Development of a Methodology to Assess the Economic Impact Required by SB513/AB969

Final Report

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Abstract

In this report, a methodology is developed to assess the impact that the California Environmental Protection Agency proposed regulations will have on the ability of California businesses to compete.

We propose that the California Environmental Protection Agency consult with economists and engineers in order to estimate the relevant additional costs of meeting the proposed regulations. Such costs will differ depending on whether or not (a) the regulated product has substitutes or (b) the regulated industry is competitive.

The ability of California businesses to compete, following a regulation, can be assessed by examining the effect of regulation on (a) labor or total factor productivity measures, (b) rate of return on investment (i.e., financial health) for California firms, (c) price and quantity of a good that is regulated as well as jobs lost, and (d) the whole economy using large models called computable general equilibrium models. Except the largest of proposed regulatory changes, which may necessitate the use of a computable general equilibrium model, a combination of the first three methods may be all that is required to carry out a good evaluation.

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Executive Summary

In this report the methodology needed to assess the economic impact required by SB513/AB969 is set out, and data available to conduct such impact studies are discussed. This summary will discuss the major points and approaches.

At the beginning of the assessment process, the California Environmental Protection Agency should hold a meeting with both economists and engineers to scope out the work necessary in the assessment process. At least the following economic issues should be discussed: estimation of the costs of the regulation, including the quantity of labor and materials needed to comply with the regulation; substitutes for the regulated product; and the industry structure for the regulated industry.

The changes in labor productivity incident upon the regulation should be computed. Where there is no significant difference in productivity, it should be taken as evidence that the regulation will cause no change in the number of jobs or businesses.

The changes in return on equity or investment incident upon the regulation should be computed. Where there is no significant difference in returns, it should be taken as evidence that the regulation will cause no change in the number of jobs or businesses.

The change in quantity of output in the target industry only incident upon the regulation should be estimated from supply and demand considerations. A practical upper bound on the change in output is the percent of price that is the cost of the regulation times the elasticity of demand. The body of the report gives other bounding expressions and some typical estimated values for demand elasticities.

The change in the number of jobs (and the number and size of businesses) depends upon more than just quantity of output in the target industry. When pollution control is as job intensive as the industry itself, the total number of jobs (jobs needed to meet the regulation plus jobs needed to produce the output) will increase whenever the demand for the product is inelastic. There are remarkably few product categories that are not inelastic.

The total impact of a regulation includes at least the following factors: the amount less of the product purchased, greater job intensity of each cleaner unit purchased, change in consumer purchases of other goods, increases in the price level, and attraction of workers to California because of environmental benefits.

A large model of the California economy was used to illustrate these points, particularly the sensitivity of jobs and business creation to migration (i.e., whether the regulation attracted more workers through a better quality of life than it lost through a higher price level).

The change in jobs is a good guide to business creation, elimination, and expansion. Where output is expected to increase, jobs are expected to increase, financial returns are expected to be greater, or productivity is expected to be greater, it is expected that there will be additional businesses and existing businesses will expand.

In summary, this report has proposed four basic methods of finding the likely effect of a regulation upon jobs and business in California: (1) productivity calculations, (2) financial ratios, (3) supply and demand considerations, and (4) model simulation. A combination of the first three methods is all that is appropriate for all but the largest of proposed regulations. The report also shows that there can be significant redistribution of business activity and jobs within the State, from producing units of the regulated output to producing units of a cleaner output and from the regulated good to substitute goods.

Development of a Methodology to Assess the Economic Impact Required by SB513/AB969

by Peter Berck

1. Introduction

Recently passed legislation, SB513/AB969, requires state agencies, including the California Environmental Protection Agency (Cal/EPA), to assess the potential impact of their proposed regulations on "California jobs, business expansion, elimination, or creation." The law also calls for an assessment of whether or not a proposed regulation would affect the "ability of California businesses to compete with businesses in other states." These requirements go beyond the previous code and require additional economic analysis on the part of Cal/EPA Boards and Departments. In this report the methodology needed to assess the economic impact required by SB513/AB969 is set out, and data available to conduct such impact studies are discussed. Special attention is paid to consumer products and to conducting analyses of regulations with small impact.

This report contains seven sections (one for each of the major approaches to this problem), conclusions, and two appendices. The sections are Preparing the Way for an Assessment; Using Productivity to Evaluate Ability to Compete; Using Business Indicators; Using Supply and Demand; Total Impact Calculations; Business Creation, Elimination, and Expansion; and Regulations that Affect Many Sectors.

1.1. Preparing the Way for an Assessment

At the beginning of the assessment process, the Cal/EPA should hold a meeting with both economists and engineers to scope out the work necessary in the assessment process. At least the following economic issues should be discussed:

Costs. The Cal/EPA estimates the additional costs of meeting the proposed regulation. The cost estimates include capital costs, research costs and development costs which are annualized, and ongoing costs. The quantity of labor and materials represented by each of these costs should be estimated. The following questions should be answered: Is there a reason to believe that these additional materials would be manufactured inside or outside of California? Would the regulation appear to favor manufacturing the product outside of the State? What is the total cost to produce the product? Does California have a special advantage (or disadvantage) in making this product? What is the selling price of the product?

Substitutes. If the price of this product rises, what will be the likely response of the buyers? Will they continue to purchase it or will they purchase a different product that serves the same needs? For instance, if the price of spray paint were greatly increased, a marked shift to brushed- or rubbed-on finishes would be expected. Would the substitution away from this product be good or bad for California business?

