WORKING

PAPERS

DID DEPRECIATION OF THE DOLLAR RENDER

THE STEEL VRAs NONBINDING?

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WORKING PAPER NO. 208

December 1994

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BUREAU OF ECONOMICS
FEDERAL TRADE COMMISSION

WASIllNGTON, DC 20580

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THE STEEL VRAs NONBINDING?

Oliver Grawe, Dolly Howarth and Morris Morkre*

I. Introduction

One of the puzzles about the recent voluntary restraint

agreements (VRAs) for steel is whether they remained truly

effective in restraining imports toward the end of the 1980s in the

face of a substantial depreciation of the dollar after 1984. 2 It

is clear that the VRAs initially caused import price to increase

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The views expressed in this paper are those of the authors alone and should not be attributed to MCI, or to the Federal Trade Commission or i ts individual Commissioners. The authors are responsible for any and all remaining errors or shortcomings.

2 The steel VRAs started with restrictions on countries of the European Community in 1982 and were considerably expanded in 1984. Eventually, the VRAs limited steel imports from nineteen countries plus the countries in the EC. They expired on March 31, 1992.

1

and created a quota premium for imports. 3 However, the 36 percent depreciation (trade weighted) of the dollar between 1984 and 1989 increased world price and is believed to have rendered the VRAs ineffective by 1989 (or even earlier) .4
This paper estimates the effect of the dollar depreciation on
the steel VRAs. This is accomplished by using a computable, partial equilibrium model of steel. We cannot determine whether the VRAs were actually binding in the late 1980s because other demand-supply factors, in addition to the external value of the dollar, also changed after 1984. However, we can isolate the impact of the exchange rate on the VRAs.
The principal result of our counterfactual simulations is that
the depreciation alone was not sufficiently large to render the VRAs ineffective. This somewhat surprising result is explained by the following.
First, only part of the change in exchange rates is typically passed through to changes in (importing country currency) prices of imported products. There is a growing literature on the exchange-rate-pass-through issue. In recent years economists have turned to various models of imperfect competition to explain partial pass through (e.g., Dornbusch (1987), Feinberg (1986), Hooper and Mann (1989)). We take a different approach. For us

3 ITC (1989A), p. 3-7.
4 According to Arce, Boltuck, et al. (1989), p. 7-9, who posed
the question that led to the title of this paper, the decline in the

partial pass through is

We then present the model (section III) and review some data issues (section IV). Our empirical results are discussed next (section V). The remainder of the paper takes up some extensions (section VI) and has the conclusion (section VII). Attached to the paper are two appendices. They provide technical details about our model (Appendix A) and the data we use (Appendix B) .

II. Issues

Steel Import Restraints
In September 1984 President Reagan directed Special Trade Representative William Brock to negotiate voluntary restraint agreements (VRAs) with major foreign suppliers of steel to the u.S. market. 5 The objective of the VRAs was to reduce the share of imports in domestic steel consumption from 26.4 percent in 1984 to 18.5 percent. The VRAs were, in effect, market share import quotas, and followed comparable import restraints agreed with the EC in 1982. 6 The actual share of imports declined steadily after 1984, to 17.9 percent in 1989. 7
The question, however, is to what extent the decline in steel imports was due to the VRAs. By 1988 and 1989 VRA-restrained

5 Howell et. al. (1988), p. 530. Tarr and Morkre (1984), p.
127.

6 Benyon and Bourgeois (1984), p. 345. For additional background on the U.S.-EC steel trade dispute, see Tarr (1988).
7 ITC (1990), p. 2.

4

countries apparently did not export as much steel to the United States as was allowed. 8 In 1988, VRA countries utilized 79 percent of the aggregate limit on steel imports. In the first nine months of 1989, the corresponding utilization ratio was 67 percent. 9 However, these utilization rates are for all steel import categories. In 1989, the utilization rates were much higher for certain country/categories: EC cold rolled strip -- 95 percent; Japanese cold rolled sheet -- 83 percent; South Korean hot rolled sheet and strip -- 88 percent. 10 There is also anecdotal evidence that the VRAs were limiting imports in 1989. For example, there
were complaints by several steel consumers, including Caterpillar
Inc., that led to a campaign to oppose extension of the VRAs in

8 USITC (1992), Quarterly Report on the Status of the Steel
Industry, USITC Pub. 2518, June 1992, p. G-5 to G-7. Note also
that during the early period of the VRAs, the procedures used by
the Department of Commerce (" Commerce") Commercehl (the)T 16.4899 11.9 433.78 3

1989. 11 Overall, it is not clear whether the VRAs restricted steel imports in 1989. 12
Several explanations for the drop in steel imports have been advanced. The ITC (1990, p. 17), for example, suggests that improvement in the competitiveness of U. S. firms and a strong demand in foreign markets led to the decline in steel imports. Another explanation is the depreciation of the U.S. dollar. Between 1984 and 1989 the value of the dollar fell by 36.4 percent (real trade-weighted exchange rate) on world currency markets. According to the GAO (1989A, pp. 5, 40), the dollar's depreciation was a major factor explaining the decline in steel imports after 1985.

