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6 Trade and Industrial Policy for a "Declining" Industry: The Case of the U.S. Steel Industry

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6.1 Introduction

The economics of the U.S. steel industry is not simple. Much maligned and much studied, the U.S. steel industry illustrates the problems of considering an industry in apparent decline. The loss of market in the 1970s and 1980s by the large integrated producers has been characterized by the joint presence of a growth in import pressures, and consequent protection, and the growth of a new lower-cost domestic source of supply based on minimill technology. Observers have characterized this industry as a classic example of Schumpeter's creative destruction in market economies, with the new replacing the old. At the same time, others have been more concerned about lost jobs and output due to the dramatic decline of the traditional part of the industry, and steel is often listed as one of the key strategic industries any major world economic and military power must preserve.

The simultaneous presence of an old and a new technology within the same industry and the importance of international competition in the U.S. steel market suggest that explicitly modeling the industry along the lines presented in the newer theories of international trade might be fruitful. While there are numerous sources of conventional microeconomic analysis of the U.S. steel industry, there is little in the way of analysis based on the newer trade theories.[1]

This paper describes a calibrated imperfect-competition model of the U.S. steel industry in the partial equilibrium tradition of Baldwin and Krugman

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1. Examples of microeconomic analysis of the U.S. steel industry include Tarr and Morkre (1984), which uses the competitive industry model as the basic framework.

(1988) and Dixit (1988). The model in this paper is distinguished in a number of ways, however, from those papers. First, the essential problem is one of dealing with the cost heterogeneity of firms within the steel industry due to the presence of old and new technologies. Second, the modeling of intertemporal competition is complicated by the small size and competitiveness of the U.S. minimill sector. The particular model used to address the nature of intertemporal competition will undoubtedly affect the results. The model used in this paper is one which might be summarized as mixed price-quantity competition during the "declining phase" of the industry, with a contestable-markets view of the longer term over which the industry may or may not be reborn as a high technology/high productivity industry.

The model used in this paper is highly stylized. It considers a hypothetical 10-year period in the industry, which could be imagined to be 1990–99. The period is characterized by constant (nongrowing) demand, constant real factor prices, and constant foreign supply prices. Furthermore it is assumed that the 1985 quotas, or voluntary export restraints (VERs), are in place over the entire 10-year period. The five-year period of 1990–94 is assumed to be one of competition between the minimills and the remaining integrated producers on their old plants. At the end of this period, it is assumed that existing integrated producers will exit the market completely, if they have not already done so. The period 1995–99 is characterized as a period of industry rebirth in which minimills in the United States are the least-cost source of domestic supply; however their success in that period will depend upon the nature of competition and the degree to which they were able to get costs down during the first five years.

The paper focuses on a basic descriptive model of the steel industry calibrated to a 1985 data set, and then a number of alternative trade and industrial policy experiments are carried out. These include (a) relaxed VERs on steel imports into the U.S. market, (b) increased protection of the U.S. market, (c) subsidies to integrated producers, (d) subsidies on operating costs during set-up periods to minimills, (e) cartelization of the market by forced mergers of integrated producers and minimills resulting in forced technical efficiency within the industry, (f) rationalization cartels with the additional constraint of price controls, and finally for reference (g) a type of second-best optimum taking the level of imports into the U.S. market as given. All of these represent elements of industry policy proposals that have come forward at one time or another for dealing with the peculiar problems of steel.

The basic result of the simulations is rather striking. The cost of the current VER protection is quite large, compared to either free trade or to a second-best optimum. For example in present-value terms the cost of protection over a 10-year period *relative to a second-best optimum* is approximately 6.85 percent of the present value of the base consumption stream, or about \$4.6 billion (1985 dollars). The welfare gains to complete elimination of protection on steel are substantially larger. However, *partial trade reform* in the sense of a small change in the level of quota protection is actually welfare reducing. The particular nature of these results is explored in some detail. It is surprising how sensitive to different policies the market shares of integrated and minimill producers are, and furthermore how sensitive cost inefficiencies within the industry are, both to policies and to the degree of protection. Furthermore, the quantitative results are somewhat more significant than other calibrated strategic trade policy exercises, suggesting that the scope for strategic trade policy may be greater than heretofore imagined.[2]

The rest of the paper proceeds as follows. Section 6.2 provides the details of the basic industry model used. Section 6.3 provides a brief summary of some salient features of the U.S. steel industry and details of the calibrations. Section 6.4 outlines the results of a variety of policy alternatives and the impact of partial trade reforms taking existing market structure as given. Section 6.5 examines some sensitivity analyses by considering issues of labor rents in base-cost calculations, alternative calibration procedures, and the sensitivity to demand elasticities. Section 6.6 concludes with some comments on the interpretation of the results and difficulties with this particular model of the steel industry.

6.2 An Industry Model

Many economists might think it is natural to use a competitive model to look at the U.S. steel industry. There are 14 large integrated steel producers using open-hearth furnaces and basic oxygen furnaces (BOFs), with many having moved to continous casting. As of 1986 there were about 55 minimill plants using electric furnaces and continuous casting, with scrap metal as the basic raw material input. Minimills are about one-sixth the size of an large integrated firm and typically produce a narrower product line. Minimill technology has been changing, however, with what can be regarded as classic industry- and firm-specific learning effects occuring within the industry. A typical start-up time is about two years for a minimill, and unit costs decline dramatically during this period. Integrated producers are operating plants well in excess of 20 years old, and modernization of these processes is technologically infeasible without complete scrapping. Minimills have a 30 to 60 percent operating cost advantage over the integrated firms. New integrated plants have been built abroad, principally in Brazil, Germany, Korea, and Japan. Crandall (1981) concluded that to build a new integrated plant in the United States was simply not economic at 1982 wages and exchange rates.

2. This is a disturbing conclusion for economists, who are prone to take noninterventionist positions. In this respect the "small numbers" that have come out of most of the quantitative strategic trade policy literature thus far are rather comforting; while theory predicts that the scope for intervention is there, quantitatively the gains do not seem to be that great. This particular resolution of the tension in the strategic trade policy literature may be temporary, as this paper suggests. For further discussion of this issue, see Harris (1989).

Thus competition within the U.S. market is between existing integrated producers, existing and new minimills coming on stream, and imports. Virtually all imports were under VER arrangements after 1983, and for most of the period 1983–88 the VERs were binding. For the purposes at hand it is assumed the import sector can be modeled simply as producing up to the level of the VER.

In constructing a model of the U.S. steel industry there are at least three reasons why imperfect competition may be a more appropriate paradigm than the static competitive model traditionally used.

1. There is a long history of price-setting practices by the integrated producers, resulting in numerous instances of policy confrontation in the industry. Oligopolistic pricing practices may be facilitated by the presence of a heavily unionized labor force within the industry.[3]

2. Minimills, while small relative to the integrated producers, have technologies which are characterized by the presence of significant sunk and fixed costs to building a plant, as well as the presence of a short but steep learning curve within a given plant life. Accounting for either of these important technological characteristics of the industry within a competitive framework is close to impossible.