Industry Structure. Is this product bought and sold by competitive industries? Alternatives include regulated industries and industries in which there is market power. Noncompetitive industries may change their price very differently from competitive ones in response to additional air regulations.

Who is the purchaser? Who buys this product? Is it a major part of their costs (in the case of a consumer, does it occupy a large budget share)? Is it mainly used by consumers or by industries? Can it be supplied from out of state or is it shipped out of state? Goods that are important inputs for industry will likely require an analysis that takes interindustry links fully into account.

2. Using Productivity to Evaluate Ability to Compete

The most common evidence presented for manufacturing sector's lack of competitiveness is its loss of productivity. Stewart (1993) reviews empirical research using this approach. There are many productivity measures that are in common use, and the choice among them is usually made based upon the quality and availability of data rather than on theoretical grounds. The two major types of productivity indices are total factor productivity and labor productivity. Total factor productivity is the ratio of output value to the value of all inputs.[1] While this measure is theoretically attractive, the value of all inputs is not often accurately measured, so total factor productivity is not frequently used. Labor productivity, some measure of the value of output to some measure of labor input, is used in many forms. The most common measures of value of output are sales (value of shipments) and value added (value of output less value of input materials). The most common measures of labor input are payroll and number of employees. Using sales rather than value added as an output measure makes the productivity measure sensitive to better use of materials. However, there is no great theoretical advantage to any of these measures, so the choice among them should be made on the grounds of quality of data available. As a practical matter, this will lead to the use of sales divided by the number of employees.

These productivity measures are taken as measures of the ability of California firms to compete. If, within an industry group, a regulation significantly changes the productivity rank of California firms, then it could be concluded that the regulation has harmed the ability of California firms to compete.

Data necessary to compute productivity by industry by state are quite limited. The *Census of Manufactures* collects these data in sufficient detail to make some comparisons among states once every five years.

Data are given in Table 1 for the four-digit standard industrial classification (SIC) code for aerosol paints and the three-digit code for soaps, cleaners, and toilet goods, which should be of interest in the future. Data by state are often not available. For instance, data for paint are not available for Arizona, which is often viewed as a competitor of California for industrial location. Surprisingly, data are also not available for New York. At the four-digit level, very little data can be found at the state level. At the three-digit level, there is a remarkable congruence of productivity measures across states. As the table shows, the major industrial states are often recorded at the three-digit level, while Arizona is still not available.

TABLE 1
Estimating Productivity Measures Using Value of Shipment per Dollar of Payroll

	Payroll	Value of shipment	Cost of compliance	Adjusted payroll	Productivity before	Productivity after
	thousands of dollars					
SIC 2851 aerosol paint						
California	$178	$1,523	$18	$196	8.56	7.78
Illinois	$156	$1,294	$0	$156	8.29	8.29
United States	$1,491	$12,701	$0	$1,491	8.52	8.52
SIC 284 soaps, cleaners, and toilet goods						
California	$261	$2,567	$26	$287	9.84	8.94
Illinois	$313	$3,757	$0	$313	12	12
Michigan	$120	$941	$0	$120	7.84	7.84
New York	$261	$2,567	$0	$261	9.84	9.84

Let us now consider the effect on productivity of a regulation that required the product to be made in a cleaner fashion or required that the product, itself, cause less pollution. Such a regulation would require more labor and/or more materials per unit of output produced, so the measured productivity of the regulated firms would fall.

To be concrete, consider the example of California production of aerosol paints. Suppose that, because of a regulation, 10 percent more labor would be required to make the same value of shipments. That would mean that, after regulation, payroll would be $196,000 rather than $178,000. Shipments would be constant at $1,523. Thus, productivity (value of shipments per dollar of payroll) would fall from 8.56 to 7.78. This takes California's productivity from above national average to well below national average and raises questions about California's competitiveness.

The above analysis included the crucial assumption that the additional costs were both labor and materials costs and that the increase in labor expense was a fair representation of the effect of the regulation. It is entirely possible for a regulation to cause a firm to substitute a more expensive material for a less expensive material. In that case, labor used might remain the same, and therefore it is possible that the measure of productivity (shipments per payroll dollar) would also be unaltered. Note, however, that the other measure of productivity (value added per employee) would move as expected.

Table 2 shows value added per employee. On the assumption that a regulation added materials costs equal to 10 percent of value added (and left payroll and employment unchanged), the table shows the effects on California's productivity. Before, the regulation valued added in paints would be $748,000. By requiring additional materials in the value of $74,800, value added would fall to $673,000. As a result productivity would fall from $117 to $105 of value added per worker. Again, California goes from above average to well below average productivity.

It would be expected that the firm forced to make the cleaner product would best be able to compete in those localities requiring the cleaner product. If California firms are forced to make both a cleaner and cheaper product, they are burdened in their quest to sell outside of California. If other localities adopt regulations similar to those in California, the firms in California will be at an advantage, as they will have had substantial experience with the reformulated products that other firms will lack.