11 "Steel consumers form coalition to oppose VRAS," Iron Age, March 1989, p. 13. Several complaints of the steel VRAs by steel users are reviewed by James Bovard, "U. S. Trade Laws Harm U. S.

Globalization of Markets for Steel Inputs
There are two reasons to suspect that a depreciation of the dollar will not have a significant negative effect on u.s. steel imports. The first is based on examination of the effects of exchange rate changes on supply prices of domestic vs. foreign industries when producers increasingly use standardized inputs traded in world markets. This is one possible facet of the widely observed trend toward increased globalization and integration of national markets. 13
Global inputs. The raw materials consumed in steel production collectively account for between 55 and 70 percent of total steelmaking production cost.N Moreover, the principal material inputs used by steelmakers, both domestic and foreign, are traded throughout the world and typically priced in terms of u.s. dollars. These material inputs include iron ore, 15 metallurgical coal, 16

13 As explained below, international trade in steel technology
and steel inputs has taken place for some time. However, foreign investment and joint ventures are a more recent phenomenon, particularly joint ventures between Japanese and u.s. steel firms with operations in the United States. See Crandall (1981) and ITC (1990), p. 44.
N ITC (1990), p. 53.
15 Iron ore has been transacted under long-term contracts since
the turn-of -the century. However, a domestic spot market developed
after International Harvester decided to sell its steel-making operations and dispose of its inventory of iron ore for a price 40 percent below the posted rail-of-vessel prices 4 164.178 288.9 260.sand

semifinished steel,17 steel scrap ,18 and other minerals. 19 There

have also been several investigations by the u.s. International

Trade Commission of various imported steel inputs that were alleged

mid-1970s. Contract prices are renegotiated annually and track world prices closely. World Steel Dynamics, Core Report KK, "NA Iron are Costs LOWi Competitive Pressures Remain," June 1990.

16 The U. S. is a major exporter of metallurgical coal. The EC, Japan, and Canada are the largest customers. u.s. Department of Energy, Quarterly Coal Report, July-September 1992, (Feb. 1993), p. 42.

Steel producers traditionally relied on coal (metallurgical coal) in the form of metallurgical coke for the bulk of their energy requirements. The United States has an abundant supply of high quality metallurgical coal. However, over the past 30 years, coke has become a less important input as it has been replaced by both more energy efficient processes and by other energy sources (e.g., fuel oil and natural gas). See ITC (1994), esp. p. 2-5.

17 Semi-finished steel imports increased from 0.7 million tons
in the late 1970s to 2.3 million tons in 1990. The 1984 VERs

limited semi-finished steel to 1.7 million tons, but the Department
of Commerce authorized imports above this level to meet domestic shortages (under the so-called "short supply provisions" of the
VRAs). See GAO (1989). Domestic trade in semi-finished steel has
also risen as domestic producers closed obsolete steelmaking plants
and modernized and expanded finishing mills. Some new domestic
steel finishing facilities have little or no hot-metal capability new pplj

clj 11.92260.45.3026 0 0 12j 5941492333.13 of m (Some)0.79.05 Tc 12.2609 0 17428 3.492333.13 Um (Some9.05)24.183Td [(S)15(m (]TJ(1989).)Tj6440113 0 0 11.8j 183.492333.13 Bureau 11.9226 0 0 11.8 98.52 035 02492333.13)Tj 12.333969 0 0 11.8 1.8 202492333.13 Mines,Tj 12.33817.2 0 0 11.8 30583.492333.13 Mapability 155167 0 0 11.8 3.8 6 02492333.13 Price)Tj 20871 0 0 11.8 380413 4721492333.13 ond c1492333.13 t4

to injure domestic competitors, cases that suggest an active international market in steel inputs. 2o Interestingly, since 1975 there have been no antidumping cases involving steel inputs, which suggests a competitive international market in which economic price discrimination is not feasible.
International markets and pricing arrangements vary for steel inputs. For example, the market for steel scrap is worldwide and prices, which are set on a spot basis, adjust rapidly to equilibrate supply and demand. 21 In the case of iron ore, although there are several international prices (typically one year contracts), the bellwether is the price quoted for delivery to
Rotterdam and bound for German steel mills. There are several
major suppliers (e. g. , Australia, Brazil, Canada) but
II ••• information on virtually every price settlement seems to be
known to everyone in the iron ore industry almost instantly. 1122