3. Given the presence of the large competitors and the nature of their technology, minimills must make strategic pricing decisions in light of present and future competition. At the same time, entry into the industry by a new minimill usually means a period of losses, followed by a period of profitability. Modeling future industry output and price is an important determinant of minimill behavior within a framework in which equilibrium depends on producers' expectations of the future.

6.2.1 Model Details

The industry life consists of two periods, each equal to five years, with a common private and social discount factor δ connecting the two periods. Two important characteristics of demand are relevant in the case of steel: no real growth in domestic demand and a fairly low price elasticity of demand (clearly less than one). It is also reasonable to assume that intertemporal substitution effects in the demand for steel are small. The demand structure in each of the two periods is therefore a linear inverse demand curve:

$$P_i = \alpha - \beta Q_i, \quad i = 1, 2, \tag{1}$$

where P_i is the market price in period i, and Q_i is total quantity sold. The advantage of linear demand over iso-elastic demand curves in this case is obvious, as it prevents industry revenues from becoming unbounded as output falls and provides a determinate solution to the monopoly problem.[4]

3. See Crandall (1981, 31–32) for a discussion of oligopolistic pricing in the U.S. steel industry.

4. An advantage of the linear demand structure over the iso-elastic is that we can consider the impact of monopolization on price and output, while calibrating the model to a base with a (absolute) price elasticity less than one.

Integrated producers, minimills, and importers produce perfect substitutes all selling at a common price in the domestic market. The level of imports under an assumed binding VER is M in both periods. Integrated producers are assumed to be operating plants which collapse at the end of the first period. They have excess capacity throughout the first period and operate with constant unit operating costs (marginal variable costs) of v dollars per unit output. Integrated producers' collective output in period 1 is denoted by x. If price is below v, integrated producers will shut down. Accounting profits, including charges against fixed capital, are typically negative for these firms, but this will play no role in the analysis.

Minimill producers have an aggregated industry technology characterized by a fixed number of plants with fixed set-up cost, F. Costs in period 1 given an output y in period 1 are

(2) $$c_1(y) = wy + F, \text{ if } y > 0; \text{ otherwise } c_1 = 0.$$

Costs in period 2 given an output level z in period 2 are

(3) $$c_2(y,z) = ay^{-\varepsilon}z.$$

The unit operating costs in period 2 are given by an iso-elastic learning function $m = ay^{-\varepsilon}$, with a learning curve elasticity of $\varepsilon > 0$, so unit costs in period 2 decline as output in period 1 increases. While the learning curve interpretation is popular, the elasticity can be nonzero for a number of reasons summarized simply as the value of experience. It will be assumed that the number of minimills is fixed; this implies that all have the same cost curves, and interpreting z and y as aggregate minimill output implies that the number of firms is buried implicitly in the constant term a in the aggregate cost function.[5]

6.2.2 Period-1 Equilibrium

In period 1 integrated producers and minimills take the supply of imports as given by the VER. They face a residual demand curve determining the quantity over which they compete. This quantity competition is treated as a duopoly between the two sectors with exogenous conjectural variations on the part of minimills and integrated producers. At this point it must be admitted that this is a clear case of heroic aggregation across two classes of firms, ignoring competition between firms of each group in the first period. A weak but not com-

5. Suppose there are n identical minimills, each producing $\gamma = y/n$ in the first period, and δ in the second period. Each minimill has a second-period cost function $\hat{c}(\delta) = b\gamma^{-\varepsilon}\delta$. Total costs to producing $z = n\delta$ are

$$c = n\hat{c}\,\delta = nb\left(\frac{y}{n}\right)^{-\varepsilon}\left(\frac{z}{n}\right) = \left(\frac{b}{n-\varepsilon}\right)y^{-\varepsilon}z,$$

which is the functional form used in equation (3).

As y is aggregate minimill output, ε could capture learning effects which spill over between firms within the minimill sector. However, the interpretation of the first-order conditions strictly requires that learning effects be firm specific.

pletely satisfactory answer to this objection is that the number of firms are implicitly buried in the exogenous conjectural variation coefficient. Another unsatisfactory defense, but one commonly used, is that there is within-group collusion but not across-group collusion.

Let ψ^I denote the conjecture of the integrated producers as to $\partial Q_1/\partial x$, and ψ^M denote the minimill conjecture $\partial Q_1/\partial y$. The first-order condition describing the integrated producers' reaction function is given by

$$P_1 - \beta x \psi^I = v. \tag{4}$$

In the case of the minimills one must take account of how current output affects future profits. Let z^* denote equilibrium output levels in period 2. By the envelope result, assuming the firm has chosen z^* such as to equate marginal revenue and marginal cost in period 2, period-1 output y must satisfy

$$P_1 - \beta y \psi^M + \delta \varepsilon a y^{-\varepsilon-1} z^* = w. \tag{5}$$

The term $\varepsilon a y^{-\varepsilon-1}$ represents the operating-cost savings per unit of period-2 output due to an additional unit of period-1 output.

The market share in the period-1 equilibrium is critical in determining future minimill costs. Any policy or external shock which lowers the market share of integrated producers raises the future competitiveness of minimills. As such, therefore, the determination of output between the two types of producers is of considerable private and social importance.

A second characteristic of this equilibrium is that we assume that $w > v$; that is, that first-period operating costs of the minimill are higher than the variable costs of the old plants in the integrated sector. This simply reflects the start-up costs of a new technology. At the same time it is expected that future operating costs in minimills, m, will be less than both v and w.

The heterogeneity of costs across firm types means that, in general, the equilibrium of this industry will not be "technically efficient"; that is, marginal costs of different firms will differ and total costs will not be minimized. In a simple static sense this is true, as w is not equal to v. In an intertemporal model, though, the definition of technical efficiency is complicated, as one must account for the cost of producing future output. A standard definition of technical efficiency would be an allocation of outputs across plants which minimized the present-value cost of producing a given aggregate output *stream.* Solving this problem yields the cost efficiency condition

$$v = w - \delta \varepsilon a y^{-\varepsilon-1} z^*. \tag{6}$$

This simply says that allocation of output between new and old plants must account for the future cost savings as a result of allocating additional output to new plants. Outcomes other than planning or monopoly solutions will not generally be technically efficient. A measure of technical inefficiency reported in the simulations is the percentage difference in true cost between old and new plants, expressed as a percentage of old plant operating costs, v. Hence we define

$$\text{(7)} \qquad \text{efficiency gap} = 100 \frac{[v - (w - \delta\varepsilon a y^{-\varepsilon^{-1}} z^*)]}{v}.$$

An approximate interpretation of the efficiency gap would be the percentage cost savings on a unit of output shifted from the integrated sector to the minimill sector.[6]

It is generally acknowledged that the minimill sector is quite competitive. A central problem in this model is allowing for the presence of competitive pressures on price and entry in some appropriate way. It would seem desirable to enforce a zero present-value condition on minimills, which by assumption are assumed to start production at the beginning of period 1 and operate through the end of period 2. The traditional way of enforcing the zero-profit condition is by changing the number of firms, but with firms ignoring the effect of their pricing behavior on the number of firms in the industry. An extreme alternative is a type of contestable-markets model, where the number of firms is taken as fixed and pricing is such as to enforce zero profits. For a variety of reasons having to do with the availability of data, it seemed desirable to avoid the issue of how many minimills the U.S. market might accommodate. To do so requires detailed information about the cost curve at all levels of output. For this reason the contestable-markets view of future price competition was adopted. The basic idea is that price is set in period 2, conditional on output and price in period 1. The price is set such that second-period profits just cover first-period losses in present-value terms. Thus equilibrium in the minimill segment of the market is characterized by a zero present-value constraint. As in the static contestable-markets theory, it is price that changes so as to ensure zero profits, not the number of firms. At the same time the price in the period-1 market game is set based on the calibrated conjectural variations.