TABLE 2
Estimating Productivity Measures Using Value Added per Employee

	Number of employees (1,000.00)	Value added	Cost of compliance	Adjusted value added	Productivity before	Productivity after
		thousands of dollars				
SIC 2851 aerosol paint						
California	6.4	$748	$75	$673	117	105
Illinois	5.4	$621	$0	$621	115	115
United States	55	$6,221	$0	$6,221	113	113
SIC 284 soaps, cleaners, and toilet goods						
California	12.1	$1,691	$169	$1,522	140	126
Illinois	11.9	$2,452	$0	$2,452	206	206
Michigan	5.5	$559	$0	$559	102	102
New York	12.1	$1,681	$0	$1,681	139	139

3. Using Business Indicators

California firms can compete with other firms as long as they make the same rate of return on their investment or, more generally, have the same financial health as other firms in their industry. Thus, the change in the rate of return caused by an environmental regulation is a measure of the regulations effect on the "ability of California businesses to compete with businesses in other states." In other words, if the regulation makes no difference in the firm's rate of return or in other indicators of the firm's financial health, then there is no reason to believe that the California firm will be disadvantaged.

Dun and Bradstreet (D&B), and other credit-reporting firms, maintain information on firms that they use for assessing their credit worthiness and financial health. It is standard practice in commerce to use data from D&B to decide whether or not a potential customer is credit worthy or whether or not a potential partner in a joint venture has the financial health to carry out their obligations. A number of financial ratios are examined in making these types of assessments, including the firm's return on equity (ROE) or on investment.

When a firm is required to change its product to comply with a regulation, that change makes its product more costly. The Cal/EPA currently estimates the increase in cost incident upon the regulation. The worst case for a firm would be for its costs to increase and not to be able to pass on any of its increased costs in the form of a price increase. Making the assumption that the regulation raises costs, but not price, the effect of the regulation on competitiveness is found by computing the financial ratios before and after the regulation.

If the financial indicators are unchanged, then the regulation has no effect on the regulated industries with respect to jobs, business status, and/or ability to compete.

3.1. An Example of Rate-of-Return Calculation Before and After a Regulation

To find the effect of a proposed regulation on ROE of affected firms, the financial data must first be found. Since actual financial data may not be available for most affected firms, financial data on typical firms prepared by companies such as D&B can be used. The D&B Industry Profile provides financial data for a typical business in each four-digit SIC code industry at either the national or regional level. Assuming that a typical firm in the Western region is also typical of a California firm, D&B data can be used to estimate ROE for affected firms. Data provided are the net after-tax profits and owners equity in the firm (i.e., the value of the firm's assets less its liabilities). The ROE is the ratio of the after-tax profit to the owner's equity in the firm.

Since ROE is calculated after tax, the cost of compliance needs to be calculated after tax as well. All firms are assumed to face the marginal tax rates of 35 percent federal and 9.3 percent state, with the state tax deductible against the federal tax. Thus, an additional expenditure of $10,000 for pollution control reduces taxation by ($930 in state tax less $325 because of state tax deductibility from federal taxes plus $3,500 in federal taxes) $4,105. A $10,000 additional expenditure, therefore, reduces net after-tax profits by only $5,895.

As mentioned earlier, these calculations are made on the "worst-case" assumption that firms can neither raise their prices nor lower their costs as a result of the regulation.

Given these preliminaries, the calculations are quite straightforward. Table 3 gives profits after tax and equity for three different industries in both the Western United States and the whole United States. A hypothetical after-tax compliance cost of $10,000 is assumed for California, represented by the Western region. The first row of the table shows how the unregulated Western region had a ROE of 16 percent in manufacturing soaps (profit divided by equity). With the additional costs incident upon regulation, profit would have been $10,000 less. Thus, adjusted profit is $166,122. The rate of return after regulation would be adjusted profit divided by equity or 15 percent. This is still considerably above the ROE of the industry in the United States as a whole, which was 12.7 percent. The remaining rows of the table show the same exercise carried out for paints and aluminum foundries.

TABLE 3
Estimating Profitability Using ROE

Industry	Region	Profit	Equity	Compliance cost	Adjusted profit	ROE	Adjusted ROE
MFG. Soaps	Western	$176,122	$1,104,095	$10,000	$166,122	16%	15%
2841	United States	49,847	392,132	0	49,847	12.70%	12.70%
MFG. Paints	Western	57,344	379,465	10,000	56,344	15.10%	14.80%
2851	United States	86,993	635,016	0	86,993	13.70%	13.70%
Aluminum Foundry	Western	77,261	399,594	10,000	67,261	19.30%	16.80%
3365	United States	75,424	407,939	0	75,424	18.50%	18.50%

The degree to which ability to compete is impaired by a lowered rate of return is uncertain. The available evidence is that there is considerable variation in rates of return both within and between sectors. For instance, the above table shows that soap manufacturing is 2.3 percentage points more profitable in the West than in the nation as a whole. Fraumeni and Jorgenson (1980) give evidence on the rate of return between sectors. They find that "thirty of the forty-six sectors have rates of return between 9 and 15 percent." This wide variation in rates of return suggests that a change in rate of return of even a full percentage point may not have important deleterious effects for competitiveness. That size change is well within the natural variance from one industry to the next. The Air Resources Board's (ARB) use of a 10 percent change in the ROE (i.e., a change in ROE from 10 percent to a ROE of 9 percent) as a threshold for a finding of no significant, adverse impact on either competitiveness or jobs seems reasonable or even conservative.

4. Using Supply and Demand

4.1. The Theory

The Cal/EPA can often provide estimates of the costs of its regulations. In order to find the change in quantity consumed or produced as a function of the change in cost, the theory of supply and demand is used. This section provides a formal analysis of the effects of raising the cost of production on the amount supplied and the price. Estimates of quantity change can then be used to estimate the effect of a regulation on the number of jobs.

