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Privatization, Concentration, and Pressure for Protection

A Steel Sector Study

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and
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Incentives for seeking protection in the steel industry — particularly import quotas as a fixed proportion of domestic sales — seem to increase with industry concentration. If protection is necessary, tariffs are preferable to import quotas.

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This paper — a product of the International Trade Division, International Economics Department — is part of a larger effort in the department to analyze the effects of trade distortions on developing countries. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Sarah Lipscomb, room S7-062, extension 33718 (March 1993, 31 pages).

In considering whether to privatize a large state-owned steel enterprise in Argentina, the question arose: Would its sale to a consortium of large domestic enterprises, and the resulting increase in firm concentration, inevitably lead to cries for protection?

To shed light on the question, Qian and Duncan examine data for steel industries in the major industrial countries. They also construct a simulation of Argentina's steel sector to study the relationships between levels of industrial concentration, substitutability between domestic and imported steels, trade policy regimes, and mark-ups of domestic prices over international prices.

Their simulation results show that heavier rents and economic distortions are generated through fixed-ratio import quotas (quotas that are a fixed proportion of domestic sales) than through use of a tariff or a fixed-quantity import quota.

The results show why industries seeking protection prefer a fixed-ratio import restraint — a practice being used increasingly often in industrial countries. If there is not perfect substitutability between domestic and imported steels, the incentives for the Argentine industry to seek protection — particularly as a fixed-ratio quota — are greater, the more concentrated the industry is.

The lesson for policymakers — who should be trying to minimize economic distortions — is that if protection is necessary, tariffs are preferable to import quotas, perhaps even to the point of making quota-type restrictions unconstitutional.

The simulation results for Argentina confirm that the less substitutable domestic and foreign goods are, the higher the rents the domestic industry can extract. So, it is important for policymakers implementing privatization schemes to ease any explicit or implicit obstacles to imports by such measures as:

- Standardizing domestic product classifications with international classifications.
- Modernizing transportation facilities to improve the speed of shipment and communication.
- Reducing bureaucratic practices related to trade in goods and services.
- Releasing foreign exchange restrictions.

The goal should be to make a foreign transaction as easy as a domestic transaction.

Privatization, Concentration, and Pressure for Protection:

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I. Introduction[1]

1. This paper presents what are essentially preliminary results from a study of the relationships between industry concentration, domestic price mark-up, and the potential demand for trade protection in a steel sector. The study was initiated by the World Bank's interest in the privatization of Argentina's steel sector,[2] where it was proposed that a major publicly owned steel company, SOMISA, be sold to a domestic consortium formed by the two largest private steel producers. Such a purchase would have led to the consortium holding 85% of the steel market in Argentina. The question posed was: if the industry became more concentrated, would there be a predisposition to greater trade protection, particularly non-tariff-barriers (NTBs) such as quotas, voluntary export restraints (VERs), and anti-dumping actions against other steel producers?[3]

[1]The authors wish to thank Messrs. W. Martin, B. J. Choe, and P. Varangis who advised us on the model-specification, Messrs. P. Meo and A. Kapur who encouraged and directed the study, and all participants at the paper's review meeting in the LAC region.

[2]"A Sector Report on the Steel Industry Rationalization and Strategic Privatization Options for Sociedad Siderurgia Argentina (SOMISA)", The World Bank, LA4TF, 1991.

[3]SOMISA (80% of its capital) was sold in November, 1992 to an international consortium led by an Argentine steel and engineering group Techint, and renamed Aceros Parana. The manner in which the company was sold prohibited the two largest national steel companies from combining to purchase it. The other consortium members include the Chilean steel group CAP, Brazil's largest steel maker Usiminas, and Brazil's state-owned iron ore producer CVRD. The remainder of SOMISA (a ship-plate mill and some office buildings) is still for sale. Techint owns one of the two private integrated steel mills in Argentina (Siderca). The other private integrated steel mill, Acindar, was not successful in its bid for SOMISA.

2. The answer to the above question has important implications to ongoing privatization operations in Latin America, Eastern Europe and Central Asia. Privatization is driven by the belief that ownership is a significant determinant of enterprise performance. Evidence shows that, regardless of the country, good performance from state-owned-enterprises (SOEs) has been very difficult to sustain. However, questions have been raised about the high degree of industry concentration that may result from the sale of SOEs to the private sector. Some believe there is no need for any concern over this issue because an open trade account would be sufficient to prevent rents accruing to oligopolistic industries. However, if higher industry concentration means higher industry protection, an open trade account itself will be in doubt.

3. It is obvious that higher concentration would make it easier for industry to extract oligopoly/monopoly rents and result in domestic prices higher than international levels. How much a higher level of concentration would raise domestic prices and how different trade policy measures (e.g., tariffs, quotas) would affect an industry's ability to increase prices at different concentration levels are much less obvious. If the level of concentration affects an industry's ability to extract rents through protection, there is most likely an association between the level of concentration and the type of protection adopted -- as different types of protection generate different levels of rents.

4. The next section presents empirical evidence on industry concentration, domestic steel price mark-ups, and trade protection schemes in the G5 countries (France, Germany, Japan, United Kingdom and United States). The section following develops a model which features an

oligopolistic domestic market and imperfect substitution between domestic products and imports, and discusses simulation results on the relationship between concentration rates and domestic price mark-ups under different trade policies.

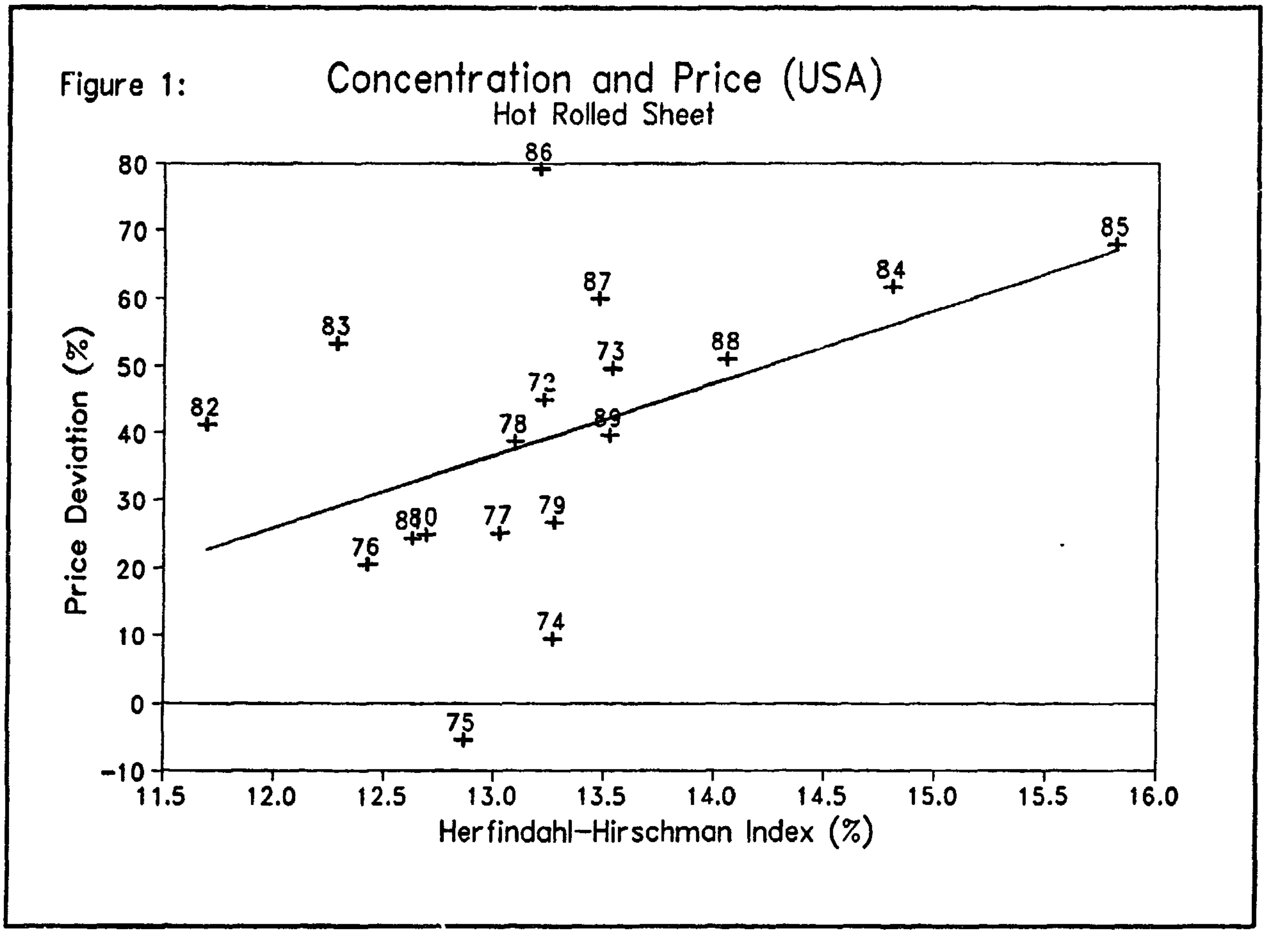
II. Empirical Evidence

5. Steel production and steel price data were obtained from the World Steel Dynamics group of PaineWebber.[4] These include time-series data (1972 to 1989) on domestic steel prices of the G5 countries, international prices (Antwerp spot, and export prices of Germany and Japan), and production statistics of the major steel companies in each of the G5 countries. This data set allows calculation of the percentage deviations of domestic prices from international prices and the construction of Herfindahl-Hirschman indices (HHI) of industry concentration for each country. By cross-plotting the percentage price deviations and the HHI, we have a weak test of the hypotheses of how concentration relates to price mark-up, and how concentration relates to trade protection.