As another way of thinking about this equilibrium, imagine a minimill forecasting future sales in the first period. One reasonable conjecture would be that output in any equilibrium would be sufficient to yield operating profits so that, over the course of a plant's life, a normal rate of return would be earned. The major problem with this equilibrium concept is that it suffers from problems of the usual ex post sort when open loop equilibria are used. When period 2 is reached, the price forecast may not be sustainable against some deviations in behavior by some fraction of the minimill sector. Price competition in particular would be ruinous, forcing operating profits to zero and losses on the plants in the industry.

One reasonable way out of this predicament is to assume that z corresponds to a long-run capacity level chosen in period 1, when the plant is set up. In the case of minimills this is not an unreasonable assumption, given that these plants are designed with a particular level of output in mind. The period-2 price is therefore stable against price cutting in the second period, as all firms

6. This interpretation is only approximate in this model however, as period-2 output, z^*, might change in response to this experiment. In a simple static model with homogeneous output and constant marginal costs in both plants, however, this interpretation would be exact.

are capacity constrained. It must be assumed however that firms do not attempt to cut capacity in period 1 in an attempt to raise price. The contestable-markets story is that firms assume, were this to happen, that new minimills would enter, lowering price in both periods, and making the initial decision unprofitable.

Without further justification we simply assume that output is set in period 2 such as to force the present value of the profit stream on a minimill to zero. Letting Π_i denote period-*i* profits in a minimill, equilibrium implies that (x,y,z) satisfies the constraint that

$$\Pi_1 + \delta \, \Pi_2 = 0. \tag{8}$$

Equation (8) provides the link connecting periods 1 and 2. Any change resulting in an increase in period-1 operating losses—say, due to an increase in fixed plant costs, F—will result in a corresponding increase in Π_2, meaning usually lower period-2 output and higher period-2 prices. Note the structure of the model: an increase in F has *no* effect on period-1 prices. There are a number of other interesting linkages induced by the zero present-value condition. For example, a relaxation of the VERs will reduce the profitability of both the minimill and integrated sector in period-1 competition. Holding second-period imports constant, this will result in higher prices in the second period as minimills attempt to recoup their higher losses in the second period. Policy instruments therefore result in an intertemporal shifting of consumer and producer surplus through the profitability constraint on the minimill sector.

6.2.3 The Second-Best Problem

We report the solution to the second-best problem of maximizing consumer surplus plus domestic producer surplus, taking the level of the quota as given. This asks how a planner would organize the industry in the aggregate efficiency-maximizing way, taking as the second-best constraint the level of imports into the market. Because quota rents are assumed to accrue to foreigners, a feature of the second-best solution is that domestic output is used as a tool to lower prices and thus transfer surplus from foreigners to domestic consumers. For example, consider the simple problem in a constant-cost industry, with domestic cost c and foreign costs c^*. If the inverse demand curve is $D(Q)$, the exogenous quota level is q^+, and domestic production is x, the second-best problem is

$$\max_{x \geq 0} W \equiv S(q^+ + x) - cx - D(q^+ + x)q^+, \tag{9}$$

where $S(Q)$ is the gross domestic surplus function. Letting P denote the consumer price in the solution to this problem, generally P will be below c, and in fact P satisfies the first-order condition

$$\frac{c - P}{P} = \frac{m}{\eta}, \tag{10}$$

where m is the import share and η is the absolute price elasticity of demand. Implicitly, $c - P$ can be thought of as a production subsidy. With $\eta = 1.0$ and $m = 0.25$, the subsidy is 25 percent of selling price. The solution must satisfy the constraint that $p \geq c^*$, otherwise foreigners would not supply q^+ to the domestic market. It is possible that a corner solution, $P = c^*$, is optimal, with an implicit production subsidy of $s = c - c^*$.

The quota-revenue function $R(q^+,x) \equiv D(q^+ + x)q^+$ is globally decreasing in x. Note however that holding x constant,

$$\frac{\partial R}{\partial q^+} \gtrless 0 \text{ as } \frac{m}{\eta} \gtrless 1.$$

From the perspective of piecemeal reform of the quota levels, it is possible that increasing the allowable imports (increasing q^+) is locally welfare decreasing if $\partial R/\partial q^+ > 0$ or $m/\eta < 1$. If x is chosen optimally in (9) then, by the envelope theorem, $\partial W/\partial q^+ = -D'(q^+ + x)q^+ > 0$, so in this case the effect on welfare is unambiguous, with an increase in the quota leading to an increase in welfare. However in the model used here, x set in a market equilibrium will not be a solution to (9).

6.4 Calibration

The model was chosen with the U.S. steel industry in mind, over a hypothetical 10-year period using 1985 data on costs, growth, and the like, as the benchmark. For the sake of concreteness the 10-year period is referred to as the decade of the 1990s. It was desirable to break this decade into two periods: a period of competition between minimills and existing integrated producers and a period in which integrated producers retire their plants and competition is between minimills and imports. Taking 10 years as a horizon beginning in 1990, we chose the period 1990–94 as the period of integrated/minimill competition. The period 1995–99 is taken as the period in which domestic minimills are the sole U.S. source of steel. Rather than building a model with 10 separate periods, a drastic simplification was adopted whereby "period 1" is thought of as a sequence of five years of identical price, output, and the like, and "period 2" is a sequence of five years of identical price and output. Aggregation across time is done simply by weighting each year appropriately given an interest rate. Thus the model's period-2 "weight" reflects a ratio of summed discount factors over years allocated to periods 1 and 2 respectively. Using a real interest rate of 8 percent the weight on period 2 is 0.68. Interpreted properly this means a $1 cash flow each year from 1995 to 1999 is worth 0.68 of a sequence of $1 cash receipts in each of the years 1990 to 1994 valued in 1990 dollars. While clearly simplifying the dynamics of the problem, the two-period model captures much of the essence of the problem and allows calibration of the model to otherwise "static" data.

Price elasticities of demand for steel are notoriously low. The estimated elasticity in this paper from Crandall (1981) is taken at −0.90. The low price elasticities reflect the presence of few good short-term substitutes, plus a demand curve which has been shrinking to the left. The inelasticity of demand means that efforts to increase output result in large price decreases, giving additional reasons for efforts by the industry to restrict output, or at least avoid output increases.

The rest of the parameters for the model are taken from the books by Crandall (1981), Barnett and Schorsch (1983), and Barnett and Crandall (1986). While there are no formal models in these books, they each take a fairly similar view of demand, costs, and future technology from the perspective of the first half of the 1980s. As of 1989 the major factor not accounted for in these books was the fall in the value of the U.S. dollar from 1985 to 1988. This has led to foreign supply prices in terms of U.S. dollars which are higher than those used in this paper. It should be emphasized that the purpose of this paper is not to offer realistic "forecasts" of the steel industry but rather to highlight the problems of a declining, internationally noncompetitive industry within a partial-equilibrium framework. High domestic costs could be due to a variety of reasons including an overvalued exchange rate.