20 For example, the u.s. International Trade Commission found USITC0.05 Tc 15.9259 0 0 11.9 495.832622.326127.8mporInvestig USITC0.05 Tc 15.9259 0 0 11.9 495.82 44 123727.8mporInvestig USITC0.05 Tc 15.9259 0 0 11.9 495.845133.8222 098mporInvestig sec Tj 13.286415. 11.9 360.02833 (p2006998mpor20)15.4347 070 11.9 140.93 0 1p2006998mporinvestig)Tj /T1_147 34 11.9 76.0444269.82006998mporinclude:14.82826980 11.9 76.04526 3.82006998mporlow14.8282 323 11.9 119.4 412201 86998mporcarbj 13.2864.247 11.9 216.212969851 86998mporferroch832e16.273212 1 0 0 . 11.9 76.0422133.61 86998mpor(USITC0.05 Tc 15.9259 0 0 11.9 495.827399 11 86998mporInvestig USITC0.05 Tc 15.9259 068 11.9 310.7371 0151766998mporInvestig

that subsidized imports of pig iron from7.8324 0 0 11r30 11.9 361.29 322.36 T

Analysis of depreciation. Figure 1 shows the effect of exchange rate depreciation on the domestic steel industry. To bring out most sharply the effect of depreciation, we adopt the following structure for expositional purposes. Assume that domestic and imported steel is homogeneous, domestic industry is perfectly competitive, and import supply is infinitely elastic ("small" country assumption) To reveal the role of global inputs two cases are contrasted. In the first case, global inputs are absent; in the second their influence is taken into account. Global inputs absent. Under perfectly competi ti ve conditions,
the usual approach, presented for example by Venables (1990), treats domestic supply and world supply as independent of each other, i.e., assumes an absence of globalization of inputs. Furthermore, the import supply price, in foreign currency, is exogenously fixed. A depreciation causes import supply price in domestic currency to increase by an amount proportional to the magnitude of the depreciation. Figure 1 illustrates the case of a
50 percent depreciation of the dollar. Initially, the exchange
rate is Ro = 1. 23 The subsequent exchange rate is Rl = 2. The

States. In 1990, M.A. Hanna Co. and Picklands Mather (owned by Cleveland-Cliffs) quoted high prices for U. i (A5.9833 o2 3Tj 15.1179 0 0 12 450 1

Figure 1
Effect of Depreciation of Dollar on Imports

If world price of imports is constant (expressed in foreign currency), a 50% depreciation of US dollar shifts import supply from

depreciation shifts import supply curve from S~Q to S~l and the domestic price of imports doubles. There is thus "full pass through" of the exchange rate change, and the quantity of imports declines from MsQ to M/.
Global inputs present. However, as emphasized above, steel supply, both domestic and foreign, depends on world traded inputs. Denote the price of these inputs by Pw• Domestic supply, Ss, and import supply, S~, are linked as both depend on Pw• As noted above, evidence suggests that Pw is denominated in u.s. dollars. Furthermore, we assume that Pw is exogenously fixed. A depreciation of the dollar then reduces the cost of traded inputs to foreigners (in foreign currency). Import supply shifts to S~2, not S~l as under full pass through. The extent of the upward shift in import supply depends on the relative importance of traded inputs in the total cost of steelmaking. There is thus less than full pass through of the exchange rate change, and the quantity of imports declines from MsQ to MS2. By extension, an increase in the degree of globalization, where traded inputs account for a greater share of total production costs, will be accompanied by a smaller pass through of exchange rate changes and a smaller effect on imports.24

24 Finally, while we choose to emphasize exchange rate pass through in examlnlng the effect of exchange rate changes on imports, the key feature in our approach is globalization of steel inputs. Our choice is based on industry practice, where contracts for traded steel inputs are denominated in u.s. dollars. However, it is important to note that the specific national currency in which inputs are priced does not alter our principal argument. To illustrate (Figure 1), suppose that Pw were expressed in foreign currency (and exogenously fixed). Although depreciation of the

12

A Widely Used Intermediate Product
Even with full pass through of an exchange rate change, there
is second reason to expect there will be only a modest decline in (and possibly even an increase in) steel imports. Steel is an input to a large number of industries that are themselves subject to competition from imports. A depreciation of the dollar increases domestic prices of both imported steel and imported steel-using final products. The consequent output expansion of domestic steel-using products increases domestic steel consumption. This lessens, and possibly reverses, the adverse effect of the depreciation on steel imports.
These results are conveniently illustrated using a geometric technique first used by Corden (1971) to analyze effective rates of

initially, curve SAo indicates domestic supply of A.25 Domestic demand

industries. For convenience, this is called the "auto" sector. We invoke the small-country assumption for steel

function of imported and domestic "autos." Finally, we assume that domestic and imported "autos" are gross substitutes, which requires that the elasticity of substitution is greater than (the absolute value of) the price elasticity of demand for composite "autos." The domestic "auto" industry is assumed to produce an aggregate output under conditions of constant costs, i.e., the supply curve of aggregate "autos" is horizontal. The production function of "autos" is a CES function of value added (labor and capital) and a Leontief function in intermediate

production function of aggregate steel is a CES function of value added and a Leontief function of a composite intermediate input.