6. Figure 1 shows such a plot for the United States for hot rolled sheet. The horizontal axis depicts the HHI, and the vertical axis represents the percentage price deviation. Each "+" sign corresponds to a particular year. The straight line is the best-fitting line through the yearly observations. It can be seen that in the United States: (i) there is no trend in steel industry concentration; (ii) there is a positive relationship between the Herfindahl index and the percentage price deviations (the estimate of the slope coefficient is 10.8, indicating that, on average, one percentage point increase in the Herfindahl index would increase the price deviation

[4]"International Steel Pricing - Core Report OO", Paine Webber, World Steel Dynamics, 1991.

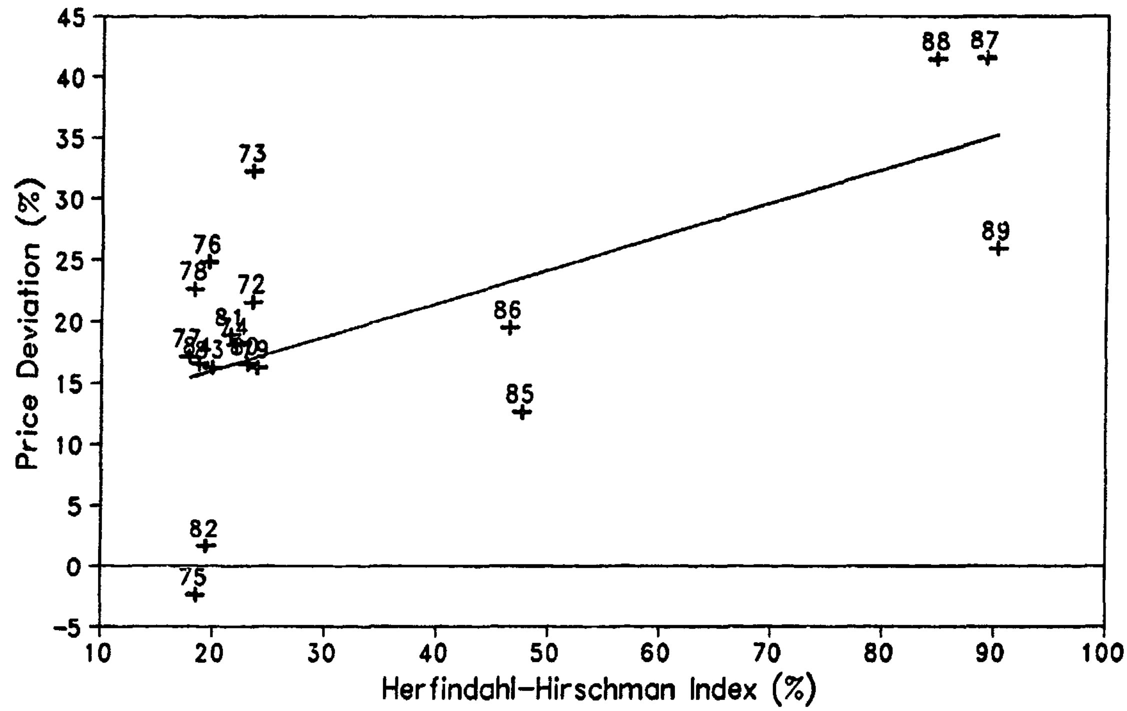
by more than 10%); (iii) it may not be by coincidence that most observations above the regression line are the years when VERs were in place (i.e., 1969-74 and 1983-89), and observations below the line are years when VERs were not in effect (i.e., 1975-82).



7. Figure 2 gives the same plot for France. Unlike the case for the United States, the Herfindahl index for France varies greatly from about 20% to well above 90% because of the merger of two major steel producers, Usinor and Sacilor, in 1987. This gives us the opportunity to observe what happens when there is a sudden change in the concentration index. The results confirm the conventional wisdom: domestic prices in 1987 and 1988 exceeded the international

price by more than 40%, and in 1989 by more than 25%. The slope coefficient estimate is 0.27, indicating that on average a 10% percent increase in the Herfindahl index would see an increase in mark-up of the domestic price over the international price of about 3%.

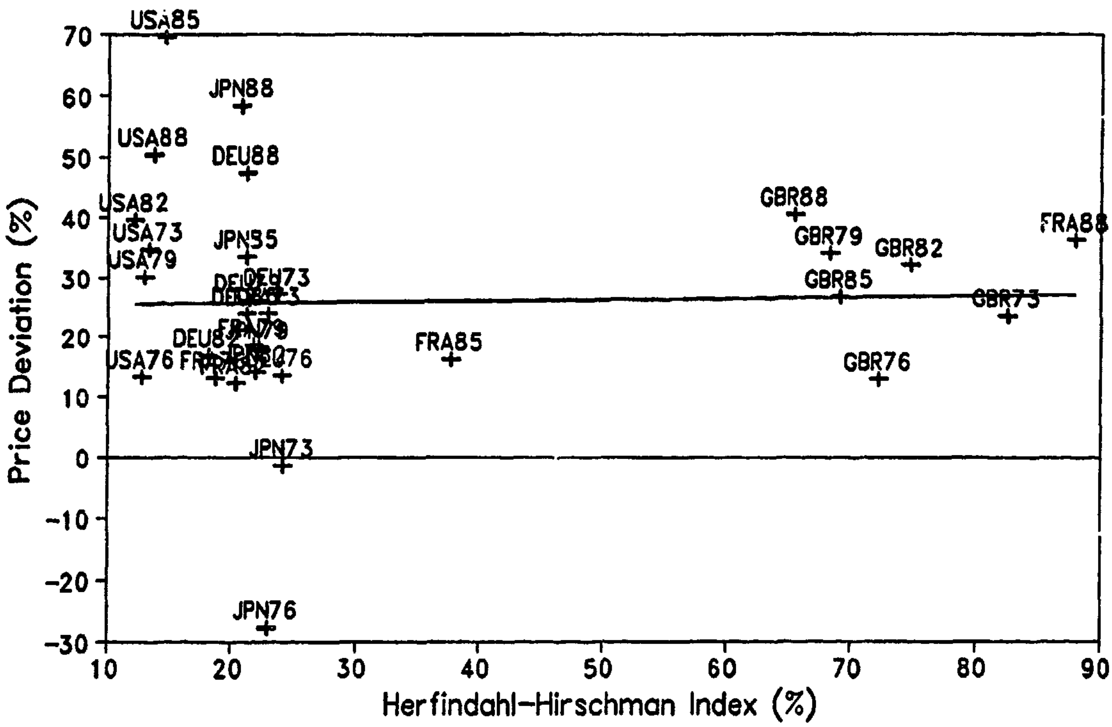
Figure 2: Concentration and Price (France)
Hot Rolled Sheet



8. For other countries (i.e., Germany, Japan and the UK), no easily observable positive relationships can be seen between the Herfindahl index and domestic prices. In Figure 3, selected yearly observations for the combined data set of the G5 countries (i.e., 1973, 1975, 1978, 1980, 1982, 1985, 1988) are plotted. The country abbreviation and year are presented on top of each observation. Unlike the cases of the United States and France, the best fitting

straight line in Figure 3 is almost flat; the slope estimates is 0.02, meaning that for a 50% increase in the Herfindahl index, the domestic price deviation would increase by a mere 1%.

Figure 3: Concentration and Price (G5)
Hot Rolled Sheet



9. The lack of success in finding a consistent positive relationship across countries between the Herfindahl index and the domestic price deviation is perhaps because of the complicated nature in which domestic price is determined not only by industry concentration but also by an array of other variables such as income growth, elasticity of substitution between domestic products and imports, prices of inputs in the steel production process, interest rates, exchange rates, technological changes, and political economy considerations. Given that all these variables

also have influence, it is difficult within a simple model to single out how industry concentration determines domestic steel prices and trade policies. In order to do that, we need to specify a more complex model to control for all other possible relationships. But such a model requires a greater range of data than are available at present.

10. In light of the difficulties of taking an econometric approach, it was decided to use a simulation model where some exogenous variations can be ignored by assuming that they are constant and some others can be controlled in the simulation process. The simulation model is described in the following section.

III. Simulation Model and Results

11. The simulation model contains five equations as listed in Table 1. It combines the features of: (i) an oligopolistic domestic market with a fixed number of firms of identical size (i.e., no one has more market power than another) which are playing Nash-in-quantity (Cournot) games,[5] and (ii) imperfect substitution between domestic products and imports. The first step in model building makes the link between the concentration measure (Herfindahl Index) and market competitiveness. The second step of the exercise is to set up a Constant Elasticity of Substitution (CES) demand framework for domestic products and imports. A detailed derivation of the model is included in Annex I. The basic behavioral characteristic of the model is that when there is imperfect substitutability between imports and domestic production, or when there is protection against imports, the higher the industry concentration the higher the domestic mark-up.

12. Equation (M.3) is the key equation which simulates the domestic price p_1 for each level of the Herfindahl index, under given assumptions (e.g., elasticity of substitution and trade policies). We apply actual values taken from Argentina's steel sector to see what could happen to the domestic steel price if the industry concentration, as reflected by the Herfindahl index were changed from one level to another. By comparing solutions across different trade policies,

[5]Each firm sets its production level believing that this will not affect the *output* of other firms.

we can answer the question as to what kind of trade protection scheme is most appealing to oligopolistic steel producers. In addition, we can solve for consumption levels of x_1 and x_2, calculate average cost and profitability, and determine the optimal size of the steel industry (this may be done later after data are available).

13. The model is used to simulate three trade policy scenarios. In the tariff-based scenario the four unknowns are p_1, p_2, x_1, and x_2, while h, m, ϵ, τ and ρ are given. In the fixed-ratio quota scenario, τ becomes unknown, but the ratio of x_1/x_2 is known. In the fixed-quantity quota scenario, x_2 is known. The scaling factor A and two technical coefficients of the CES model, a_1 and a_2, need to be calibrated from observations of ρ, x_1, x_2, p_1, and p_2 of a benchmark year.