The facts on the state of the industry in the mid-1980s are fairly indisputable, although engineering estimates of costs are always subject to some disagreement. As of the mid-1980s the U.S. market for carbon steel products was about 94 million tons per year. Barnett and Crandall (1986, 96–98) suggested that at current rates of economic growth, this demand would remain about constant over the 1990s. In 1985 dollars the current price was in the range of $430 to $440 per ton. Imports accounted for about 25 percent of the U.S. market, with most of those imports covered by a VER agreement. The supply price of foreign imports depended on the country supplying, the method of production, and of course the exchange rate. The lowest cost source of imports was probably Korea, coming in at about $270 per ton using a 1985 exchange rate. These may obviously have changed but for the moment we will assume these costs remained constant. Given that the trade policy instrument of choice has been VERs, we will assume that all quota rents accrued to non–U.S. residents. Note that because of this, from a social point of view policies which indirectly shift quota rents may be nationally beneficial.

Integrated U.S. producers (about 14 firms) had mid-1980s unit operating costs of about $403 per ton (1985 dollars). All of the sources cited above agree that new greenfield integrated plants, with a minimum efficient scale (MES) of around 4 million tons per year, were not competitive in the United States at existing prices. As far as the integrated sector goes, therefore, the central question is when it will be displaced, and, until then, how large a market it might get in the absence of draconian government intervention.

Minimills constitute the new competitive and growing sector of the U.S. steel industry. Thus far they have operated on a much smaller scale than the integrated plants, at about 500,000 tons per year. The minimill sector has been growing rapidly from about 15 percent of the U.S. market in the early 1980s to a projected 27 percent in 1989. This sector remains very dynamic, with technology changing both in terms of increased productivity and changing scale. Some observers feel that efficient scale is growing within the minimill sector, and some consolidation is likely to take place. Engineering studies provide two important numbers on minimill technology: best-practice operating costs (at around $311 per ton) and the fixed costs of building a minimill plant.[7] Some of these studies also argue that the plant life of a minimill, in the range of 10 years, is significantly shorter than that of an integrated facility. This provides some justification for focusing on a 10-year horizon in the model.

The literature is not as helpful at providing information on the intertemporal structure of costs in the minimill sector, which are an important point in this exercise. First, an estimate of the operating costs in the early life of the representative plant is necessary, including start-up costs. While there are numerous qualitative stories about these costs, I have not found any precise estimates. Using the well-known "10 percent" rule, therefore, it is assumed that operating costs in new minimills, inclusive of start-up costs, are 10 percent above the operating cost found in existing integrated facilities. From the static perspective of near-term supply, this means that the existing integrated facilities are the least-cost source of domestic supply.

The second important parameter describing minimill technology is the "learning elasticity," ε. While the general literature on learning gives ranges for this parameter from 0.10 to 0.40, they differ by product and length of product cycle. It seems that a modest estimate for this parameter value is 0.15, meaning a one percent increase in output over the first five years of the plant reduces future operating costs by 0.15 percent. The cost function parameter, a (the constant in the learning curve), is then calibrated such that at the observed level of minimill output the best-practice operating cost of $311 per ton is reached after five years of plant operation.

This calibration is summarized in table 6.1. The observed price-cost margins and market shares are used to calibrate the reaction coefficients ψ^I and ψ^M. In the case of minimills one must also infer the zero present-value output level in period 2; this turns out to be about 72 million tons. It is interesting that the value for both reaction coefficients are fairly close to zero, implying that pricing is a long way from Cournot duopoly, reflecting competition both with and between the integrated and minimill sectors of the market. The calibrated values of the reaction coefficients suggest the minimill sector is the least aggressive, and the integrated sector the most aggressive, in terms of price cutting. This is partially consistent with the evidence of substantial excess capacity in the integrated sector, forcing integrated producers to price close to marginal variable cost as a means of maintaining output. At the same time the minimill sector is also fairly competitive, but it still suffers significant losses in the first

7. The engineering literature is surveyed by Barnett and Crandall (1986, chap. 5).

Table 6.1 **Parameters and Data for Calibrated Intertemporal Model of U.S. Steel Market, 1990–95**

Parameter	Data
Average annual U.S. consumption	94 million tons
Base price (1985 $)	$435 per ton
Price elasticity of demand	$\eta = -0.90$
Import share of market under VER's (%)	25
Integrated producer share of market (%)	48
Minimill share of market (%)	27
Integrated average annual operating cost	$403 per ton
Foreign least-cost supply (Korea) price	$270 per ton
Minimill fixed costs (hundred million $)	22.08
Minimill intertemporal cost elasticity	$\varepsilon = 0.15$
Minimill five-year target operating cost at existing output rates	$311 per ton
Discount factor on 1995–99 period	0.68 (or 8% real interest rate)
Calibrated reaction coefficients for period-1 market structure:	
Integrated producer $\partial Q_0/\partial x \equiv \psi' = 0.006553$	
Minimills $\partial Q_0/\partial y \equiv 0.04508$	

five years as prices are not sufficient to cover operating and fixed costs. The low operating costs in the second half-life of the plant, however, provide profits sufficient to ensure the present-value constraint is satisfied. It should be noted that in both periods the domestic price is sufficiently above the foreign supply price to ensure the VERs are binding and are giving rise to positive quota rents in equilibrium.

6.5 Simulation Results

In this section a number of alternative simulations are presented, which are designed to shed light on the current state of the industry and policies which have been recommended from time to time to deal with the steel industry. A summary of these results are presented in table 6.2. Eight different simulations are reported and discussed below.

6.5.1 The Second-Best maximum

For a point of reference it was decided to calculate a second-best optimum, maximizing consumer surplus plus producer surplus subject to the constraint that the quota, or level of imports, be taken as given and prices are bounded from below by foreign supply prices. What is interesting about the solution to this second-best problem is that prices are close to the foreign supply prices, quota rents are negligible, and the minimill market share is quite large relative to all other equilibria, with one exception. The fact that prices are driven below domestic production costs in both sectors reflects the second-best nature of the

Table 6.2 Alternative Policy Simulations for U.S. Steel Industry, 1990–99 (CV calibration method; high demand elasticity)