IV. Data

The model is calibrated

TABLE 1

ELASTICITIES USED IN COUNTERF ACTUAL SIMULATIONS

Demand Elasticities Low Central High
Own price elasticity of demand for "autos" (EAd -0.8 -1.0 -1.2
Elasticity of substitution in consumpution between domestic 0.9 2.06 5.0
and imported "autos" (cr Ad
Elasticity of substitution in steel-using firms between domestic
and imported steel (crsc) 1.1 3.05 5.0
Supply Elasticities i ..
Elasticity of transformation
between domestic and exported "autos" (cr AX) 1.6 2.9 4.2
Elasticity of transformation between domestic and exported 1.6 2.9 4.2
steel (asx)
Production Function Elasticities ......

.....

Elasticity of substitution for domestic "auto" industry (a AD) 0.5 0.81 1.12
Elasticity of substitution for foreign "auto" industry (a AF) 0.5 0.81 1.12
Elasticity of substitution for domestic steel industry (as D) 0.84 1.0 1.16
Elasticity of substitution for foreign steel industry (aSF) 0.84 1.0 1.16

Notes: The central elasticity estimates were obtained primarily from De Melo and Tarr (1992), who have surveyed the results of researchers, and from Shiells, Stem and Deardorff (1986) .. The central values for steel are taken directly from the literature. The central values for "autos" are averages of the elasticity estimates available for
the industries that comprise "autos." The principal industries used to develop central estimates for "autos" are: metal products (excluding machinery), machinery (excluding electrical), and transportation equipment. The low
and high elasticities are, where possible, one standard deviation from the central estimate.

VRAs, the effect of the depreciation of the dollar is simulated. If the quantity of steel imports is less than the level permitted by the VRAs, then the VRAs are ineffective.
The objective of the VRAs was to reduce the share of steel imports in domestic consumption on a volume basis from 26 percent in 1984 to 18.5 percent. Alternatively, import volume was

I

Variable

Imported Steel

Price

Quantity

(share in domestic consumption)

Domestic steel for home market

Price

Quantity

Domestic steel for export market

Price

Quantity

Imported "autos"

Price

Quantity '--

TABLE 2

EFFECTS OF VRAs ON STEEL IMPORTS

(benchmarked to 1984 data)

I

Initial Data

(billions of 1984 dollars) Low
Elasticity
Case

1.00 1.51

12.67 8.71

(18.56) (12.83)

1.00 1.00

55.60 60.03

1.00 1.00

1.32 1.42

1.00 1.00

137.95 138.02

Counterfactual Estimates
for Market Share
VRA's Imposed on Steel Imports

Central High
Elasticity Elasticity
Case Case

1.16 1.09

8.73 8.74

(l2.83) (12.83)

1.00 1.00

59.63 59.53

1.00 1.00

1.41 1.41

1.00 1.00

138.21 138.50

Variable

Domestic "autos" for home market

Price

Quantity

Domestic "autos" for export market

Price

Quantity

Aggregate consumption of "autos"

Price

Quantity

TABLE 2

EFFECTS OF VRAs ON STEEL IMPORTS--Continued (benchmarked to 1984 data)

Counterfactual Estimates
for Market Share
VRA's Imposed on Steel Imports
Initial Data

(billions of 1984 dollars) Low Central High
Elasticity Elasticity Elasticity
Case Case Case

1.00 1.007 1.002 1.001

612.84 609.32 611.24 611.33

1.00 1.00 1.00 1.00

93.15 91.57 92.32 92.41

1.00 1.006 1.002 1.001

750.78 747.34 749.44 749.83

Sources: The 1984 benchmark

reveal the interrelationships between the imported, domestic, and exported steel products.
The demand/supply diagrams in Figure 4 for steel show that VRAs create a shortage of imports, which increases their price (panel A). The higher price of imports causes an increase in the demand for the substitute domestic product (panel B). Higher output of the domestic product causes export supply to increase, due to economies of scope, which has a feedback effect increasing supply of domestic product, also due to economies of scope. Thus, the VRAs on imports causes output of both domestic and exported products to increase.
The diagrams in Figure 5 complement those in Figure 4 and show
how the VRAs affect the optimum output ratio of producers and the optimum consumption ratio of consumers. The uni t revenue of aggregate production (panel D) and unit cost of composite consumption (panel E) are dual to the CET function for domestic and
export products and the CES function for domestic and imported products, respectively. 30 We exploit the property of the unit
revenue curve that the slope of a line tangent to the curve is the
optimum supply ratio of the export product to the domestic product.