14. Tables 2 and 3 present the simulation results.[6] The year 1991 is used as the benchmark year -- a year when there were no non-tariff barriers in Argentina and the tariff (τ) for general carbon steel imports was about 25%. The hot-rolled sheet price is used as the representative price for steel. In the domestic market, prices were as follows: p_1=\$440/ton and p_2=\$468.75/ton (because of the tariff). The international price (p^*) was \$375/ton, and the marginal cost (m) is assumed to be the same as p^*. Consumption of domestic steel (x_1) was 1,691 thousand tons and imports totaled 306 thousand tons -- both measured in crude steel equivalent terms. The price and income elasticities of aggregate steel demand (ϵ and i) are assumed to be -0.6 and 1, respectively.

[6]Results are presented in levels in Table 2, and in percentage changes (calculated as the log differences) in Table 3.

Table 1: The model structure

$$x = f(x_1, x_2) = (a_1 x_1^{\rho} + a_2 x_2^{\rho})^{\frac{1}{\rho}} \qquad \text{(M.1)}$$

$$x = A p^{\epsilon} Y^{i} \qquad \text{(M.2)}$$

$$p_1 - m = \frac{h p_1 (1-\rho)(P_1 + P_2)}{P_2 + \epsilon P_1 (\rho - 1)} \qquad \text{(M.3)}$$

$$\text{where } P_1 = p_1^{\frac{\rho}{\rho-1}} a_2^{\frac{1}{\rho-1}}, \quad P_2 = p_2^{\frac{\rho}{\rho-1}} a_1^{\frac{1}{\rho-1}}$$

$$\frac{x_1}{x_2} = \left(\frac{a_2 p_1}{a_1 p_2}\right)^{\frac{1}{\rho-1}} \qquad \text{(M.4)}$$

$$p_2 = (1+\tau) p^{*} \qquad \text{(M.5)}$$

Variable	Unit	Description
x_1:	('000 tons)	consumption of domestic steel
x_2:	('000 tons)	consumption of imported steel
x:	('000 tons)	total steel consumption (domestic and imported)
ϵ:		price elasticity of total steel consumption
Y:		total income of domestic consumers
i:		income elasticity of steel consumption
p_1:	(\$/ton)	domestic price of domestic steel
p_2:	(\$/ton)	domestic price of imported steel
p^*:	(\$/ton)	international price of steel
m:	(\$/ton)	marginal cost of steel producers
τ:	(%)	tariff or implied tariff rate
h:	(%)	Herfindahl-Hirschman Index
A:		scaling factor
a_i:		technical coefficient of CES model (i=1,2)
ρ:		technical coefficient of CES model, related to elasticity of substitution σ, where $\sigma = 1/(\rho-1)$

15. The three trade policy scenarios are as follows. The first (tariff=25%) relates to the actual situation where there are no non-tariff barriers and a simple tariff is set at 25%. The second assumes a fixed-quantity import quota of 306,000 tons (the volume of steel imports in 1991). The third scenario assumes a fixed-ratio import quota where the share of imports is fixed at roughly 19% of total consumption (using the actual 1991 value). Two values are selected for the elasticity of substitution between domestic steel and imports (σ=-3.33 and σ=-6.67) for each of the three trade policy scenarios.[7] In addition to solving for p_1, p_2, x_1, x_2 and x, the model also solves for τ as the implied tariff rate for trade policy scenarios when import quota systems are in place. Variable p is the composite price of domestic steel and imports (see Annex I), and it represents the average cost of steel consumption (including both domestic and imported steel).

16. The simulation model was run through the complete range of the Herfindahl index between the values 0 and 1 for each combined set of assumptions (six blocks as shown in Table 2). The responses of prices and quantities are shown in continuous form in graphs in Annex II. In Table 2, three snap shots at possible values of the Herfindahl index before and after the suggested merger in Argentina are presented. We had to make rough estimates of the index due to the lack of detailed production data for the major integrated steel mills in Argentina. At the time there were four integrated steel producers. After privatizing SOMISA, the state-owned company, there would be three. If the buyer of SOMISA were to be the consortium formed by

[7] A simple calculation based on yearly changes of real prices and quantities of imports and domestic consumption of steel in Argentina during the 1971-85 period gives an elasticity of substitution equal to -3.63. If the model specification is reasonable and the Herfindahl index was indeed 25% in 1991 (the benchmark year), and given the initial conditions set for the other model parameters (for 1991), the elasticity of substitution would be in the range -3.33 to -6.67.

the two private steel plants, it is likely that the steel industry would have been further concentrated. Thus, we felt that the number of integrated steel producers could be changed from four to three and possibly to two. Assuming that all the remaining major integrated producers are roughly equal in size, and the non-integrated steel mills (8-9 of them) are negligible in the Herfindahl index calculation, the HHI value would be 25% before the privatization process, and 33% or 50% afterwards.

17. As expected, all six blocks in Table 2 show that as the HHI increases, domestic price (p_1) also increases. However, the degree of the increase in (p_1), and hence the domestic price mark-up, varies greatly depending on the assumptions. When the tariff rate is 25% and the elasticity of substitution (σ) is -3.33, the increase in concentration from four firms to three would raise p_1 by 6.6% (\$473.87 to \$506.19), and increase the aggregate steel price index (p) by 5.1%. At the same time, total steel consumption would decline by 3% -- demand for domestic steel falls 8.3% and import demand increases by 13.7%. Further concentration from three firms to two increases the market distortion. The price for domestic steel increases by a further 12.8% (\$506.19 to \$575.33), the aggregate steel price index rises a further 9.3%, and aggregate steel consumption declines a further 5.6%. If the elasticity of substitution (σ) is doubled to -6.67, while keeping the tariff rate at 25%, the domestic market distortion brought about by concentration of the industry is much less severe than is the case when σ=-3.33. When the number of the firms changes from four to three, p_1 increases by only 3.3%, p increases by 2.6%, and total steel consumption declines 1.6%. If steel available to be imported is more substitutable for the domestically-produced steel product, the industry concentration becomes less

powerful in terms of the ability to extract oligopoly rents. The substitutability between domestic steel and imported steel may be improved by easing any explicit and implicit obstacles to steel imports such as: (i) standardizing domestic product classifications with international ones; (ii) modernizing transportation facilities to reduce shipping backlogs; (iii) reducing bureaucratic practices related to trade; and (iv) relaxing foreign exchange restrictions.

18. Historically, steel industries worldwide have exhibited preferences for quantitative restrictions on imports over the use of simple tariffs. Figure 1 seems to confirm why this is so, at least for the United States. We simulated two different forms of import quotas for Argentina in order to assess the incentive for pressure for the imposition of quotas from Argentina's steel, industry given an increase in concentration.

19. When a fixed-quantity import quota is in effect and the elasticity of substitution (σ) is -3.33, the change from four firms to three increases p_1 by 8.8% ($480.43 to $524.39). This is not much higher than the simple tariff case, where p_1 increased by 6.6%. The aggregate steel price index (p) rises by 8.4%, because imports are fixed, and the price of imported steel increases by 6.9%. Consequently, total consumption of steel declines by 5%. The implied tariff is 44% for the same level of imports as for the simple tariff of 25%. If the number of firms is reduced from three to two, the market distortion would become a lot worse. Domestic price (p_1) increases by a further 20%, and aggregate price increases by a further 19%. Total steel consumption declines a further 11.5%. Similar to the tariff case, if the elasticity of substitution is increased to -6.67, the market distortions become less severe. When the number of firms is

reduced from four to three, prices, p_1 and p, would only increase by 5.1% and 5.0%, respectively, and the implied tariff becomes 30%.

20. In many of the existing VER schemes the quotas are set as a fixed percentage of total domestic consumption, rather than as fixed volumes. Fixed-ratio import quotas have the advantage over fixed-quantity import quotas from the domestic producers' point of view because imports can also be forced to contract when the market is weak. Thus, we simulated the effect of industry concentration under a fixed-ratio import quota system. It turns out to be the worst scenario of the three in terms of market distortions. In the case of σ=-3.33 and the number of firms declining from four to three, both p_1 and p increase 9.6% and total consumption declines 5.8%. The implied tariff rate jumps from 37% to 51%. If the number of firms changes from three to two, p_1 and p increase by a further 24.2%, total consumption falls by a further 14.5% and the implied tariff jumps to 92%. As in the other two scenarios, the higher value of the elasticity of substitution softens substantially the negative impact of industry concentration. In fact, the simulation results are very similar to the fixed-quantity import quota scenario. The only notable difference is that the quantity of imports is less because it is forced to decline.