There are underlying assumptions about using the theory of supply and demand that should be kept in mind. First, with respect to demand, it is assumed that the demand curve reflects all the factors, including income and price, that determine purchases of the product. With respect to supply, it is assumed that the agents are cost minimizing, competitive agents with unchanging technology. The force of the assumptions on supply is that the firm will already have taken full advantage of all current technical possibilities to reduce its costs. That is, that the regulation will not spur the firm on to find a cheaper way of manufacturing its product. Put another way, regulation will not spur the firm on to discover a cheaper way to do business, as the firm will already be doing business in the cheapest possible way.

Consider the very simple case where a competitive firm supplies a single good. There are two costs to manufacturing that good. The first is the usual manufacturing costs with marginal cost, mc.[2] The second is the cost of pollution reduction which is \$c/unit of output. We seek to discover the effect of changing c on output and price.

A profit-maximizing firm sets price equal to marginal cost, so $p = mc(q) + c$. Solving this expression for q gives the supply curve $q = S(p - c)$, where $S = mc^{-1}$. The supply curve is S—the amount a producer supplies as a function of the market price. Adding a cost of c per unit is the same as reducing the price that the firm receives by c. Market equilibrium requires supply to equal demand: $D(p) = S(p - c)$. That is, the amount that consumers wish to purchase at price p must equal the amount that producers wish to supply at that price. To find the effect of changing c, p is treated as a function of c and the total derivative is taken with respect to c. The derivative of D and of S are denoted D' and S', respectively.

$$D' \, dp/dc = S'(dp/dc - 1).$$

It is convenient to multiply both sides by P/Q to convert the expression into elasticity form. Note that D' P/Q is the price elasticity of demand, ε_d. The price elasticity of demand is the percent change in quantity demanded when price changes by 1 percent. Note that ε_d is a negative number, because demand curves slope down. Similarly, S' P/Q is the price elasticity of supply, ε_s. It is positive, because supply curves slope up. Making these substitutions and solving gives the amount that p changes when c changes:

$$dp/dc = \frac{-\varepsilon_s}{\varepsilon_d - \varepsilon_s} .$$

The effect on quantity is found via the chain rule: dQ/dc = d D(p)/dp dp/dc, so the amount by which quantity changes when c changes is

$$dQ/dc = D' \frac{-\varepsilon_s}{\varepsilon_d - \varepsilon_s} .$$

This expression can be converted to elasticities by multiplying both sides by c/Q and the right-hand side by P/P. The percent change in quantity caused by changing costs of by 1 percent (when they were previously c) is

$$\varepsilon_q \text{ w.r.t. } c = \frac{-\varepsilon_s \, \varepsilon_d}{\varepsilon_d - \varepsilon_s} \frac{c}{p} .$$

To get some sense of scale, think of a regulation that changes c from 0 to 10 percent of price. If the elasticity of demand were -0.7 and the elasticity of supply were 1, then quantity would change by 4 percent.

Since it is often very difficult to find estimates for ε_s and ε_d, it is instructive to examine some extreme cases. These extreme cases provide bounds for the change in quantity incident upon a regulation.

Case 1. Demand is perfectly inelastic. Since ε_d is 0, dp/dc = 1 and price increases by the full amount of the increased pollution-abatement costs. Quantity does not change, so the demand for factors of production, such as labor, will not change.

Case 2. Perfectly elastic demand. In this case the demand curve is flat and the elasticity of demand is infinite. Therefore, dp/dc is zero and dQ/dc = - S' (which can be derived from taking the limit as D', so ε_d approaches infinity).

Case 3. Perfectly inelastic supply. Since ε_s is zero, dp/dc is zero. That is, consumer prices do not change. The change in quantity is also zero. The supplier absorbs the whole of the cost increase.

Case 4. Perfectly elastic supply. In this case the supply curve is flat and the elasticity of supply is infinite. Now, dQ/dc is D', ε_q w.r.t. c = ε_d c/p, and dp/dc = 1.

With the assumption that supply is upward sloped, demand is downward sloped and neither curve is perfectly elastic or inelastic. These four cases bound all of the possible outcomes. The useful bounds on the decrease in quantity from an increased pollution-abatement cost of c are $-S' c$ and $D' c$. Both of these quantities are a larger decrease than the actual decrease. The limits for price change are the full amount of the increased pollution-abatement cost, c. Thus, if either ε_s or ε_d is known, the decrease in quantity sold can be usefully bound.

The elasticity of demand and supply depends upon both in-state and out-of-state agents. There seems to be two important cases: The use of the product in California causes pollution, and the manufacture of the product in California causes pollution.

In the first case, the regulation should (and usually does) impose the cost of a reformulated product upon all producers, both in and out of state. If there are fixed costs to reformulating the product, then it is likely that only the producers with large sales or market shares will incur the costs. Since it is most likely that California firms sell disproportionately to California consumers, the share of California firms will probably increase (and certainly not decrease) as a result of a regulation requiring reformulation. Thus, the loss of California sales quantity should be bounded above the market share of California firms times ε_d c/p. A nontraded product is just a special case of the above analysis, where the market share for California firms is one.