30 Unit revenue and unit cost are price indices and are
independent of physic81.9 226.76 32 0 0 11.9 166.t311.9 484.(products

Price

Figure 4
Effects of VRAs on Steel Imports

VRAs increase price of import product from Pm 0 to Pm 1, which increases demand for domestic product from Dd 0 to D/. Consequent expansion in output of domestic product increases supply of export product from Sx 0 to Sx 1, due to economies of scope, which has feedback effect, also due to economies of scope, increasing supply of domestic product from Sd 0 to Sd 1.

Panel A
Import Product

� ~�m�

Price

Panel B
Domestic Product

Sd °

I

Sd

Price

Panel C
Export Product

PI ..... . rn I.. . .. pO

d

P:

pOI �~�.�.�.�.�.�.�.�.�.�.�.� SO m �~� m
D!

� Q�~� Q: Quantity Q: I Q d Quantity QO x

QI x

SO x

� S�~�

DO x

Quantity

Figure 5
The Effect of Import Restraint on Exports

Increase in price of import product

As indicated in panel E, the increase in import price under
the VRAs increases both the price of import product relative to the price of the domestic product and the average cost of the composite consumption good. This change in relative prices induces consumers to reduce consumption of import product relative to domestic product.
The implications of Figure 5 are reflected in results reported
in Table 2. Specifically, prices of domestic and export products are unchanged. Moreover, shipments of domestic product and export product are both 7 percent higher than in the benchmark (59.63/55.60 = 1.41/1.32 = 1.07).

Effects of the Depreciation of the u.S. Dollar, given VRAs
The effects of the depreciation of the dollar are given in Table

Variable

Steel VRAs: BindingINot Binding (YIN)
Market share of steel
imports by quantity (%)

Imported steel: price (USD)
quantity

Domestic steel for home market: price (USD)
quantity

Domestic steel for export market: price (USD)
quantity

TABLE 3

EFFECTS OF DEPRECIATION OF US DOLLAR ON STEEL AND "AUTOS"
WITH PRE-EXITING VRAs RESTRICTING STEEL IMPORTS

(benchmarked to 1984 data)

All Intermediate Products are Traded Internationally and Priced All Intermediate Products (except steel) are Nontraded: in U.S. Dollars: Partial Pass Through of ER Change Full Pass Through of ER Change

Low quantndingINo-e

Variable

Imported "autos": price (USD)
quantity

Domestic "autos" for home mkt: price (USD)
quantity

Domestic "autos" for export mkt: price (USD)
quantity

Aggregate consumption "autos": price (USD)
quantity

TABLE 3 (Continued)

EFFECTS OF DEPRECIATION OF US DOLLAR ON STEEL AND "AUTOS"
WITH PRE-EXITING VRAs RESTRICTING STEEL IMPORTS

(benchmarked to 1984 data)

All Intermediate Products are Traded Internationally and Priced All Intermediate Products (except steel) are Nontraded: in U.S. Dollars: Partial Pass Through of ER Change Full Pass Through of ER Change

Low Central High Low Central High
Elasticity Elasticity Elasticity Elasticity Elasticity Elasticity Case Case Case Case Case Case

(------------------------------------percent change from benchmark that has VRAs---------------------------------)

14.92 14.78 14.64 36.40 36.40 36.40
- 11.72 -24.79 -51.25 -24.43 -49.78 -87.37

-2.59 -2.91 -3.26 -7.70 -10.54 -16.40 2.43 6.17 13.92 7.40 19.72 46.06

14.92 14.78 14.64 36.40 36.40 36.40 33.43 72.50 132.41 100.64 306.78 1,041.48

0.43 -0.08 -0.93 -0.73 -4.55 -12.71 -0.35 0.08 1.12 0.58 4.77 17.72

devote more attention to it below. 32
Table 3 shows that the VRAs continue to bind steel imports under partial pass through but cease to bind under full pass through. At one level, these results can be explained as follows. As shown in Table 2, the VRAs cause the price of steel imports to increase by 16 percent. Under full pass through, the 36 percent depreciation of the dollar results in an increase in the supply price (in USD) of imports by 36 percent. In this situation the depreciation negates the effect of the VRAs. However, under partial pass through the import supply price of steel increases by only 13.56 percent, the same as the increase in the demand price (in USD) for the domestic steel export product. In this situation, the depreciation does not negate the VRAs.
The above explanation is not complete, however. For example,
it ignores what happens to the "auto" industry and the consequent effects on steel. The depreciation is a boon to domestic "auto" producers. Import supply to the home

shipments of domestic "autos" for the home market and that exports of "autos" both increase. The increase in "auto" production increases the demand for steel. This is illustrated in Figure 6. The increase in composite steel demand is represented by the shift from curve QSC1 to curve QSC2 (panel F), where Qsc designates quantity of composite steel. The VRA constraint is represented by ray OR, whose slope is the maximum ratio of imported steel to