Table 2: Simulation results on concentration ratios and trade policies (in levels)

Tariff=25%

	σ=-3.33			σ=-6.67		
HHI	25%	33%	50%	25%	33%	50%
p_1	473.87	506.19	575.33	438.13	452.89	479.85
p_2	468.75	468.75	468.75	468.75	468.75	468.75
p	472.76	497.32	545.66	444.64	456.56	476.88
x_1	1271.93	1170.31	972.00	1394.67	1315.14	1165.23
x_2	360.27	413.03	525.63	299.85	352.70	459.59
x	1632.20	1583.34	1497.62	1694.52	1667.84	1624.82

Fixed-Quantity Import Quota x_2=306.31

	σ=-3.33			σ=-6.67		
HHI	25%	33%	50%	25%	33%	50%
p_1	480.43	524.39	640.94	437.33	460.14	513.90
p_2	502.36	538.14	629.57	466.21	487.84	538.32
p	484.87	527.24	638.44	443.53	466.17	519.38
x_1	1301.30	1222.49	1056.65	1390.76	1340.81	1237.38
x_2	306.31	306.31	306.31	306.31	306.31	306.31
x	1607.61	1528.80	1362.96	1697.07	1647.12	1543.69
τ	34%	44%	68%	24%	30%	44%

Fixed-Ratio Import Quota x_2/x=19%

	σ=-3.33			σ=-6.67		
HHI	25%	33%	50%	25%	33%	50%
p_1	482.68	531.52	677.10	437.18	461.68	524.09
p_2	514.22	566.24	721.34	465.75	491.85	558.33
p	488.90	538.37	685.83	443.33	468.17	531.45
x_1	1309.88	1236.28	1069.14	1390.04	1345.30	1246.76
x_2	289.76	273.48	236.50	307.49	297.59	275.80
x	1599.64	1509.75	1305.64	1697.53	1642.90	1522.56
τ	37%	51%	92%	24%	31%	49%

Table 3: Simulation results on concentration ratios and trade policies (in % changes)

Tariff=25%						
	σ=-3.33			σ=-6.67		
HHI	25%	33%	50%	25%	33%	50%
p_1	.	6.6%	12.8%	.	3.3%	5.8%
p_2	.	0.0%	0.0%	.	0.0%	0.0%
p	.	5.1%	9.3%	.	2.6%	4.4%
x_1	.	-8.3%	-18.6%	.	-5.9%	-12.1%
x_2	.	13.7%	24.1%	.	16.2%	26.5%
x	.	-3.0%	-5.6%	.	-1.6%	-2.6%
Fixed-Quantity Import Quota x_2=306.31						
	σ=-3.33			σ=-6.67		
HHI	25%	33%	50%	25%	33%	50%
p_1	.	8.8%	20.1%	.	5.1%	11.1%
p_2	.	6.9%	15.7%	.	4.5%	9.8%
p	.	8.4%	19.1%	.	5.0%	10.8%
x_1	.	-6.2%	-14.6%	.	-3.7%	-8.0%
x_2	.	0.0%	0.0%	.	0.0%	0.0%
x	.	-5.0%	-11.5%	.	-3.0%	-6.5%
τ	.	24.6%	44.5%	.	21.4%	37.1%
Fixed-Ratio Import Quota x_2/x=19%						
	σ=-3.33			σ=-6.67		
HHI	25%	33%	50%	25%	33%	50%
p_1	.	9.6%	24.2%	.	5.5%	12.7%
p_2	.	9.6%	24.2%	.	5.5%	12.7%
p	.	9.6%	24.2%	.	5.5%	12.7%
x_1	.	-5.8%	-14.5%	.	-3.3%	-7.6%
x_2	.	-5.8%	-14.5%	.	-3.3%	-7.6%
x	.	-5.8%	-14.5%	.	-3.3%	-7.6%
τ	.	31.8%	59.4%	.	25.4%	44.9%

IV. Conclusions

21. The analysis of data from steel industries in the G5 countries can neither confirm nor reject the hypothesis that increased industry concentration leads to greater domestic price distortions. Data from US and French steel industries seem to support the hypothesis, but data from German, Japanese, and UK industries give ambiguous results. No doubt the evolvement of trade policies and domestic marketing organizations can be very complex, and without an elaborate econometric model it is difficult to properly test the hypothesis.

22. Therefore, a simulation model was constructed, based on the behavioral assumption that an oligopolistic industry will take advantage of higher concentration, under circumstances of imperfect substitution between imports and domestic products, to increase mark-ups over international prices. The results from the simulation show how the extent of the price differential depends on the degree of market segregation between domestic products and imports. Trade protection schemes and the elasticity of substitution between domestic and imported steel are two major determinants of the degree of market segregation. Simulations confirm that higher substitution elasticities mean lower domestic price distortions, and that quantitative import restrictions protect domestic steel producers more than simple tariffs. Fixed-ratio import quota generate much larger rents for domestic industries than a tariff or a fixed-quantity import quota. These results show why industries seeking protection through the restriction of imports prefer to have import quotas which are a fixed-ratio of domestic consumption. Given that the data used

in the model are reasonably representative of the Argentine steel industry, the incentive for the industry to seek protection, particularly in the form of quotas, seems to be large.

23. The results depend critically on the assumption of imperfect substitutability between imports and domestic products. If substitution possibilities are great, as some believe, then the industry's ability to extract rents is zero in the absence of import restrictions or low if there is protection -- regardless of the degree of concentration. Thus, estimating the elasticity of substitution is an important area for empirical work. The Cournot assumption is another important area for research as the results from the simulation model are determined in part by the assumption about the price-setting behavior of firms. As regards other areas for further work, it will be useful to address the question of economies of scale, as the gains from economies of scale with fewer firms can offset losses due to higher concentration. It would also be desirable to endogenous the trade policy setting behavior within the model.

Annex I. Construction of the Simulation Model

1. The model combines features of: (i) an oligopolistic domestic market with a fixed number of identical firms (i.e,, no one has more market power than another) where the firms are playing Nash-in-quantity (Cournot) games, and (ii) imperfect substitution between domestic products and imports.

2. The first step makes the link between the concentration measure (Herfindahl Index) and market competitiveness. The set up of the model is the following. Each of the n firms produces $q^i=q_1^i+q_2^i$, where q_1^i is its domestic shipments and q_2^i is exports, and the marginal cost is m. Total production of the industry is $q=q_1+q_2$, where q_1 is total domestic shipments and q_2 is total exports. Total domestic consumption is $x=f(x_1,x_2)$, where $x_1=q_1$ and x_2 is imports. There is a single domestic price p_1 and a single international price p^*. The international market is assumed to be perfectly competitive, thus $p^*=m$. Domestic consumers face p_2 as the price for their imports, where p_2 may be greater than p^* due to trade protection measures. The inverse market demand function for domestic product is assumed to be $p_1=p(x_1, x_2, p_2, Z)$, where Z is a vector of other variables. For firm i which produces q^i, its profit is:

$$\pi^i=p_1q_1^i-mq_1^i \qquad \text{(A.1)}$$

The first-order condition (for q_1^i) is:

$$\frac{\partial \pi^i}{\partial q_1^i}=p_1+\frac{\partial p_1}{\partial q_1}q_1^i-m=0 \qquad \text{(A.2)}$$

which can be re-written as Lerner's measure as:

$$L\equiv\frac{p_1-m}{p_1}=-\frac{\frac{\partial p_1}{\partial q_1}q_1^i}{p_1}=-\frac{\partial p_1}{\partial q_1}\frac{q_1}{p_1}\frac{q_1^i}{q_1}=-\frac{s_1^i}{\epsilon_1} \qquad \text{(A.3)}$$

where s_1^i is the share of the domestic shipment of the i^{th} firm in total domestic shipments, and ϵ_1 is the demand elasticity for domestic product. Expression (A.3) holds for each firm, so the weighted average price-cost margin for the industry equals:

$$\sum_{i=0}^{n} s_1^i\frac{p_1-m}{p_1}=-\sum_{i=0}^{n}\frac{s_1^{i2}}{\epsilon_1}=-\frac{h}{\epsilon_1} \qquad \text{(A.4)}$$

where h is the Herfindahl-Hirschman index based on each firm's domestic shipments. Since p_1 and m are identical across all firms, and the sum of all shares equals one, the expression (A.4) can be re-written as:

$$\frac{p_1-m}{p_1}=-\frac{h}{\epsilon_1} \qquad \text{(A.5)}$$

Since $\epsilon_1<0$, expression (A.5) says that higher industry concentration results in higher domestic price over the marginal cost.

3. From the industry profit expression $\pi=p_1q_1-mq_1$, we can write down the first order

condition (for q_1) based on the so-called effective (or perceived) marginal revenue expression:

$$\frac{\partial\pi}{\partial q_1}=p_1+\lambda\frac{\partial p_1}{\partial q_1}q_1-m=0 \tag{A.6}$$

where λ determines the market competitiveness. If there is a monopoly, λ=1, expression (A.6) would represent the usual monopolistic behavior. If the firms in the industry act like price takers, then λ=0 and (A.6) coincides with the condition of perfect competition. Substituting (A.5) into (A.6) and solving for λ:

$$\lambda=-\frac{-\frac{h}{\epsilon_1}p_1}{\frac{\partial p_1}{\partial q_1}q_1}=\frac{h}{\epsilon_1}\frac{p_1}{q_1}\frac{\partial q_1}{\partial p_1}=\frac{h}{\epsilon_1}\epsilon_1=h \tag{A.7}$$

Thus, the Herfindahl-Hirschman index h determines the market competitiveness.