The second case is a traded product that is made in California, and the regulation causes an increase in production costs in California but not in other states. Now, the demand for California production is the demand from in- and out-of-state consumers, less the supply of out-of-state producers. This is empirically difficult to find. A useful bound on the loss of economic activity remains $-\varepsilon_s$ c/p, where it is the local supply elasticity. This formula gives only the cutback that the firm would make in output if it (and not consumers) had to bear the entire cost increase. The purpose of the productivity and financial feasibility estimates is to show that the firm's supply elasticity is small. Location in California confers advantages in terms of nearness to market, transportation, and resources that other locations do not have. These advantages in location are what originally caused the industry in question to locate in California. The regulation may erode those advantages. The financial and productivity analysis gives measures of how much those advantages are eroded. If there is no significant erosion of those measures, then it is a reasonable implication that the advantages of California location still outweigh the costs of the regulation and that the firms will not have a very large elasticity of supply even in the long run.

4.2. Job Changes

Environmental regulation makes output more expensive, which is to say that each unit of output requires more capital, labor, and materials with regulation than it would without regulation. Indeed, it is the additional materials, labor, and even capital that are the expense of compliance. Thus, a regulated product would be expected to have more jobs per unit of output than an unregulated product. As the previous section showed, the market outcome of a regulation will be for less units to be produced, which would lead to less jobs. Thus, there are two counterbalancing effects of a regulation on jobs: One effect leads to more jobs, and the other leads to less jobs.

More formally, let the number of jobs be L(Q, c), i.e., a function of output, Q, and regulator imposed costs, c. Jobs are a function of c, because c calls for the expenditure of real resources to produce a cleaner product. The job intensity of the regulation is dL/dc, while the job intensity of the product is dL/dQ. A small change, Δc, in the regulatory costs results in [dL/dQ dQ/dc + dL/dc] Δc more or less jobs. In other words, the change in costs leads to less output which leads to less jobs, but it also leads to more jobs per unit of output which leads to more jobs. (A regulation for which dL/dc is zero is a tax or pollution fee, and it is just a special case.)

An important special case of the job analysis is where pollution-abatement expense and production expense each create approximately the same employment. More exactly, employment is proportionate to expense of either type, with constant of proportionality, α. Assume that there are no "pure" profits in the industry so that revenue and production costs are the same. Before regulation, jobs are then α P Q. Therefore, dL/dQ is proportionate to αP and dL/dc is proportionate to αQ. Using D' as the upper bound on dL/dQ, an upper bound on the direct job effects is $\alpha Q \Delta c [\varepsilon_d + 1]$. Thus, the direct effects of the regulation cause more jobs any time the demand elasticity lies between -1 and 0, which is inelastic.

The regulation has many indirect effects as well. For a consumer product, the main concern is that, if consumers have greater expense for the regulated product, then they must have lesser expense for another product or products. As long as they spend the same total income and the California job intensity of the products that they purchase is about the same, there will be no employment or business effect from regulating a product in a way that increases its costs.

4.3. A Consumer Product: Consumer Response to Higher Prices

Consumers respond to higher prices for goods and services by purchasing less of those goods and services. The percent less goods purchased when prices increase by

1 percent is called the elasticity of demand. There are several studies that have been done to estimate the elasticity of demand for various goods. The most comprehensive of these studies is Houthakker and Taylor (1966). They present estimates of demand for 83 categories of expenditure. Their methods predict both the short-run and long-run response to a price change and an income change. A summary of the long-run response to a price change follows.

Data on which these estimates are based end in 1964. More modern studies do not use nearly as many categories as Houthakker and Taylor, and they do not generally make use of American data. Therefore, they are less suited to the task of evaluating the effects of a price for a single consumer product.[3] Blanciforti, Green, and King (1986) give estimates for 11 categories of goods for the United States with data ending in 1978. For these aggregate categories, all estimated own-price elasticities were between -0.3 and 0, except for durables with an elasticity of -0.72 (see Appendix A).

Appendix B gives the short- and long-run price elasticities found by Houthakker and Taylor. Of the 83 items on their list, only 44 items had a price elasticity other than 0. An additional 24 items had an elasticity greater than -1 (i.e., between -1 and 0.0 or, in one case, positive). Of the remaining categories, those with the largest response were:

Toilet articles	-3.04
China, glassware, tableware and utensils	-2.55
Intercity railway	-3.19
Intercity bus	-2.17
Wheel goods, durable toys, sports equipment, boats, and pleasure aircraft	-2.39
Radio and television repair	-3.84
Flowers, seeds, and potted plants	-2.65
Motion pictures	-3.67

These higher-elasticity products are all in the optional-purchases category. They do not include food, housing, or within-city transport. Rather, they include vacation travel, movies, cosmetics, toys, and gardening supplies. In the more aggregate British studies, no product has elasticities this high. The highest elasticity is for alcohol, and even that is below two.

Of particular interest is cleaning and polishing preparations, and miscellaneous household supplies and paper products, which have no detectable price elasticity in the Houthakker and Taylor study. Spray paint would be in this class of products and would, therefore, be expected to have a demand elasticity very near zero.

Those users who gave up spray paint because of its higher costs would also be likely to switch to other finishes, such as those that are brushed or rubbed on. Thus, the change in the overall category of paints is extremely likely to be near zero.

Since the quantity of spray paint is likely to remain the same and the quantity of overall finishes sold is very likely to remain the same, the net effect of employment in California should be near zero or even positive if reformulated paint requires more labor than the older paint.

5. Total Impact Calculations

When a product is made more expensive and cleaner, the major effects on California jobs and businesses are as follows:

1. Consumers purchase less of the product. A bound on the amount less that they purchase is given by the percent increase in price times the demand elasticity.