33

Figure 6
Effects of U.S. Dollar Depreciation on Steel Imports

Depreciation of USD increases domestic "auto"

Finally, it should be emphasized that there is some magnitude
of exchange rate depreciation that will eliminate the effects of steel VRAs, even with globalized inputs. We can use our model to solve for this threshold exchange rate, which is found to be 41 percent. If the exchange rate depreciation were 41

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Steel Imports
quantity (Mn tons)
quantity (Bn 1984 USD)

Domestic Steel for US Market
quantity (Mn tons)
quantity (Bn 1984 USD)

Domestic Steel for Export Market
quantity (Mn tons)
quantity (Bn 1984 USD)

Price of Domestic Steel
BLS index
Model

TABLE 4

COMPARISON OF ACTUAL DATA WITH SIMULATIONS OF MODEL BASED
ON PARTIAL PASS THROUGH AND FULL PASS THROUGH OF EXCHANGE RATE

(Central Elasticity Case)

-_ ..... _ .. __ ... __ ._- ---_ .. _ .. _--- ---

. ... Before VRAs and Depreciation of U.S. After VRAs and Depreciation
Dollar of U.S. Dollar

.. 1984 Actual 1989 Actual 1989 Simulation

26.16 17.32
12.67 9.83*
8.25*'"

73.74 84.10
55.60 67.10*
97.58**

0.98 4.58
1.32 2.33*
5.94**

100 99.8
100 99.6*
98.5**

Note: * is for results of partial pass through simulations and ** is for full pass through simulations.

- - .. �-�-�-�-�~�-�-�-�-�-

Percent Change 1984
to 1989

-33.8%
-22.4%
-34.9%

+14.0%
+20.7%
+75.5%

+367.3%
+76.5%
+350.0%

-0.2%
-0.4%
- 1.5%

Sources: For quantity data and BLS price index, U.S. International Trade Commission, Steel Industry Annual Report, USITC Pub. 2316, September 1990, pp. 2 and 23. Note that BLS index above is ratio of BLS indices for steel mill products to finished goods. For data denominated in USD, see sources listed in Table 2 plus calculations from model.

of imperfect competition (e.g., Dornbusch (1987), Feenstra (1989), Hooper and Mann (1989), Venables (1990)). As empirical evidence suggests that partial pass through is widespread,38 it therefore appears to follow that imperfect competition must also be widespread. However, one of the consequences of this paper is to suggest that this inference is not warranted. It is not valid to infer imperfect competition based solely on partial pass through of the exchange rate. We have shown that partial pass through can also obtain in competitive markets with constant returns to scale, if markets for inputs are global.

expect that imports may not be very responsive to domestic price changes (e.g., due to transportation constraints,

of this result is that a policy that restricts imports also increases exports. We have analyzed this situation above, in section V, and illustrated it

question. Indeed,
threshold exchange

we can apply our model to solve for the
rate depreciation that just makes the VRAs
nonbinding. That depreciation is found to be 41 percent.
Our principal result is for a case where material inputs into steel and II autos II are globalized and priced in U. S. dollars. Under these conditions, there is partial pass-through of the exchange rate, a case that appears to receive wide support among empirical researchers. In contrast, when we consider the less plausible case where material inputs are not globalized there is

relative supply prices of domestic and foreign producers to the home market and also a smaller effect on imports.
Thirdt and a consequence of the second pointt partial pass through of exchange rate does not necessarily signal market imperfections or monopoly power. If all producers use a world traded inputt partial pass through will be observed even when industries are perfectly competitive and operate under conditions of constant costs.

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APPENDIX A

MODEL

I. Introduction

The model used to estimate the effect on steel imports of changes in the foreign exchange rate
is a partial equilibrium model that assumes all markets are perfectly competitive. The principal features of the model are as follows. Steel is a modelled as a pure intermediate product that is used in the production of a final tradeable product, which is referred to as "autos." The most noteworthy aspect of the model is the treatment of inputs. Inputs into autos and steel are divided into two types: nontraded and traded. Prices of nontraded inputs are exogenous and fixed in terms of the relevant foreign currency. In contrast, traded inputs are assumed to be traded on world markets at prices that are denominated in terms of U.S. dollars, and are also assumed to be exogenous. However, changes in the foreign exchange rate will affect local currency prices of traded inputs in foreign countries. Our interest is with the effects of changes in foreign exchange rate.

