit-Cost Study, Second Progress Report," National Bureau of Standards, July 31. mimeo.

[42] Schneider. L.. K. Benjamin, and K. Murphy (1981) "Governmental Regulation of Cigarette Health Information," 24 Journal of Law and Economics pps. 575-612.

[43] Shopland, Donald, and Clarice Brown (1985) "Changes in Cigarette Smoking Prevalence in the U.S.: 1955-1983," Annals of Behavioral Medicine, Vol. 7, No. 2, pp. 5-8.

[44] United States Public Health Service (1981). The Health Consequences of Smoking: The Changing Cigarette. U.S. Department of Health and Human Services.

[45] United States Public Health Service (1982). The Health Consequences of Smoking for Women, U.S. Department of Health and Human Services

[46] United States Public Health Service (1983). The Health Conseauences of Smokina Cardio-Vascular Disease. U.S. Department of Healthand Human Services.

[47] Warner, K. (1986) "Smoking and the health implications of a change in the federal cigarette excise tax," 255 Journal of the American Medical Association pps. 1028-1032.

[48] Willig, Robert (1976) "Consumer's Surplus Without Apology" 66 Amer. Econ. Rev. 589-597 (September).

U.S. **GOVERNMENT PRINTING** OFFICE : 1987 *0* – 193–851 QL *3*