4. In order to simulate the effect of industry concentration on the domestic price using expression (A.6), we need to explicitly specify $(\partial p_1/\partial q_1)$. The next step of the exercise is to set up the CES (Constant Elasticity of Substitution) demand framework for domestic products and imports. Following Armington[8], total domestic consumption x can be specified as:

$$\begin{aligned} x&=f(x_1,x_2)\\ &=(a_1x_1^{\rho}+a_2x_2^{\rho})^{\frac{1}{\rho}} \end{aligned} \tag{A.8}$$

where a_1 and a_2 are technical parameters, and $\sigma=(1/(\rho-1))$ is the elasticity of substitution. The

[8] Armington, P., "A Theory of Demand for Products Distinguished by Place of Production", *IMF Staff Papers*, Vol. XVI (1969), pp. 159-78.

corresponding total cost of consuming quantity x thus is:

$$\begin{aligned} c &= \left(a_1^{\frac{1}{1-\rho}} p_1^{\frac{\rho}{\rho-1}} + a_2^{\frac{1}{1-\rho}} p_2^{\frac{\rho}{\rho-1}}\right)^{\frac{\rho-1}{\rho}} x \\ &= p(p_1,p_2)x \end{aligned} \tag{A.9}$$

where $p(p_1,p_2)$ can be considered as the aggregate price index by imposing the restriction $a_1^\sigma + a_2^\sigma = 1$, Assuming the demand function for total domestic consumption x is in the Cobb-Douglas form:

$$x = Ap^{\epsilon} Y^{i} \tag{A.10}$$

where ϵ is the price elasticity of demand, i is the income elasticity of demand, and A is the scaling factor. From Shepherd's lemma, the demands for x_1 and x_2 are:

$$x_1 = \frac{\partial c}{\partial p_1} = \frac{\partial p}{\partial p_1} x + \frac{p}{x} \frac{\partial x}{\partial p} \frac{\partial p}{\partial p_1} x = \frac{\partial p}{\partial p_1} x(1+\epsilon) \tag{A.11}$$

$$x_2 = \frac{\partial c}{\partial p_2} = \frac{\partial p}{\partial p_2} x + \frac{p}{x} \frac{\partial x}{\partial p} \frac{\partial p}{\partial p_2} x = \frac{\partial p}{\partial p_2} x(1+\epsilon) \tag{A.12}$$

Thus the derivative of x_1 with respect to p_1 is:

$$\frac{\partial x_1}{\partial p_1}=\frac{\partial \frac{\partial c}{\partial p_1}}{\partial p_1}=(1+\epsilon)\left[\frac{\partial \frac{\partial p}{\partial p_1}}{\partial p_1}x+\frac{\partial p}{\partial p_1}\frac{\partial x}{\partial p}\frac{\partial p}{\partial p_1}\right]$$
$$=(1+\epsilon)\left[\frac{\partial \frac{\partial p}{\partial p_1}}{\partial p_1}x+\left(\frac{\partial p}{\partial p_1}\right)^2\frac{x}{p}\epsilon\right] \quad \textbf{(A.13)}$$

Since $q_1=x_1$, by substituting (A.11) for x_1 and (A.13) for $(\partial p_1/\partial q_1)$, we can re-write (A.6) as:

$$p_1-m=-h\frac{\partial p_1}{\partial p_1}(1+\epsilon)x\frac{1}{(1+\epsilon)x\left[\frac{\partial \frac{\partial p}{\partial p_1}}{\partial p_1}+\left(\frac{\partial p}{\partial p_1}\right)^2\frac{\epsilon}{p}\right]} \quad \textbf{(A.14)}$$

Expression (A.14) would be simplified to the following:

$$p_1-m=\frac{hp_1(1-\rho)(P_1+P_2)}{P_2+\epsilon P_1(\rho-1)} \quad \textbf{(A.15)}$$

$$\textit{where } P_1=p_1^{\frac{\rho}{\rho-1}}a_2^{\frac{1}{\rho-1}}\ ,\quad P_2=p_2^{\frac{\rho}{\rho-1}}a_1^{\frac{1}{\rho-1}}$$

The ratio of x_1 over x_2 can be derived from (A.11) and (A.12) as:

$$\frac{x_1}{x_2}=\left(\frac{a_2p_1}{a_1p_2}\right)^{\frac{1}{\rho-1}} \quad \textbf{(A.16)}$$

Finally, p_2 is linked to international price p^*:

$$p_2=(1+\tau)p^* \quad \textbf{(A.17)}$$

where τ is the tariff or the tariff equivalent if quantitative restraints are in place.

5. The simulation model includes four equations, (A.10), (A.15), (A.16), and (A.17). In the tariff-based scenario the four unknowns are p_1, p_2, x_1, and x_2, while h, m, ϵ, τ and ρ are given. In the quota-based scenarios, τ is unknown, but we would either know x_2 for the case of the fixed-quantity import quota, or we know the ratio of x_1/x_2 for the case of the fixed-ratio import quota. Three unknown parameters, a, a_1 and a_2, need to be calibrated from observations of ρ, x_1, x_2, p_1, and p_2 of a benchmark year using expressions (A.10), (A.16) and the identity $a_1^\sigma+a_2^\sigma=1$.

6. Once the solution for p_1 is obtained, we can compare it with the average cost of a "typical" steel producer and calculate the optimal size of the country's steel industry.

Annex II. Graphical Presentation of Simulation Results/a

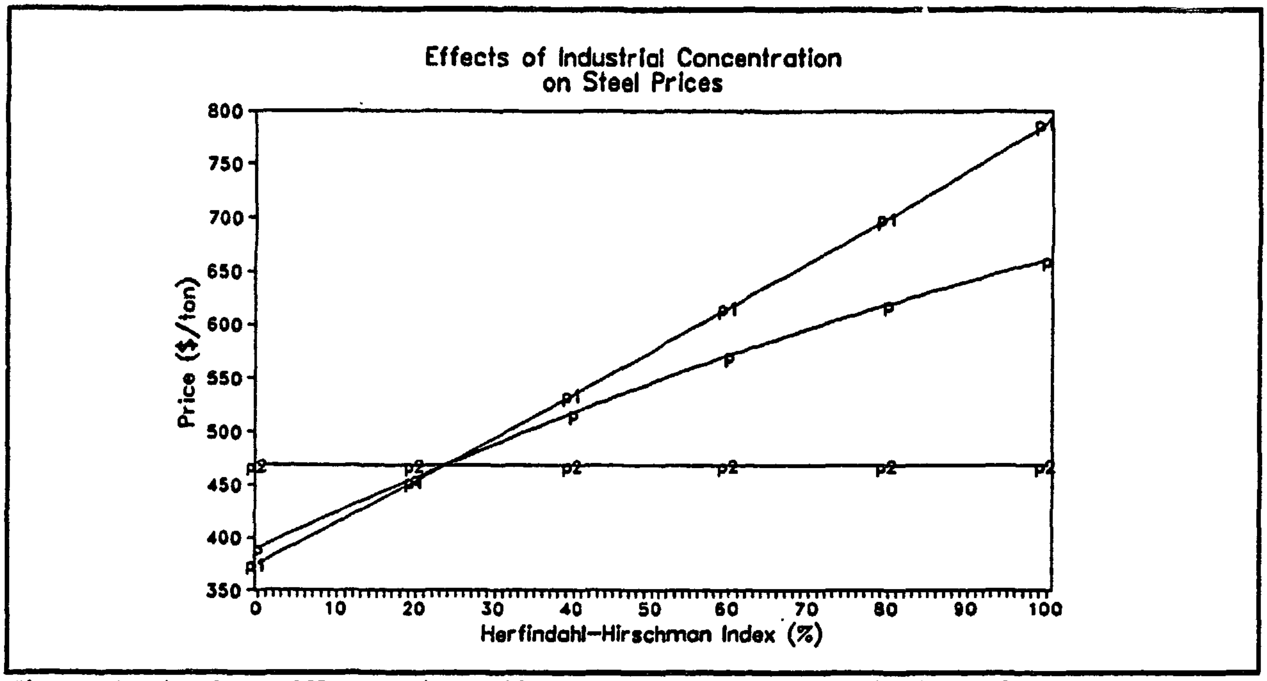


Figure 4: Simple Tariff Scenario [tariff=25%, elasticity of substitution=-3.33]

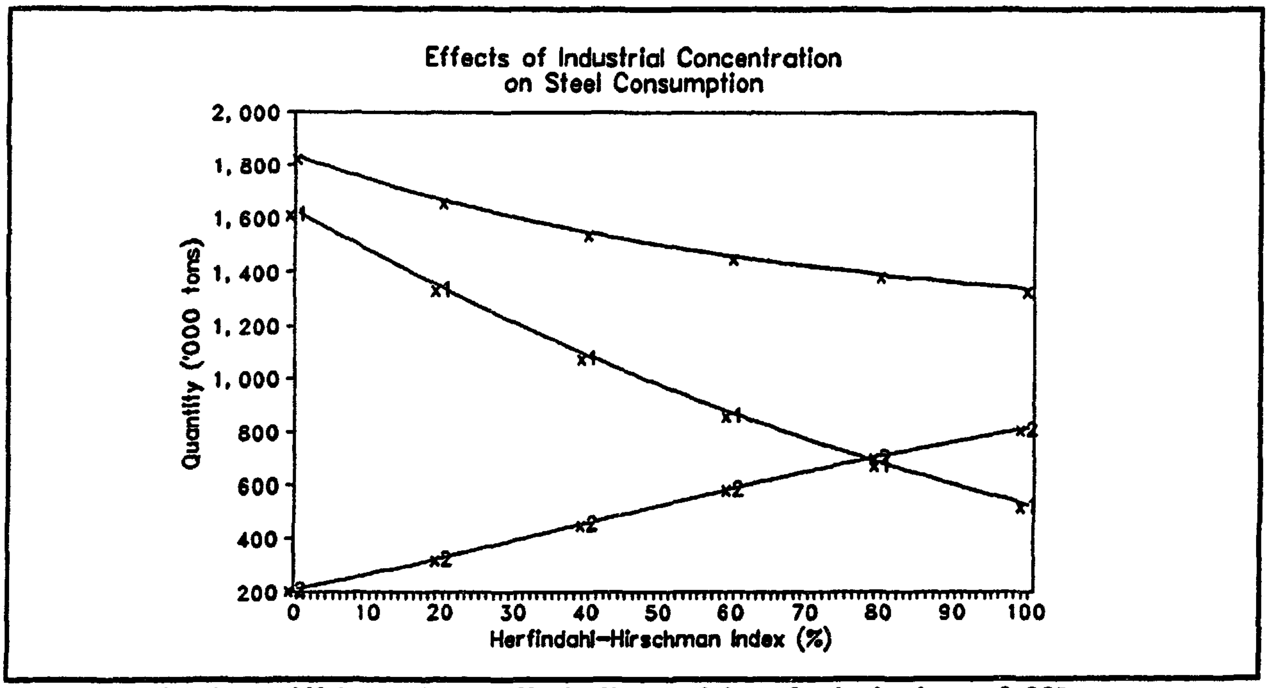


Figure 5: Simple Tariff Scenario [tariff=25%, elasticity of substitution=-3.33]

/a Meanings of interior labels can be found in Table 1. "T" is implied tariff for NTBs.