In other respects our model follows the familiar approach adopted by empirical researchers of international trade policy issues. 1 In particular, our model incorporates product differentiation for both steel and autos. We assume that there are significant differences between domestic and imported products, and also between domestic and exported products. Specifically, domestic consumption of composite steel and composite autos are constant elasticity of substitution (CES) functions of domestic and imported varieties. Domestic output of aggregate steel and autos is a constant elasticity of transformation (CET) function of product varieties destined for domestic and export markets. Prices on products imported from or exported to world markets are treated as exogenous ("small" country assumption) and supply prices of aggregate products produced domestically are constant, which assumes constant returns to scale.

II. Model

Demand and Supply for Final Steel-Using Product 47T Tc4 Td (Prices)Tj 0..45s6.587

The demand for the final product ("autos") in which steel is consumed as an intermediate

Given total demand for steel, auto producers minimize total cost expenditures on domestic and foreign steel varieties. In an analogous procedure to the derivation of equations (2) to (4), this yields the demand equations for the domestic (Dso) and foreign (DsF) varieties, and the average price of composite steel (P sc), as shown in equations (10) to (1 2):

(10)

(11)

(12)

The supply equations for steel are derived analogously to the derivation of equations (5) to (7).
Given total steel output (Oso), domestic steel firms maximize total revenues from sales to domestic (Sso) and foreign (Ssx) markets, and receive an average price of (P QSo), which is a weighted average of domestic (P

With respect to pricing behavior there is an important distinction between traded inputs and nontraded inputs. Traded inputs are assumed to be denominated in U.S. dollars. Nontraded input prices are demonated in the currency where production takes place.

In the case of domestic autos, average unit cost (UCQAD) is shown in equation (16):

(16)

PVAAD is the price of value added in autos, as before Psc is the average price of composite steel, and PWA is the price of non-steel intermediate inputs. TXAD is the indirect tax rate for autos.

The value added production function for domestic autos is the CES function:

where LAD and KAD are labor and capital in domestic autos, PAD < 1, and the elasticity of substitution between labor and capital is aAD = 1/(1-PAD)' The dual for the production function, the price/unit cost of value added in autos, is given in equation (17):

(17)

where WD and RA are the domestic wage rate and world rental rate for capital in autos.

For foreign autos, the equations for unit cost and price of value added are similar to the corresponding domestic equations, and are given in equations (18) and (19):

(18)

(19)

where WF is the foreign wage rate.

Note that prices of intermediate inputs and capital are assumed to be determined on world markets and expressed in U.S. dollars. Therefore in equations (18) and (19) these prices are divided by the exchange rate to convert them to foreign currency units.

In the case of domestic steel, unit cost is given in equation (20):

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(20)

where, since value added in steel is a CES function of labor and capital, the price of steel value added (PV Aso) is as shown in equation (21):

(21)

where Rs is the world rental price of capital for the steel industry.

The corresponding equations for the foreign steel industry are (22) and (23):

(22)

(23)

The equilibrium conditions for the model state that the demands for domestic varieties of autos
and steel equal their respective supplies, equations (24) and 25)' and that the average prices of domestic autos and steel equal their respective unit costs, equations (26) and 27):

(24)

(25)

(26)

(27)

We also assume that when domestic firms sell exported varieties of autos and steel they receive
the average prices of foreign produced autos and steel. This is expressed in equations (28) and (29):

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(28)

(29)

Finally, we close the model by fixing the exchange rate, ER, the domestic demand for steel used
by producers of nontraded products, DSNO' the prices of the world traded inputs, Pws, PWA' RA, Rs, and the domestic and foreign wage rates, Wo and WF• The remaining 29 variables in the model are endogenous, and listed in Table

1. DAC
2. DAD
3. OAF
4. SAD
5. SAX
6. QAD
7. PAC
8. PAD
9. PAF
10. PAX
11. PQAD
12. UCQAD
13. DSAD
14. Dsc
15. DSF
16. DSD
17. SSD
18. Ssx
19. OsD
20. Psc
21. PSD
22. PSF
23. Psx
24,POSD
25. UCOSD
26. PVAAF
27. PVAAD
28. PVAsD
29. PVAsF
TABLE A1
ENDOGENOUS VARIABLES IN MODEL
Demand for composite autos consumed domestically
Demand for domestic variety of autos
Demand for imported variety of autos
Supply of domestic variety of autos
Supply of
of
export variety of autos

o
autosutos
USD)PVA
imported
autos
autos

APPENDIX B

DATA USED IN MODEL

The model presented in Appendix A is benchmarked to annual data for year 1984. The
steel industry is represented by Bureau of Economic Analysis (SEA) industry 37 (Primary iron and steel manufacturing), and steel-using tradeables industries ("autos") are represented by a group of 26 BEA industries (see Table B3). Most data were obtained from the 1984 U.S. input-output table. 1 Other data were estimated using methods and sources described in Table B2.