	Status Quo	VERs Relaxed	VERs Tightened	Monopoly	Rationalization Cartel	Integrated Subsidies	Minimill Subsidies	Second-Best Maximum
Price 1 (hundred $ per ton)	4.35	4.25	4.42	6.01	4.27	3.69	4.28	2.83
Price 2 (hundred $ per ton)	3.52	3.93	3.38	5.46	4.35	4.33	2.85	2.71
Minimill output 1 (million tons, per annum)	25.42	19.27	28.48	36.71	51.57	18.04	38.21	70.08
Integrated output 1 (million tons per annum)	45.08	29.83	54.78	1.65	20.50	65.34	33.83	30.15
Minimill output 2 (million tons per annum)	86.67	55.26	103.57	48.95	70.45	71.07	99.85	102.43
Quota level (million tons per annum)	23.50	47.00	9.40	23.50	23.50	23.50	23.50	23.50
Minimill unit cost 2 (hundred $ per ton)	3.11	3.24	3.06	2.94	2.79	3.27	2.92	2.67
Welfare 1 (billion 1985 $)	2.1739	2.1798	2.1956	1.3722	2.0861	2.3576	2.1459	2.2223
Welfare 2 (billion 1985 $)	3.4744	3.0658	3.6097	2.5807	3.3651	3.1966	3.8271	4.1159
Welfare cost[a] (%)	32.88	36.71	31.27	52.77	36.45	32.95	29.89	26.03
Efficiency gap[b] (%)	16.90	13.59	18.20	0.00	−0.26	22.70	9.41	0.00
Integrated producer surplus (billion 1985 $)	.1462	.0646	.2154	.0326	.0500	.3060	.0830	−.3629
Quota rents[c] (billion 1985 $)	.5203	1.1199	.2054	1.2184	.6346	.4929	.3935	.0318

Note: "Price 1" refers to annual price in period 1 (years 1–5), "price 2" refers to annual price in period 2 (years 6–10), etc.

[a]Welfare cost is measured as

$$100 \times \frac{\text{present value of free-trade welfare} - \text{present value of actual welfare}}{\text{present value of benchmark consumption}}$$

[b]Efficiency gap is eq. (7) expressed as a percentage.

[c]Quota rents are the present value of quota rents over both periods.

problem, with quota revenues being distributed abroad as discussed in section 6.3. Clearly in period 1 of the second-best optimum, given a price of $271 per ton, steel producers are receiving a substantial subsidy. Domestic output becomes an instrument whereby the quota rents on imports are reduced, resulting in welfare gains to the domestic economy in the absence of other instruments to reduce the quota rent transfer. The justification for using this particular second-best optimum as a reference point is motivated by the observation that free trade in steel is probably irrelevant as a domestic policy objective; the best that can be hoped for is to maximize efficiency within the domestic industry taking as given the level of imports, and in this case the policy that ensures that level of imports is met—the VER. Obviously tariffs are welfare-superior to VERs, but they are presumed to be unavailable as a policy tool.

Another characteristic of the second-best optimum is that the technical efficiency gap, as defined in equation (7), is zero, meaning the present-value costs of total domestic production are being minimized, or equivalently that the output allocation in the solution is technically efficient.

Welfare cost is measured relative to a free-trade equilibrium in which the equilibrium price is $270 per ton in both periods and imports have 100 percent of the U.S. market. Thus the welfare loss of the second-best maximum expressed as a percentage of the present value of consumption in the status quo, or benchmark, is 26 percent. From a pure efficiency point of view, free trade is vastly superior to any of the alternative equilibria considered.

6.5.2 The Status Quo

The status quo is basically the benchmark data set with slight changes.[8] There are at least two important observations about this equilibrium. First, in the status quo there are much higher prices and positive profits on integrated producer capacity, while in the second-best equilibrium the integrated producers actually operate at a loss. In a true first-best equilibrium the latter would never occur, but in this framework the presence of transfers to foreigners means that domestic output is used as a device to lower prices and hence the transfers.

Second, it is noteworthy that the allocation of output across sectors is quite different than in the second-best optimum. The share of minimill output in total domestic output is considerably greater in the second-best optimum than in the status quo. Indeed market shares are almost exactly reversed across the two equilibria. The cost efficiency gap in the status quo is a reflection of this difference; at 16.9 percent the efficiency gap indicates too much period-1 output is allocated to old plants in the integrated sector. Interpreting the welfare results requires some caution. The welfare cost number is the welfare loss relative to free trade expressed as a percentage of the present value of the status

8. The benchmark consists of an average of data over the first half of the 1980s expressed as a "typical" year. The model has two periods which differ. The calibration process is such that second-period price and output may differ from the benchmark first-period price and output.

quo consumption stream. This number can be quite sensitive to the assumed foreign supply price. In any case the welfare cost of any of these simulations as compared to free trade is substantial. At a welfare cost of 32.88 percent, the existing structure of protection and industry organization results in very large welfare costs. However, as remarked earlier, free trade may not be the relevant basis for comparison. Compared to the second-best outcome, which takes the level of imports and protection in the form of quotas as given, the status quo situation is only 6.85 percent worse than the second-best. This number might be interpreted as the impact of inefficiently allocated market resources, given the existence of an institutionally constrained level of protection. We shall return to this point later. It is also noteworthy that the second-best allocation relative to the market allocation shifts welfare intertemporally toward the second period. This suggests that the status quo market allocation, which is "biased" against the minimill sector's output, tends to result in an intertemporal distortion as well, shifting consumer surplus toward the current period at the expense of the future period.

6.5.3 Partial Trade Liberalization

A natural question is to ask what marginal value the VERs might have in maintaining domestic output, and what welfare benefits or costs they induce. The simulation "VERs relaxed" looks at the effect of doubling the level of allowable imports in *both* periods on the equilibrium of the model. This has the effect on consumers of reducing period-1 price and raising period-2 price, reflecting the significantly reduced output of the minimill sector in period 1 and thus reduced period-1 profitability. Relative to the status quo, integrated firms' output falls by about 33 percent and minimill output by about 24 percent. Also, not surprisingly, integrated producer surplus falls sharply with the output reduction and import expansion. What is a little surprising is that quota rents actually rise as a result of the increase in allowable imports. The quota-revenue function is actually increasing in the level of imports around the observed equilibrium. Relaxing the VERs actually reduces welfare both because period-2 prices are forced up and because quota rents more than double. The increase in welfare cost to doubling the allowable imports is about 4.8 percent (as a percentage of the base stream of consumption). Quantitatively this is fairly significant and at the same time suggests that a *movement* toward free trade can be nationally welfare decreasing. This conclusion is explored further below.

6.5.4 Increased Protection

If trade liberalization will not work, what about enhanced protection? The "VERs tightened" column in table 6.2 reports the effect of reducing the level of imports under a VER tightened to ten percent of the total market (base). In this case the domestic price rises in period 1, but falls in period 2, although not by a great amount. Consumers on balance are worse off, not surprisingly.

Protection does little for the minimill sector; most of the output gains due to the increased size of the domestic market accrue to the integrated producers in period 1, although the minimill sector obviously expands output in period 2 and produces at a lower cost relative to the benchmark equilibrium. There are some small welfare gains from this policy, about 1.6 percent, but hardly large enough to suggest that protection is the cure-all for the industry. From a technical efficiency perspective, increased protection actually reduces the cost efficiency of the industry, by shifting output toward the integrated sector.

6.5.5 Monopolization

In the course of the steel industry's history it has occasionally been suggested that, by cartelizing the industry, the efficient rationalization of existing resources in the industry and restructuring might be promoted. The Japanese model of a recessionary cartel is often cited. Given that a multiplant monopolist would act as a true joint-profit maximizer, this certainly makes sense. However, the consequences for consumer welfare of this policy are bound to be detrimental, and in the presence of VERs might be extremely harmful from a national efficiency perspective. The "monopoly" column in table 6.2 bears this out. Welfare costs are an astounding 53 percent, explainable in large part by the low initial price elasticity of demand. A significant fraction of these losses are caused by transferring surplus to foreigners through the quota rents generated by higher prices. The dramatic price increases experienced under this policy obviously make it politically unacceptable as an industrial policy. Note that, as theory predicts, monopoly results in a cost-efficient industry with an efficiency gap of zero percent.