2. Each unit of the product that they purchase may represent more jobs and more business. The reformulated product has different or more materials in it, and these additional or more expensive materials can be expected to require more labor and more business activity for their production. Viewed differently, the consumer gets more product each time a unit of the good is purchased.

3. If the consumer spends less money on the product at hand, more money will be spent on other products. This also works the other way: More money spent on the product leaves less money to be spent on other products.

4. The price level in California increases. The change in the Divisia Input Index of prices is given by the product of the expenditure share of the product and the percent price change.

5. Workers are attracted to California when they perceive the benefits of the cleaner air as being worth the increase in the price level caused by the regulation. Conversely, they leave California when the increase in air quality is not commensurate with the increase in the cost of living. It is this trade-off that is largely determinative of the change in the number of jobs in California.

5.1. An Illustration of these Principles Using the California Computable General Equilibrium (CGE) Model

The CGE models are large models that include all major economic relationships for the region being studied. In brief, they include supply and demand relationships for each factor of production, typically labor and capital, and each category of output. The model solves for prices that make excess demand for these goods equal to imports and the demand for factors equal to supply plus investment in the case of capital and migration in the case of labor. The model also accounts for the effects of income on demand. The model that was used for these simulations is fully described in Robinson, Hoffman, and Subramanian (1994). As will be seen below, the estimated effect on California of a regulation depends upon factor-mobility assumptions.

5.2. When to Use a CGE

The CGE models are an appropriate tool, where the regulation being analyzed has a large and pervasive effect on the California economy. The models are most appropriate for situations in which the feedback effects between people and firms matter. For instance, a tax change that decreases consumption and, hence, might decrease production and employment. Another example is extensive and large restriction of NOx emissions under the State Implementation Plan. The analysis in a CGE is typically at the level of a sector that includes many SIC codes and has over a percent of gross state product. The model is unlikely to register changes much smaller than hundreds of millions of dollars, so regulations that have cost to business in the thousands or low millions will be hard to evaluate with this tool. Finally, CGEs require a great number of estimated economic relationships, many of which are not known with great precision. Thus, these models are expensive to use, because the results must be tested for sensitivity to the assumptions in the model. For these reasons, the use of CGEs should be limited to regulations that make a considerable difference to the California economy.

5.3. An Example

Consider an environmental regulation that increases the cost of producing a class of consumer products (all products are characterized as chemical, construction, or metal in these examples) by 5 percent. Such a regulation is much broader than those proposed by the ARB for consumer products, such as spray paint. The SIC code of which spray paint is a tiny part is only 2/10 percent of the gross domestic product (GDP), while metal products in the CGE sector are 1.5 percent of the GDP. The cost increase is taken as being used to purchase materials and labor in the same proportions as the government purchases materials and labor. This assumption is made because of a lack of information about the labor and materials requirements for a hypothetical regulation.

The model was run with three different assumptions about factor mobility. In the first case, it is assumed that neither capital nor labor will leave the state as a result of this regulation. In the second case, capital but not labor movement is assumed, and in the third case movement of both factors is assumed. What follows is the result of running the model.

If all home chemical-type products were to have their costs of production increased by 5 percent and neither capital nor labor were to leave California as a result, employment in the industry would increase. There would be 465 less employees working on the part of the production process that made the old part of the product but over 3,000 new employees working on the part of the product that made it cleaner, for a gain of several thousand employees. The net effect on jobs in California would, by assumption, be zero. This is the assumption that workers did not leave. As a result, other industries must lose several thousand employees. To see if it is reasonable for workers to stay in the new, cleaner regime, the loss in consumption, which is about 0.3 percent of consumption, would be compared to the value of the clean air. If the value of the clean air to workers were 0.3 percent of their consumption or more, then the assumption that workers will not leave is reasonable.

In this simulation, the return to capital (which is assumed to be mobile within California but not between California and the rest of the United States) would fall by 0.003 percent. If capital were mobile (the second case mentioned above), there would be enough capital flight so that consumption would fall by 1.2 percent.

If all factors were mobile, there would be no measurable negative effect. There are at least two reasons for this result: an extremely small outmigration of workers would restore equilibrium in the labor factor market, and the construction of the experiment and the model would take funds from consumers who would otherwise save money, which is then not spent in California, and use that money to purchase immediate goods and services in California.

If there is a lesson to be learned from these simulation results, it is that regulation can just as easily rearrange the pattern of business and employment as it can cause elimination or expansion.

6. Business Creation, Elimination, and Expansion

Environmental regulation can have an effect upon business creation, elimination, and expansion. A reasonable interpretation of the results presented so far is that, when the quantity of output and number of jobs are expected to decrease from a regulation, then the regulation will result in the elimination of marginal businesses. The most direct tool for looking at the effect on business is the financial ratios. When profitability is projected to fall from a regulation, then it is reasonable to conclude that there will be business elimination. Where there is information on individual firm's rate of returns or information on the distribution of rates of return, those firms with the lowest rates of return are most likely to be eliminated. On the other side of the coin, where a regulation is predicted to cause significant increases in pollution-control expenditures, there will be business creation or business expansion to meet those needs. The simulation results of the CGE model presented above suggest that regulations will have both the effect of contracting directly affected business while expanding or creating new business in unaffected and pollution-control sectors of the economy.

A short guide for a minor regulation ought to be: Where there is no change in financial ratios or projected output, there will be no elimination, expansion, or creation of business.