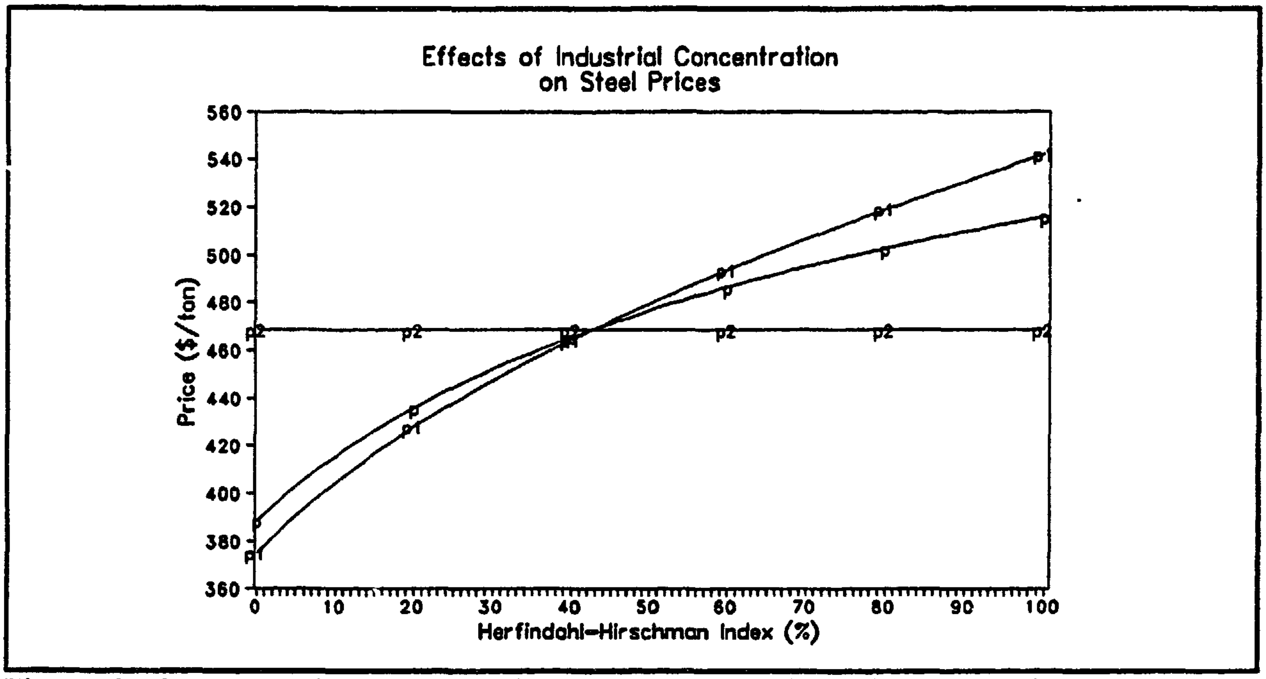


Figure 6: Simple Tariff Scenario [tariff=25%, elasticity of substitution=-6.67]

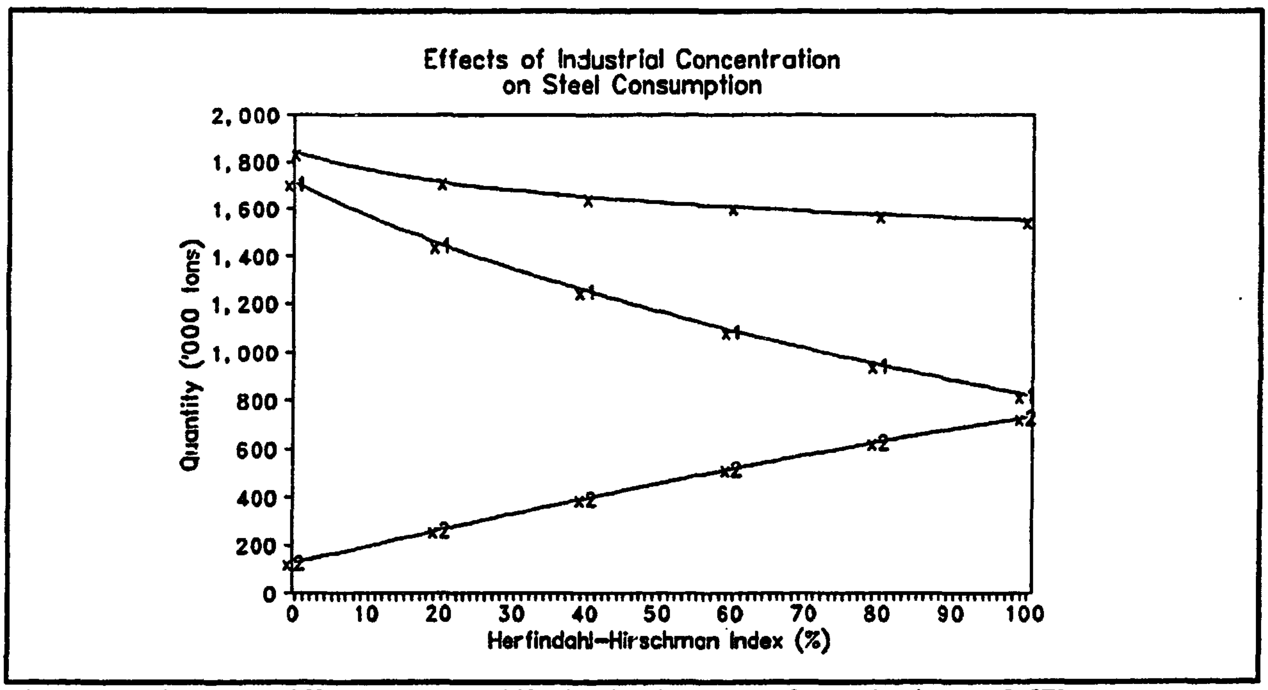


Figure 7: Simple Tariff Scenario [tariff=25%, elasticity of substitution=-6.67]

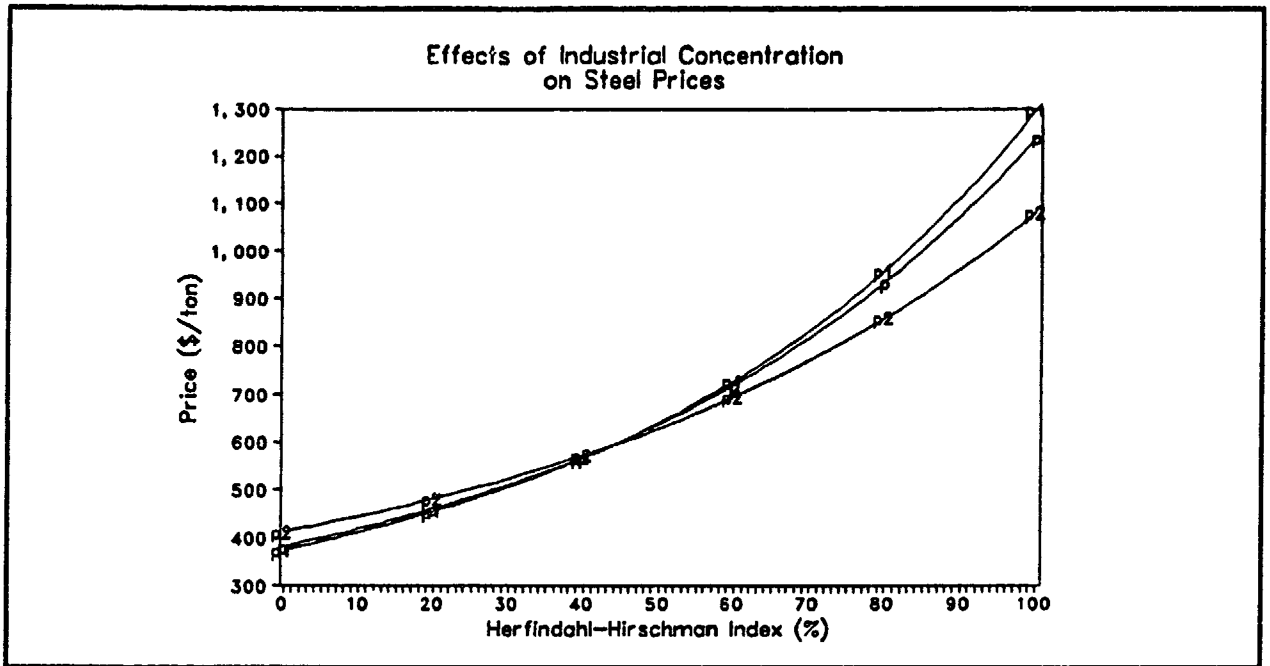


Figure 8: Fixed Quantity Quota Scenario [import quota=306.3 thousand tons, elasticity of substitution=-3.33]