6.5.6 Rationalization Cartels

The stories about rationalization cartels one reads in the industrial policy literature seem to imply that a monopolist could rationalize and restructure the industry, but at the same time, some other policy tool would be used to keep prices low. It is not clear what model of industry one has in mind here. A public steel monopoly maximizing aggregate welfare subject to a budget constraint might be one model. A more practical model, however, might simply be a monopolist maximizing profits subject to price constraints. Such a policy simulation is reported in the "rationalization cartel" column. Prices are constrained in this equilibrium not to exceed 4.36, reflecting the use of the status quo equilibrium price as a reference point. The results are quite interesting. The rationalization process involves an expansion of minimill sector output and a contraction in integrated sector output relative to the status quo. Unit costs in period 2 in the minimill sector are 10 percent lower under this policy than in the status quo. This result, together with the second-best results clearly suggest that in the status quo equilibrium minimill output is being crowded out by integrated sector output relative to the "efficient" policy. Under the rationalization cartel policy, first-period minimill sector output more than doubles, going up by 202 percent.

Whatever the technical efficiency gains from a rationalization cartel is does not rank high in terms of total welfare. There are fairly significant welfare losses under this model. The cartel attempts to make profits on the minimill sector, exploiting the relatively generous price constraint available in the second period. To do this it cuts back on the integrated sector output in the first period; this is welfare reducing because price exceeds marginal cost of production in integrated plants. In period 2 there is a transfer from consumers to the cartel.

6.5.7 Subsidies to Integrated Producers

A policy often suggested is to subsidize the costs of declining industries presumably with the objective of preserving output and jobs. In this case we focus on subsidies equal to 20 percent of operating costs, best thought of as a wage subsidy. The policy more or less produces the intended results; integrated sector output with a 20 percent operating subsidy expands by about 20 million tons relative to the status quo and price is reduced in period 1. The intertemporal linkage through the zero present-value condition shows up clearly. In the second period price rises by about 12 percent, reversing the pattern of declining prices over time evident in the status quo. The net welfare effect is positive relative to the status quo, although very small. The benefit seems to come largely from the fact that price is closer to the marginal cost of integrated producers in period 1. Intertemporally the policy shifts welfare from period-2 to period-1 consumer and producer surplus.

6.5.8 Subsidies to Minimills

The infant industry argument might suggest that because the minimill sector is "too small" relative to the second-best optimum it should be subsidized. As it turns out, a 20 percent operating subsidy to minimills results in about a 50 percent increase in output in this sector, with the major benefit in form of reduced prices in the second period. The subsidy which is offered during the industry's first five years has the effect of also reducing integrated sector output by about 25 percent and produces net welfare gains of about 2.9 percent. While not insignificant, the quantitative gains might be reduced if one were to attach a deadweight loss to the additional tax revenue required by subsidies.

6.5.9 Trade Reforms Again

The results on trade reform do not at this point seem clear. In particular the large welfare costs in the status quo–free trade comparison do not seem to reconcile with the welfare decrease of more generous VERs against steel imports. In figures 6.1–6.3 we present the results of varying the quota level from 0 to 48 million tons into the market in both periods. Results are presented so as to set the welfare gain equal to zero in the status quo situation of a VER of 23.5 million tons.

Figure 6.1 presents the apparently "paradoxical" results that as the quota is

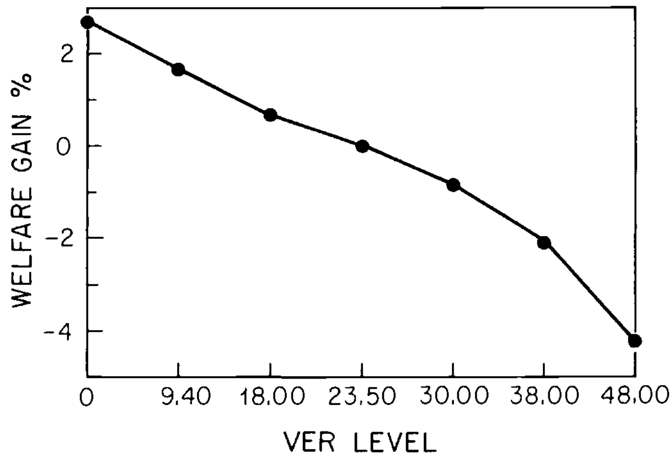

Fig. 6.1 Protection and welfare: U.S. steel industry

reduced the welfare *gain* is positive, rising to a high of 2.8 percent when all imports are excluded from the market, while there is a welfare loss of 4.2 percent when imports are about half the domestic market. The apparent conclusion is that, on a partial reform basis, over a fairly wide range of import penetration levels, the optimal trade policy is to restrict imports of steel.

This would be an erroneous conclusion, however. The real problem has to do with the use of an inefficient instrument, the VER; in this case the policy choice is driven by the issue of shifting the implicit terms of trade between U.S. and foreign steel suppliers because rents accrue to non–U.S. residents. Suppose an instrument were available such as a tariff or quota auctions such that all quota rents accrued to the U.S. economy in lump-sum fashion. The estimated impact on welfare is dramatically different as illustrated in figure 6.2. Using a quota-rent-inclusive measure of welfare we see that the conclusions about protection are actually reversed. Prohibiting imports results in a welfare loss of about 5 percent,[9] while progressive liberalization of the market by allowing increased imports increases welfare continuously. Neither welfare gains nor welfare costs to significant trade reform are trivial. They are all substantially in excess of the usual 1 percent gains in much of the partial-equilibrium strategic trade literature. Figure 6.3 illustrates the perverse effect protection has on industry cost efficiency. Restricted levels of quota protection raises the efficiency gap between integrated and minimill producers, contributing to the usual welfare losses imposed by protection.

It is important to emphasize that the paradoxical results on partial trade re-

9. Note that the base is redefined in this situation to be one in which the rents on the 23.5 million tons of imports accrue to U.S. residents.