7. Regulations that Affect Many Sectors

When a pollution-control regulation affects a large number of industries, the methods proposed above can still be used. There are two methods. First, a large collection of industries could simply be analyzed and then the effects over industries could be summarized. Since this might be very tedious, the information on the industries could be aggregated and then the analysis could be carried out. That is, instead of isolating a three- or four-digit SIC coded industry, a two-digit or one-digit industry could be used. By choosing a higher level of aggregation, the ability to find the differential effect of the regulation on the component industry is given up, but computational ease is gained. Where pervasive, significant, economywide effects are expected, the use of CGE modeling would be appropriate.

8. Summary and Conclusions

There are at least three main ways to show that a regulation has a small impact on jobs and on the ability of California businesses to compete. In the case of a consumer good, a regulation that does not change the financial indicators or productivity of the industry to any significant degree is unlikely to have a large elasticity of supply. Since business activity and job changes are bounded above by the $-\varepsilon_s$ c/p, a finding of a low ε_s and a low c/p is enough to be assured that the regulation will have minimal job or business effects. If the good was used by other businesses, they would need to be monitored so that they would not be adversely impacted either. Generally, if the regulated product comprises a very small part of the expenditures of other industries, this will be true. The method appropriate for a consumer good is to bound the loss of economic activity from demand considerations. Thus, the loss of California sales quantity should be bounded above the market share of California firms times ε_d c/p. Jobs, of course, will vary less than quantity sold, because the expenditure caused by the regulation also creates jobs.

There are also intangible costs of compliance with regulations. Regulated firms must monitor their own compliance, keep current with regulations, and often report to relevant government agencies. It is also possible that compliance acts as a break on technical progress, particularly when regulations spell out a process that must be used rather than a result that must be achieved.

In the long run, the most important determinant of jobs and economic activity is the attractiveness of California as a place to live and work. Assuming free entry and exit of capital and constant returns-to-scale, consumers will bear the costs of regulations in the form of higher prices. These higher prices come with a cleaner environment. If the work force prefers the cleaner environment with higher prices, then there will be no long-term, negative impacts of the regulation on the competitiveness of California or on California jobs.

Footnotes

[1]There are alternative aggregate input indices that are usually specified. A common one is a Divisia Input Index which is based on cost shares. In that case the value of inputs is cost and the index is just cost divided by revenue.

[2]Let C(q) be the cost of making q units of a good, then marginal cost is (approximately) C(q + 1) - C(q) or the amount that it costs to make q + 1 units less the amount that it costs to make q units.

[3]The most recent study of demand is Blundell, Pashardes, and Weber (1993), but it uses British data and has only six categories of product. For the sake of comparison, the own-price elasticities in this study are food, -.564; alcohol, -1.582; fuel, -.448; clothing, -.526; transport, -.483; and services, -.554. Deaton and Muellbauer (1980) is a very well-known and much earlier use of the British data. They have the same categories as the later study and use a less recent data set.

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Glossary of Terms, Abbreviations, and Symbols

α:	Constant number.
c:	Cost of pollution reduction per unit of output (also referred to as a regulatory cost).
Cal/EPA:	California Environmental Protection Agency.
Δc:	Small change in c.
CGE:	Computable general equilibrium models. Large models used to study primarily, but not exclusively, major policy changes, including all major economic relationships, such as supply and demand for each factor of production and each category of output. The models solve for prices that make excess demand for goods equal to their imports and demand for factors equal to their supply.
D:	Market demand curve, which is a function of price, p. If there is more than one consumer in the market, it is the sum of quantities demanded by each consumer at price p.
D':	Change in D due to a small change in price, p.
demand curve:	Amount that consumers wish to purchase at a given price, p.
Divisia Input Index:	Product of expenditure shares of a good and the percent change in the price of the good.
ε_d:	Price elasticity of demand. It is the percent change in quantity demanded when price changes by 1 percent, and it is a negative number because a demand curve slopes down.
ε_s:	Price elasticity of supply. It is the percent change in quantity supplied when price changes by 1 percent, and it is a positive number because a supply curve slopes up.
ε_q w.r.t. c:	This is read as elasticity of output, q, with respect to (w.r.t.) c. It is the percent change in a firm's output when the cost of pollution control changes by 1 percent.
equity:	Value of the firm's assets less its liabilities.
L(Q, c):	Number of jobs, which depend on output, Q, and c.
mc(q):	Marginal cost. It is the cost of producing an additional unit of output and depends on quantity, q.
mc^{-1}:	The same as S.

productivity:	Ratio of the value of output to the value of input. Total factor productivity measures the value of output to the value of all inputs, and labor productivity measures value of output to the value of labor input.
profits:	Total revenue minus total costs.
q:	Quantity supplied by a firm.
Q:	Output of a product from an industry.
ROE:	Denotes return on equity. It is the ratio of after-tax profits to owner equity in the firm.
S:	Supply curve, which is a function of output price, p, and regulatory cost. If there is more than one firm in the industry, S is the sum of quantities supplied by each firm in the industry at price p.
S':	Change in S due to a small change in price, p.
supply curve:	The amount a producer supplies as a function of the market price, p.