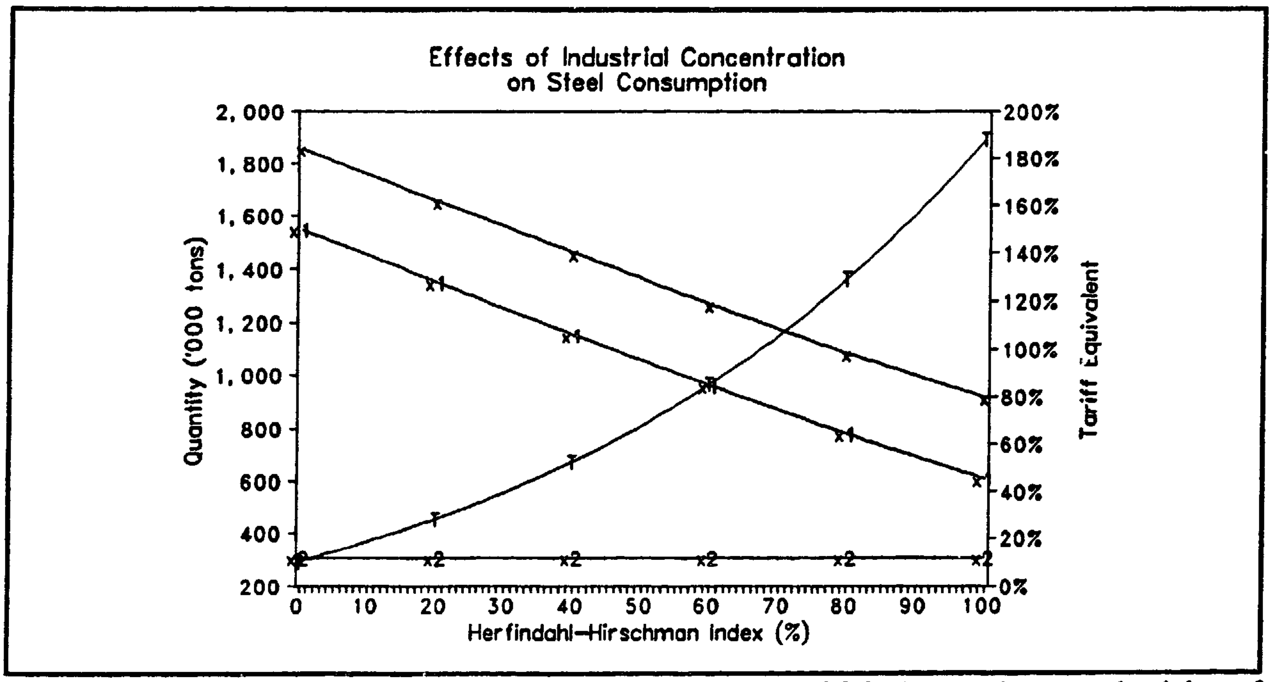


Figure 9: Fixed Quantity Quota Scenario [import quota=306.3 thousand tons, elasticity of substitution=-3.33]

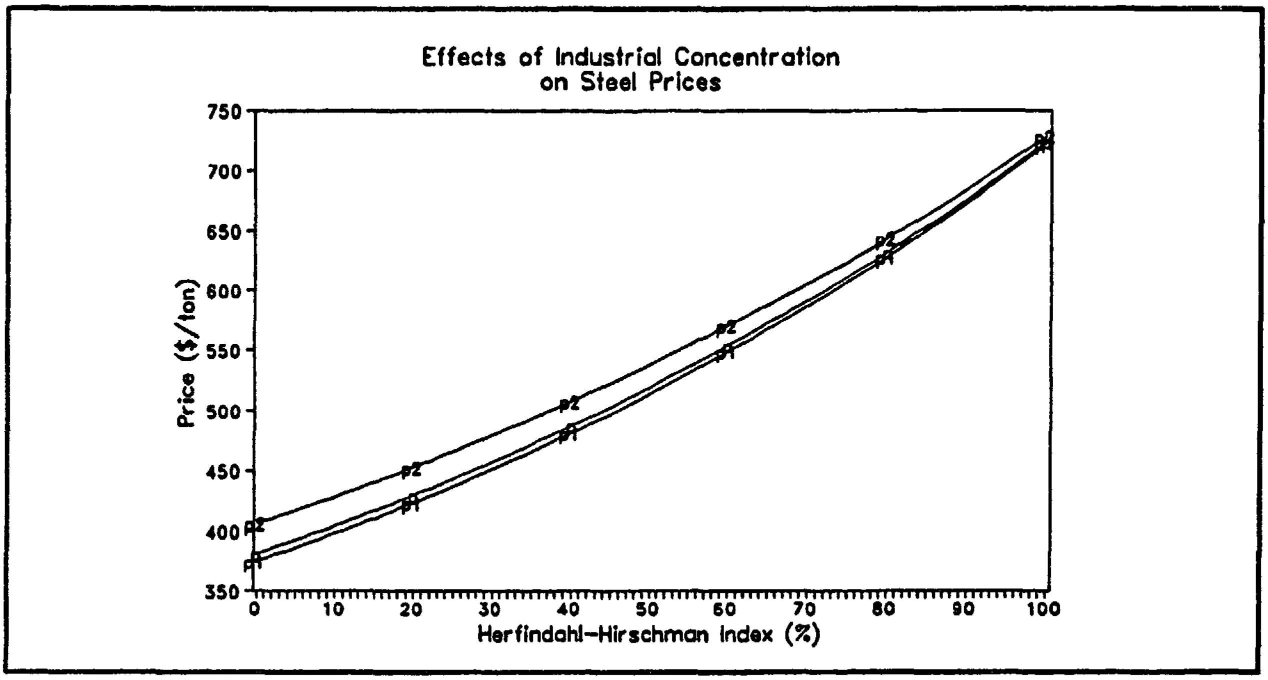


Figure 10: Fixed Quantity Quota Scenario [import quota=306.3 thousand tons, elasticity of substitution=-6.67]

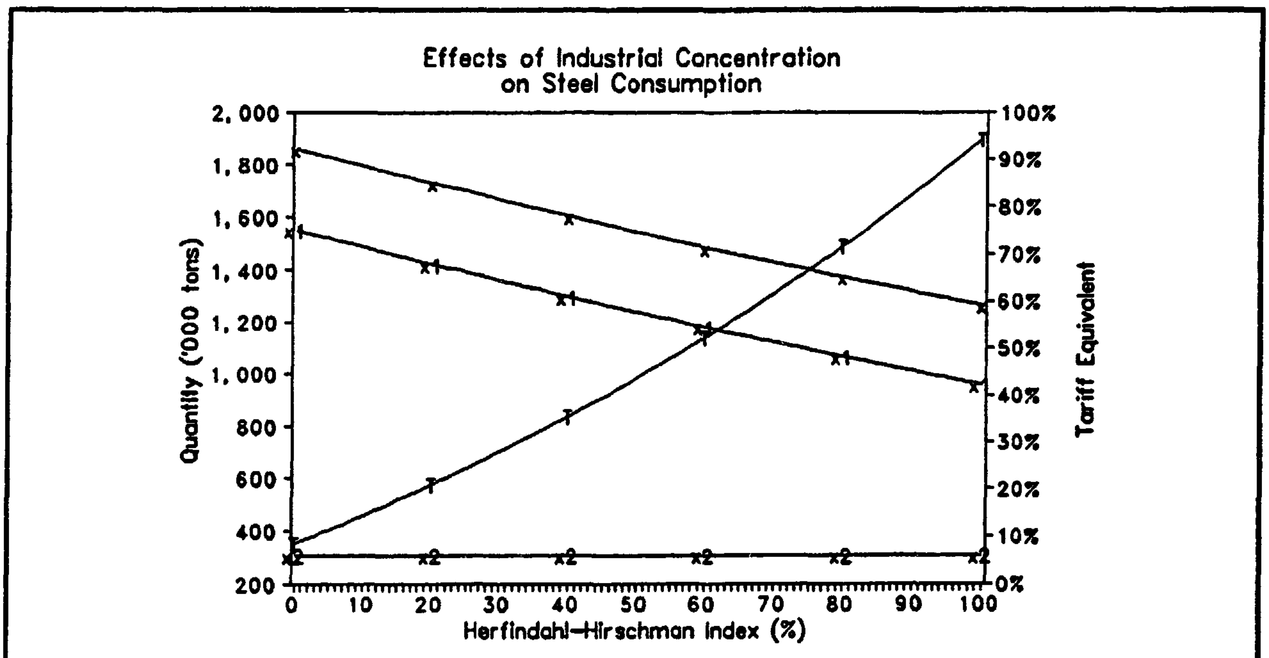


Figure 11: Fixed Quantity Quota Scenario [import quota=306.3 thousand tons, elasticity of substitution=-6.67]

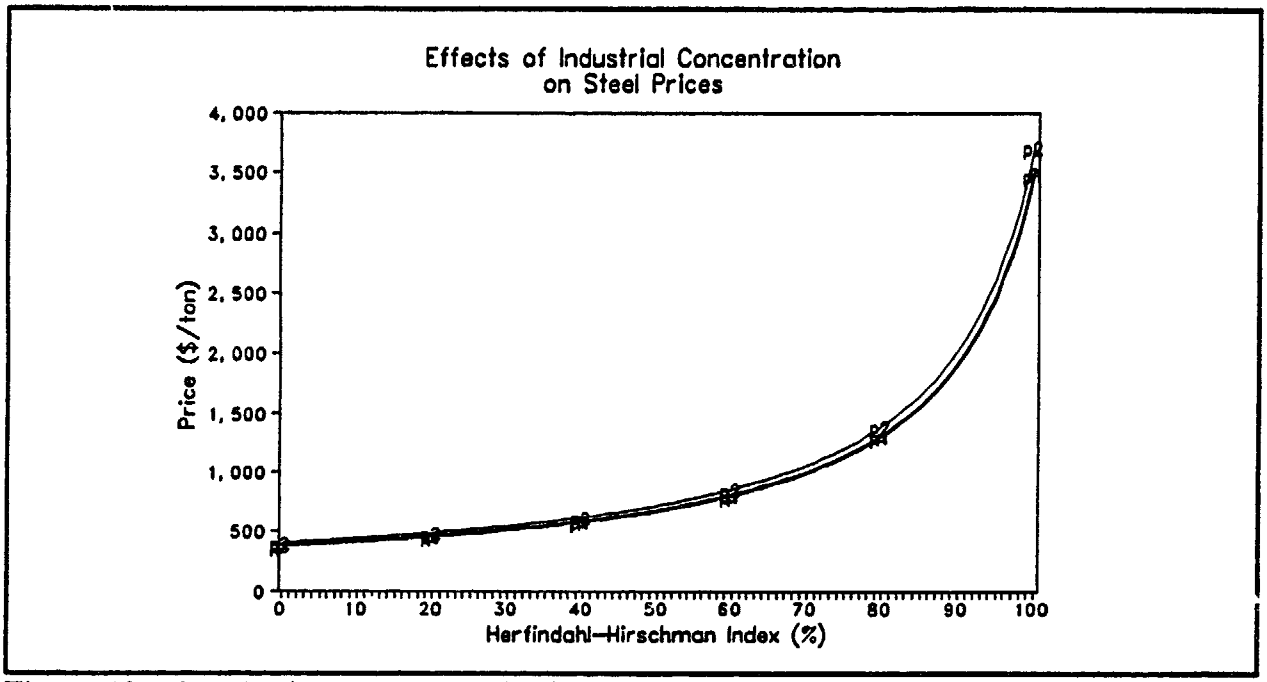


Figure 12: Fixed Ratio Quota Scenario [import ratio=19%, elasticity of substitution=-3.33]