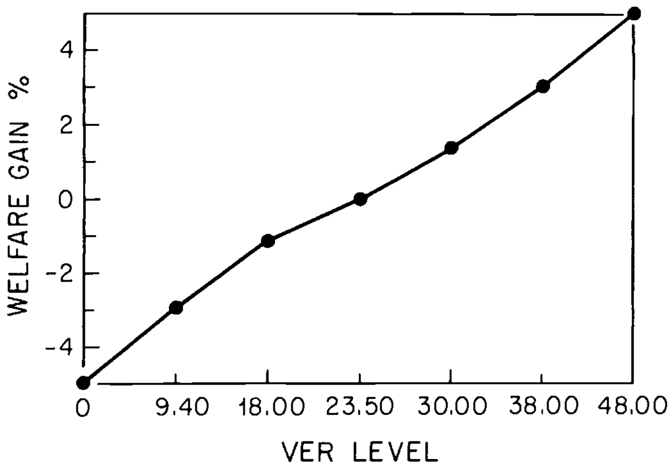

Fig. 6.2 Quota-rent-inclusive welfare change: U.S. steel market

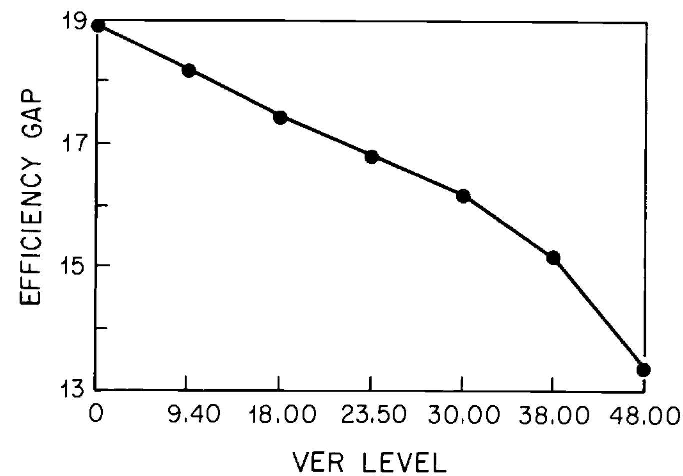

Fig. 6.3 Protection and technical inefficiency: U.S. steel industry

form are closely linked to the assumption of imperfect competition. In a perfect-competition model increasing the level of allowable imports, given a constant foreign supply price which is less than the domestic price, is always welfare nondecreasing. With imperfect competition there are a number of complications: (i) Price exceeds marginal cost in domestic production. By increasing imports and reducing domestic production the cost of this distortion is enhanced. (ii) In the competitive model, relaxing the VER would reduce price, increase total output, and leave costs unchanged. In the imperfect-competition model of this paper, the learning-cost effect in the minimill sector implies that a relaxed VER reduces current minimill output and thus raises future minimill cost and hence price. Therefore it is the interaction between the joint assumptions of a rent-transferring voluntary restraint agreement (VRA) and an imperfect market structure which leads to the possibility that tighter quotas could be welfare increasing.

What can we conclude from this exercise? There are three points to make:

1. In the presence of VERs on which foreigners are collecting rents, partial trade reforms involving changes in the level of quotas must be carefully considered. Partial liberalization may well be nationally harmful.

2. Industrial subsidy policies targeted to particular subsectors can have a substantial effect on the allocation of output between the subsectors. In general, subsidies to the new technology in this framework are appropriate, although the welfare gains would be enhanced were other instruments available to solve the quota-rent transfer problem.

3. Trying to correct the technical efficiency losses by rationalizing integrated capacity and shifting output toward the new technology part of the industry is of dubious quantitative significance within this model, at least over the range of parameter values considered. Given the possible cartelizing side effects of such policies one would want to proceed very carefully.

6.6 Alternative Specifications and Procedures

Tables 6.3–6.5 report some alternatives to the exercise reported in the last section. In many calibration exercises the empirical aspect of the procedures adopted are never clear-cut.[10] In the steel industry the cost figures in the integrated sector are particularly suspect because of a rather high wage differential of about 20 percent between it and average manufacturing in the United States. If this wage differential reflects rents to labor, and not differences in the opportunity cost of labor in alternative sectors, the results could be seriously misspecified. In table 6.3 we report the same policy exercises assuming such a distortion in labor markets. Standard theory suggests that the integrated sector may be too small due to the presence of the wage premium to employment in the integrated steel sector. Assuming that these rents exist implies that the integrated sector would have a much greater output in the second-best equilibrium than in the status quo, reversing the "no-rent" simulation result. The aggregate welfare cost of the status quo measured against the second-best is 7.8 percent—about 1 percent more than in the calibration without labor rents. The other notable distinguishing feature of these simulations is that the efficiency gap is much less than in the simulations without labor rents. In this instance the issue of output allocation across plants within the steel sector is less serious than in the previous case, as integrated producers are actually lower cost than

10. See the discussion of this issue in Harris (1988, chap. 4).

Table 6.3 **Alternative Policy Simulations for U.S. Steel Industry, 1990–99** (CV calibration method; labor rents = 20% of wage bill in integrated sector; high demand elasticity)

	Status Quo	VERs Relaxed	VERs Tightened	Monopoly	Rationalization Cartel	Integrated Subsidies	Minimill Subsidies	Second-Best Maximum
Price 1 (hundred $ per ton)	4.35	4.25	4.42	5.83	4.28	3.69	4.28	2.70
Price 2 (hundred $ per ton)	3.52	3.93	3.38	5.60	4.35	3.94	2.85	2.69
Minimill output 1 (million tons per annum)	25.41	19.27	28.49	19.98	30.20	18.04	38.21	41.03
Integrated output 1 (million tons per annum)	45.08	29.83	54.78	21.37	41.71	65.34	33.83	61.64
Minimill output 2 (million tons per annum)	86.67	55.26	103.57	46.21	70.57	78.51	99.85	102.83
Quota level (million tons per annum)	23.50	47.00	9.40	23.50	23.50	23.50	23.50	23.50
Minimill unit cost 2 (hundred $ per ton)	3.11	3.24	3.05	3.22	3.02	3.27	2.92	2.89
Welfare 1 (billion 1985 $)	2.3362	2.2872	2.3928	1.6261	1.1790	2.5929	2.2676	2.5589
Welfare 2 (billion 1985 $)	3.4744	3.0657	3.6096	2.3472	3.2034	3.1965	3.8271	3.8912
Welfare cost[a] (%)	32.21	37.07	30.01	54.17	52.16	31.21	29.67	24.69
Efficiency gap[b] (%)	8.76	5.12	10.17	0.01	−1.04	18.87	0.53	−0.56
Integrated producer surplus (billion 1985 $)	.1465	.0646	.2153	.3930	.1051	.3060	.0830	−.8193
Quota rents[c] (billion 1985 $)	.5205	1.1199	.2054	1.1987	.6356	.4318	.3935	−.010

Note: See note to table 6.2.

[a]Welfare cost is measured as

$$100 \times \frac{\text{present value of free-trade welfare} - \text{present value of actual welfare}}{\text{present value of benchmark consumption}}$$

[b]Efficiency gap is eq. (7) expressed as a percentage.

[c]Quota rents are the present value of quota rents over both periods.

they appear to be in the market allocation, which is biased against the minimills.

One of the key problems in the calibration of the model is the use of the conjectural variations as the "free parameter." Numerous commentators have remarked as to the possible misspecifications this may impose on the model. An alternative in the case of minimills is to assume the sector as a whole acts as a Bertrand-pricing oligopolist. Given the fairly large number of minimills relative to integrated producers, this may be appropriate. In table 6.4 the results are based on the model in which the period-1 operating costs, w, of minimills are calibrated assuming Bertrand pricing by minimills. In this model that calibration produces a cost estimate for w of 5.12, which is greater than the 4.43 estimate used in the previous case. This change in calibration procedure now means both (a) that operating costs are higher in the minimill sector than the first set of simulations reported and (b) that pricing by the minimill producers is more competitive. This tends to put the integrated producers at a disadvantage in that their rivals are pursuing a more aggressive output strategy, but also at an advantage given the now-higher minimill costs.