Table 4.10

A Comparison of the Elasticities for the Dynamic Linear Expenditure System and the Dynamic Linear Approximate Demand System with Homogeneity Imposed: Estimates for Eleven Aggregate Commodity Groups

Commodity group i		DLES			D/LA/AIDS/H			Direction of Change From DLES to LA/AIDS/H	
		Elasticities		Pigou Relationship[b] ϕ	Elasticities		Pigou Relationship[b] ϕ	Elasticities[a]	
		Expenditure	Own-price		Expenditure	Own-Price		Expenditure	Own-price
Food	(1)	0.59	-0.20	0.34	0.37	-0.43	1.16	-	+
Alcohol plus tobacco	(2)	0.47	-0.10	0.21	0.24	-0.25	1.04	-	+
Clothing	(3)	0.81	-0.20	0.25	0.75	-0.59	0.79	-	+
Housing	(4)	0.14	-0.11	0.79	0.01	-0.25	25.00	-	+
Utilities	(5)	0.94	-0.20	0.21	0.62	-0.69	1.11	-	+
Transportation	(6)	0.79	-0.21	0.27	0.44	-0.38	0.86	-	+
Medical care	(7)	0.41	-0.19	0.46	0.31	-0.37	1.19	-	+
Durable goods	(8)	3.63	-0.72	0.20	4.42	-0.12	0.03	+	-
Other nondurable goods	(9)	1.48	-0.29	0.20	1.13	-0.92	0.81	-	+
Other Services	(10)	0.68	-0.20	0.29	0.71	-0.24	0.34	+	+
Other miscellaneous goods	(11)	0.57	-0.13	0.23	0.39	0.03	0.08	-	-

[a]Based on the absolute value of the own-price elasticity.
[b]The Pigou relationship is calculated as the absolute value of the own-price elasticity divided by the expenditure elasticity.

APPENDIX B

Expenditure Categories in Chapter 3 and its Appendix

Table 4.2. Elasticities for 82 PCE Categories

Item	Total expenditure		Price	
	Short-run	Long-run	Sh	Long-run
1.0	.2898	.6207		
1.1	.4972	.7115		
1.2	1.6126		−2.2[illegible]93	
1.3	.6799	1.0342		
1.4	−.6052			
1.5	.2075	.8615	−.4556	−1.8919
2.1	.9433		−.9135	
2.2	.5206	.7230	−1.3067	−1.8147
2.3	1.1423	.5131		
2.4	no equation estimated			
2.5, 2.6	.6534		−.9293	
2.7	1.0025	1.6447	−.4100	−.6726
2.8	.9472	1.1657		
3.1	.2453	3.7406	−.1993	−3.0391
3.2	.8675	1.3598		
4.1	.0707	2.4495	−.0351	−1.2150
4.2	1.5315		−.1839	
4.3	1.1283		−.6044	
4.4	1.2735			
5.1	2.5975	.5275		
5.2	1.1827		−.6337	
5.3	.4692	.7749	−1.5448	−2.5512
5.4	2.0879	1.1759		
5.5	2.2298	.6466		
5.6	.9929	1.6627		
5.7	1.5211	1.8277	−.4693	−.5638
5.8a	.1319	1.9364	−.1289	−1.8926
5.8b	3.1087			
5.8c	.8746	.5861	−.2028	−.1359
5.8d	.7514		−.7317	
5.9	.3158		−.2556	
5.10	1.8875		−.6635	
5.11	.5577	1.2657	−.1272	−.2885
6.1	.6221	3.0422		
6.2	1.2883	1.3906	−.3681	−.3973
6.3	.2770	1.1465		
6.4	.3799	.9976		
6.5	1.3289		−.2708	
6.6	.3651	3.7114		
6.7	.6900	2.0162	−.3136	−.9162
7.1	−2.9560			
7.2	.4025		−.5334	
7.3	.6229	1.0714		
7.4	1.1642			
7.5	.4264		−.3707	
7.6	.6462			
7.7	.6900		−1.9382	
8.1a	5.4646	1.0749		

Table 4.2 (*continued*)

Item	Total expenditure		Price	
	Short-run	Long-run	Short-run	Long-run
8.1b	1.3976	1.9290	−.8624	−1.1904
8.1c	.9429	.8955	−.4002	−.3801
8.1d	.5493	1.3572		
8.1e	.1677	4.4758		
8.1f	.3708	1.2596		
8.2a	.7167	1.3785	−.6221	−1.1967
8.2b	1.1460		−.6299	
8.2c			−.7185	−.9127
8.3a			−1.4151	−3.1948
8.3b	.1720	1.8944	−.1967	−2.1657
8.3c	5.8723			
8.3d	2.7059			
9.1	1.6726	1.4223		
9.2	.3841		−.4185	
9.3	.5864	2.0107	−.2970	−1.0186
9.4	1.3696	3.7162	−.8804	−2.3889
9.5	4.1978	2.9950		
9.6	.6372	5.1978	−.4711	−3.8427
9.7	1.0312	3.3208	−.8233	−2.6514
9.8a	.8126	3.4075	−.8748	−3.6685
9.8b	.7407	1.2604	−.1827	−.3109
9.8c	.0452	1.0697		
9.9	.8686	5.4354		
9.10	1.4239	1.9143		
9.11	1.2843	2.2770		
9.12	1.2112	2.1498	−.5675	−1.0073
10.1	2.1512			
10.2	2.7674			
10.3	.3542	1.1251	−.5182	−1.6459
11.0	1.8456		−1.0156	
12.1	.2355	3.0873	−.1351	−1.7707
12.2	1.7339			
12.3	.8590	1.1980		
12.4	3.7149		5.5554	