Steel Industry

All values described below are annual data for 1984 for Primary Iron and Steel
Manufacturing, BEA industry 37. All values are in millions of U.S. dollars.

Steel exports are $1,318 (XSDO) and steel imports are $12,670 (DSFO). The net value of domestic steel production is gross industry output ($67,964) minus intermediate consumption of steel ($11,044), or $56,920 (QSDO).

The value of tradeable inputs into domestic steel is total intermediate inputs ($41,356) minus
the primary iron and steel intermediates ($11,044) plus the estimated "other" value added2 ($4,264, derived in table B2)' or $34,576 (WSDO).

The value of nontradeable inputs into domestic steel (i.e., labor compensation and indirect
taxes) is total value added ($26,608) minus the estimated "other" value added ($4,264), or equal to $22,344 (ZSDO).

U.S. produced steel consumed in the U.S. is net value of domestic steel output ($56,920)
minus steel exports ($1,318), or $55,602 (DSDO). This amount ($55,602) plus steel imports ($12,670) is apparent steel consumption in the U.S., $68,272 (DSeO).

Major Steel-Using Tradeables Sectors

All values described below are for the 26 SEA industries that represent steel-using
tradeables industries. These industries are listed in Table B#. All values are in millions of U.S. dollars.

Exports by steel-using tradeables sectors are $93,147 (XADO) and imports of steel-using tradeables are $137,945 (DAFO). The amount of steel used in the production of tradeables is

1 U.S. Department of Commerce, Bureau of Economic Analysis, "Annual Input-Output Accounts of the U.S. Economy, 1984," Survey of Current Business, Nov. 1989, pp. 25-40, Table 1.

2Note that the total value added is the sum of compensation to employees, indirect taxes, and "other" value added (i.e., returns to owners of capital). Only compensation to employees and indirect taxes are nontradeable.

$55,022 (SADO). The amount of steel used in nontradeable sectors is apparent steel consumption in the U.S. ($68,272, DSCO) minus steel used in tradeables ($55,022), or $13,250 (SNDO).

The amount of domestic nontraded inputs in U.S. steel-using tradeables is the sum of estimated compensation to employees ($268,881, derived in Table 82) and indirect taxes ($8,956, derived in Table 82), or $277,837 (ZADO). The amount of tradeable inputs (excluding steel) in the U.S. steel-using tradeables sectors is the sum of all

tradeables WA

is

TABLE B1

Data (1 984) Used in Model

VARIABLE NAME VALUE (Mn) DESCRIPTION
XSDO $1,318 Value of U.S. steel exports
DSFO $12,670 Value of

TABLE B2

Estimates of Certain Variables

26,608 - 22,344 = 4,264

1984 estimated "other" value added was used to calculate the variables WSDO and ZSDO.

II. Major Steel-Using Tradeable Sectors "major sectors" (see Table B3)

A. 1984 Compensation of Employees

Compensation of employees, major sectors5 (Survey of Current Business Table 6.4B)

1982 1984 Percent Change
215,515 253,501 +17.6257

1982 compensation of employees, BEA major sectors = 228,590

1984 estimated compensation of employees, major sectors
228,590 x 1.176257 = 268,881

B. 1984 Indirect Business Taxes

The ratio of 1982 indirect business taxes to 1982 total industry output for each of the major
sectors (BEA industry) was multiplied by the corresponding value for 1984 total industry
output for each oTm (1982)m (228,5908287.5 480.Tc 9.8681 0 0 9.110.3022 c 10.021 (o28,5908287.5 4

TABLE B3 (Part I)
Major Steel-Using Tradeable Sectors in BEA Classification

BEA INDUSTRY DESCRIPTION
13 Ordnance and Accessories
22 Household furniture
23 Other furniture and fixtures
39 Metal containers
40 Heating, plumbing, and fabricated structural metal products
41 Screw machine products and stampings
42 Other fabricated metal products
43 Engines and turbines
44 Farm and garden machinery
45 Construction and mining machinery
46 Materials handling machinery
47 Metal-working machinery and equipment
48 Special industry machinery and equipment
49 General industrial machinery and equipment
50 Miscellaneous machinery, except electrical

TABLE B3 (Part II)

Major Steel Using Tradeable Sectors in Survey of Current Business Classification

1. Furniture and fixtures
2. Fabricated metal products
3. Machinery, except electrical
4. Electric and electronic equipment
5. Motor vehicles and equipment
6. Other transportation equipment

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SOURCES

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