The results of the Bertrand minimill pricing are that the welfare losses are about 8.7 percent relative to the second-best—certainly larger than in the first set of simulations. As in the last case however the conclusions about the relative share of the two sectors in an efficient allocation is reversed. In the second-best equilibrium the minimill sector is much smaller than in the first set of simulations. Indeed you will note that the efficiency gap has actually changed sign. As a result, subsidization of the minimills results in quite significant welfare losses relative to the status quo.

One parameter value which seems of some dispute in the case of steel is the demand elasticity. Some estimates come in much lower than −0.90. Jondrow (1978), for example, estimates it to be in the range of −0.45—half the assumed value. Low demand elasticities are an important part of the problems plaguing declining industries, so it was thought to be a useful exercise to see how conclusions changed if a much lower demand elasticity was assumed. These results are reported in table 6.5, again employing the conjectural variations calibration method. Obviously with lower demand elasticities prices are much more sensitive to output changes around the benchmark. This shows up dramatically in the "monopoly" column of table 6.5 with a period-1 monopoly price of 43! Clearly the linear demand specification is suspect at this point. The welfare costs of trade restrictions are of course dramatic given the steep demand curve and the redistributive implication of a VER. The status quo is characterized by a welfare loss of 99 percent relative to free trade; however relative to the second-best equilibrium the welfare loss is only about 8.5 percent. The other qualitative conclusions do not change much.

Table 6.4 **Alternative Policy Simulations for U.S. Steel Industry, 1990–99 (cost calibration method; Bertrand minimill pricing)**

	Status Quo	VERs Relaxed	VERs Tightened	Monopoly	Rationalization Cartel	Integrated Subsidies	Minimill Subsidies	Second-Best Maximum
Price 1 (hundred $ per ton)	4.35	4.31	4.40	5.83	4.30	3.71	3.95	2.71
Price 2 (hundred $ per ton)	4.00	5.52	3.80	5.79	4.35	4.33	3.39	2.71
Minimill output 1 (million tons per annum)	25.50	8.96	31.94	9.51	16.09	15.15	78.39	20.32
Integrated output 1 (million tons per annum)	45.01	38.88	51.74	32.35	55.53	67.88	0.00	82.16
Minimill output 2 (million tons per annum)	77.43	24.34	95.38	42.53	70.50	71.07	89.30	102.53
Quota level (million tons per annum)	23.50	47.00	9.40	23.50	23.50	23.50	23.50	23.50
Minimill unit cost 2 (hundred $ per ton)	3.11	3.63	3.00	3.60	3.33	3.36	2.62	3.21
Welfare 1 (billion 1985 $)	2.1109	1.6805	2.1464	1.6218	1.1353	2.3321	1.3751	2.5365
Welfare 2 (billion 1985 $)	3.3042	1.7655	3.5765	2.0504	2.9899	2.9812	3.9467	3.5586
Welfare cost[a] (%)	36.69	58.30	33.46	56.33	54.10	36.67	41.07	27.93
Efficiency gap[b] (%)	−18.52	−17.30	−19.81	0.03	−4.19	−0.94	−36.43	0.34
Integrated producer surplus (billion 1985 $)	.1459	.1093	.1923	.5812	.1483	.3301	0.00	−1.0840
Quota rents[c] (billion 1985 $)	.5962	1.6583	.2303	1.2288	.6397	.4971	.4034	.038

Note: See note to table 6.2.

[a]Welfare cost is measured as

$$100 \times \frac{\text{present value of free-trade welfare} - \text{present value of actual welfare}}{\text{present value of benchmark consumption}}.$$

[b]Efficiency gap is eq. (7) expressed as a percentage.

[c]Quota rents are the present value of quota rents over both periods.

Table 6.5 Alternative Policy Simulations for U.S. Steel Industry, 1990–99 (CV calibration; low demand elasticity)

	Status quo	VERs Relaxed	VERs Tightened	Monopoly	Rationalization Cartel	Integrated Subsidies	Minimill Subsidies	Second-Best Maximum
Price 1 (hundred $ per ton)	4.39	4.26	4.46	42.73	4.36	3.63	4.32	2.71
Price 2 (hundred $ per ton)	3.67	4.10	3.50	42.25	4.36	4.06	2.99	2.70
Minimill output 1 (million tons per annum)	21.39	16.48	24.07	28.06	50.54	15.55	30.71	51.49
Integrated output 1 (million tons per annum)	49.79	31.32	61.14	7.69	20.67	56.33	40.53	21.24
Minimill output 2 (million tons per annum)	71.84	47.95	86.10	36.20	71.21	71.48	72.47	72.74
Quota level (million tons per annum)	23.50	47.40	9.00	23.50	23.50	23.50	23.50	23.50
Minimill unit cost 2 (hundred $ per ton)	3.19	3.31	3.13	3.06	2.80	3.34	3.02	2.79
Welfare 1 (billion 1985 $)	48.4590	48.4577	48.4902	19.4739	44.3387	48.6609	48.4371	48.7260
Welfare 2 (billion 1985 $)	49.5378	49.1644	49.6690	33.4732	49.6472	49.3318	49.8203	50.0519
Welfare cost[a] (%)	99.12	103.07	97.26	716.12	161.67	98.17	96.49	89.59
Efficiency gap[b] (%)	17.19	14.50	18.45	0.07	0.07	29.00	8.12	0.07
Integrated producer surplus (billion 1985 $)	.1782	.0714	.2658	2.9775	.0673	.2288	.1187	−.2803
Quota rents[c] (billion 1985$)	.5522	1.1783	.2170	15.7265	.6535	.4364	.4280	.0023

Note: See note to table 6.2.

[a]Welfare cost is measured as

$$100 \times \frac{\text{present value of free-trade welfare} - \text{present value of actual welfare}}{\text{present value of benchmark consumption}}.$$

[b]Efficiency gap is eq. (7) expressed as a percentage.

[c]Quota rents are the present value of quota rents over both periods.

6.7 Conclusion

Policies to favor new industries over old are at the crux of the debate on industrial policy in many countries. The steel industry provides an interesting case study of an industry that can be thought of as containing both declining and expanding subsectors, both of which compete in the short term with imports for the same market. What this paper suggests is that the answer to the question of in which direction the industry should be pushed depends on market structure, costs, and demand conditions. In the case of the U.S. steel industry, taking the level of imports as the relevant constraint, the existing industry structure is inefficient, but cost estimates are crucial to deciding in which direction the industry should be pushed. Taking the existing industry structure as given, small changes in trade and industrial policy can affect welfare, but the conclusions are very sensitive to the disposition of the rents created under the VER programs. It is quite possible that restricting imports is welfare increasing, given the imperfectly competitive nature of the steel industry.

These results must be qualified by the relatively simple structure of the model used and the crude nature of the data used in calibration. Perhaps more fundamental, however, is the structure of the model itself. A particular worry is the fact that integrated plants are assumed to exit after five years of operation. Clearly with some expenditures it is possible to keep these plants operating over a period longer than the next five years. Endogenizing this decision is the next logical step to take in model construction.

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