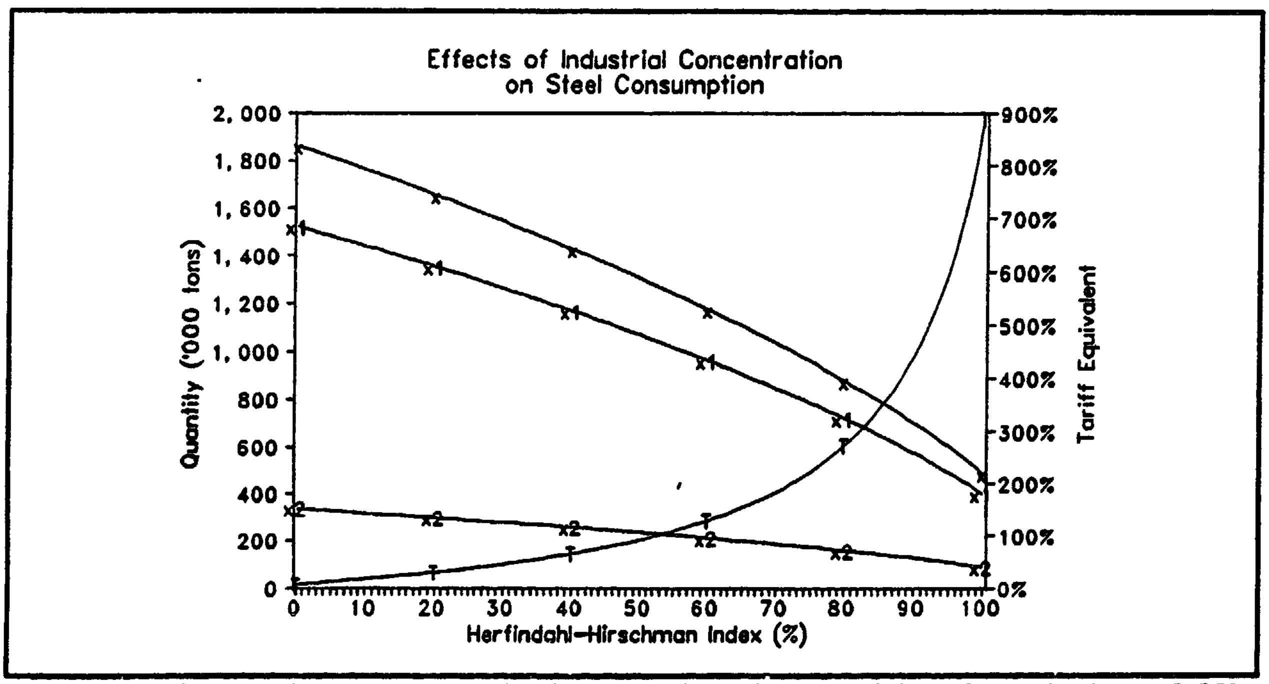


Figure 13: Fixed Ratio Quota Scenario [import ratio=19%, elasticity of substitution=-3.33]

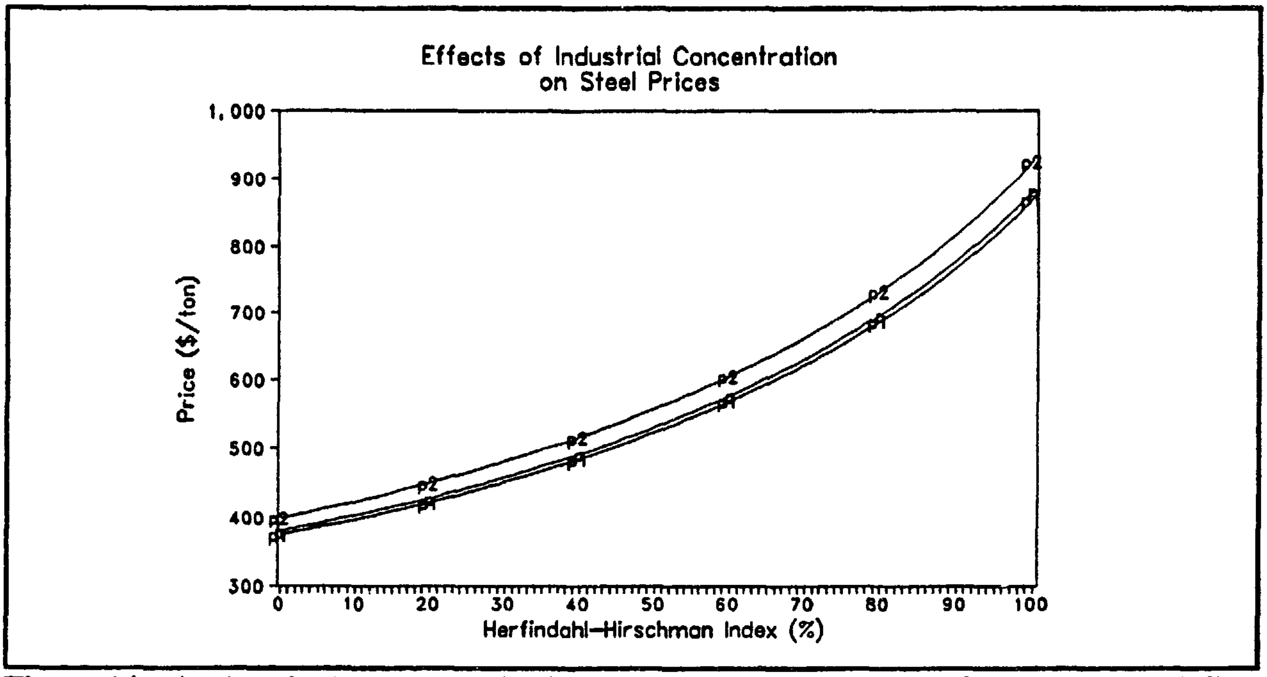


Figure 14: Fixed Ratio Quota Scenario [import ratio=19%, elasticity of substitution=-6.67]

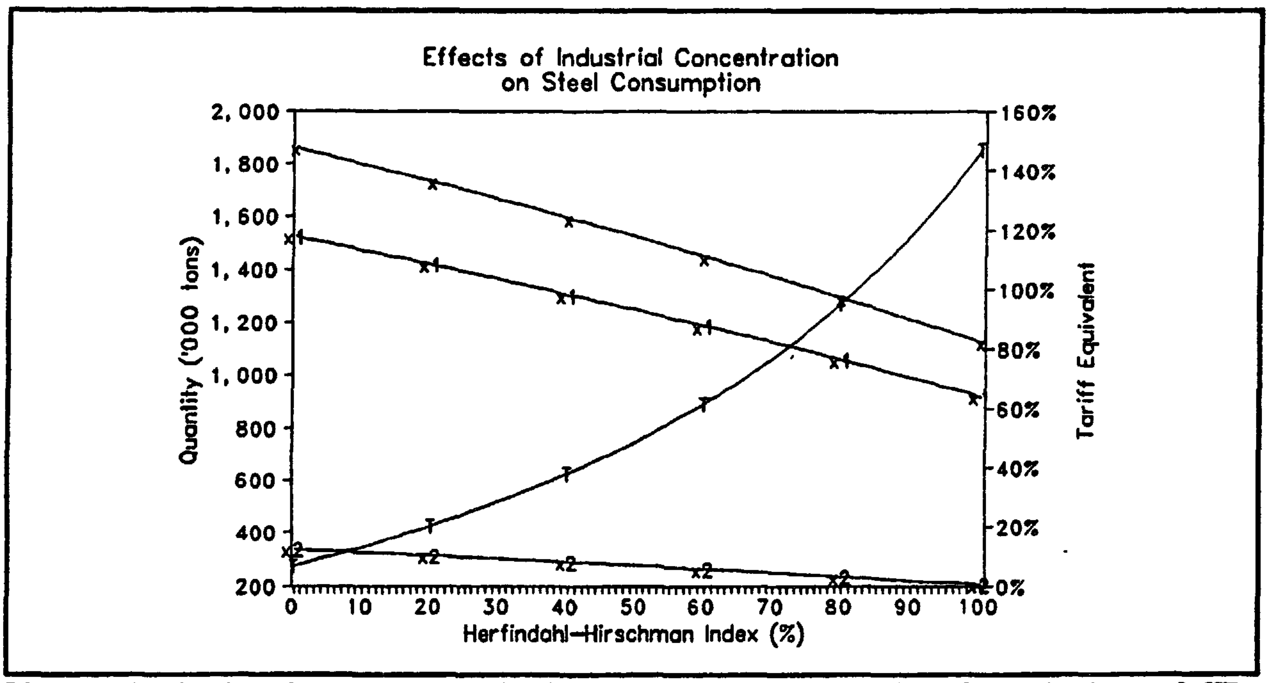


Figure 15: Fixed Ratio Quota Scenario [import ratio=19%, elasticity of substitution=-6.67]

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