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Bruce A. Blonigen
Benjamin H. Liebman
Wesley W. Wilson

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ABSTRACT

A primary function of trade policy is to restrict imports to benefit the targeted domestic sector. However, a well-established theoretical literature highlights that the form of trade policy (e.g., quotas versus tariffs) can have a significant impact on how much trade policy affects firms' abilities to price above marginal cost (i.e., market power). The US steel industry provides an excellent example to study these issues, as it has received many different types of trade protection over the past decades. We model the US steel market and then use a panel of data on major steel products from 1980 through 2006 to examine the effects of various trade policies on the steel market. We find that the US steel market is very competitive throughout our sample with the exception of the period in which they received comprehensive voluntary restraint agreements (i.e., quotas) and were able to price substantially above marginal cost. All other forms of protection were in tariff form and had little effect on market power, consistent with prior theoretical literature on the nonequivalence of tariffs and quotas. We also find evidence that market power eroded over time in steel products where mini-mill producers gained sizeable market share, highlighting the role of technology in the market as well.

Bruce A. Blonigen
Department of Economics
1285 University of Oregon
Eugene, OR 97403-1285
and NBER
bruceb@uoregon.edu

Benjamin H. Liebman
Department of Economics
Saint Joseph's University
5600 City Avenue
Philadelphia, PA 19131-1395
bliebman@sju.edu

Wesley W. Wilson
Department of Economics
1285 University of Oregon
Eugene, OR 97403-1285
wwilson@uoregon.edu

I. Introduction

For over 50 years, GATT and WTO rounds have substantially reduced trade barriers across the world. Yet, there are a number of key industries in which trade barriers are present, topical, and used strategically to improve the position of domestic industries including agriculture, lumber, textiles and apparel, automobiles, and steel. Of note, the form of trade policy measures varies widely across sectors and countries, and the theoretical literature often highlights important potential differences between various trade policies on market outcomes. Yet most prior empirical literature focuses only on the effects of a specific trade liberalization event or policy. In this paper, we evaluate and compare the effects of trade policy on the US steel industry over the past three decades, where a range of different trade policies provides an excellent opportunity to examine their differential market impacts.

The US steel industry has been the recipient of practically every form of trade protection in the past four decades (see Table 1). Long dominant in world markets, US steel became a net importer of steel in the early 1960s. By 1969, rising import shares and declining employment led to voluntary restraint agreements (VRAs) with Japan and the European Community (EC) which lasted through 1974. Subsequent years have included further rounds of negotiated VRAs, trigger mechanisms, antidumping (AD) and countervailing duty (CVD) cases, and the safeguard action by the Bush administration in the early 2000s. Over these decades, the steel industry has been one of the largest and most frequent users of US trade protection programs. Steel industry protection programs account for over one-third of the over 1400 US AD and CVD cases since 1980, and steel is one of only a few high-profile industries that have been allowed VRAs or safeguards.

Previous literature on the steel industry and trade protection is mainly characterized by papers that analyze the impact of only a particular trade policy during a relatively short period of time. Crandall (1981) and Canto (1984) examine the effect of the US VRAs from 1969-1974, finding that these VRAs had only a very modest effect in raising import prices for US steel firms, with no discernible impact on rates of return or employment. Nieberding (1999) examines whether the withdrawal of 1982 US AD cases against imported steel affected market power for three large US steel producers and finds only mixed evidence for any positive effects. Lenway, Rehbein and Starks (1990) and Lenway, Morck, and Yeung (1996) undertake event study analysis of abnormal returns for US steel firms upon announcements of major trade policy implementation that occurred in the late 1970s and early 1980s. Their evidence suggests that the stock market reacted positively to a number of these events, especially the 1982 and 1984 VRA announcements, but this experience varied significantly across firms, depending on such factors as previous lobbying activity, size, financial leverage, and whether the firm was a mini-mill or integrated producer of steel.[1] More recently, Chung (1998) finds that AD and CVD duties from 1982 through 1993 had only modest impacts on import penetration, while Bown (2004) and Durling and Prusa (2006) find that AD and safeguards significantly decrease trade in targeted products. Liebman (2006) finds little evidence that the 2002-2003 safeguard actions affected US steel prices. Given the wide-varying methodologies, periods of study, and sometimes contrary results, it is very difficult to get a complete and comparable evaluation of the effects of various trade policies on imports and performance.[2]

This paper provides a comprehensive look at the effect of trade policies on the steel industry's performance over the past three decades. We do this by estimating a general model of the US steel market consisting of equations representing demand, import supply, and US pricing,

[1] Integrated firms produce steel by combining iron ore and coking coal in blast furnaces, while mini-mills produce steel from recycled scrap that is melted down in electric arc furnaces.
[2] In addition to the literature cited that uses econometric techniques to evaluate trade policies *ex post*, there is also a significant literature that examines these policies with computable general (or partial) equilibrium models, including de Melo and Tarr (1990) and many US federal government agency reports. These studies also typically focus on only single trade protection instances and vary in their model specifications.

using annual observations of a panel of 20 major steel products from 1980 through 2006.[3] From this model, we are able to not only estimate the effects of different forms of protection on both import penetration and market power in the US steel industry, but also control for many factors the previous literature has claimed may contribute to the US steel industry's (poor) performance – including macroeconomic shocks, technological change, exchange rate movements, and various supply and demand shocks.[4]

Importantly, our examination of trade policy on market outcomes can provide evidence for a well-established, but mainly theoretical literature, on the non-equivalence of tariffs and quantitative restrictions. Beginning with the seminal paper by Bhagwati (1965), a theoretical literature has shown that quantitative restrictions can affect market power of one or more firms competing in a market, whereas tariffs have no such impact.[5] To our knowledge, there has been surprisingly little to no prior work to explore this empirically.

Our paper's econometric results provide a number of important results. First, we find that the US steel market is generally a highly competitive one, as we are unable to reject the hypothesis that baseline markups are zero over our sample; that is, pricing which is consistent with perfectly competitive conditions. However, there is significant evidence that the voluntary restraint agreements (VRAs) in the 1980s led to both substantial decreases in import penetration and increases in the US industry's ability to price above marginal cost, especially during the 1985-1989 period when virtually all import sources were covered under negotiated agreements and data suggest that quotas were binding. On the other hand, we find that while other forms of trade policies, such as tariffs and AD duties significantly lower import volumes, there is no

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[3] See Bresnahan (1989) for a general discussion of estimating price-cost margins.

[4] For example, Crandall (1996) and Moore (1996), among others, have argued that mini-mill production may be more important for explaining the decline of large integrated steel producers in the US than imports.

[5] Other related papers in this literature include Mai and Hwang (1988), Krishna (1989), Rotemberg and Saloner (1989). Feenstra (1988) provides theory and evidence for a different type of nonequivalence of quantitative restrictions and tariffs: quantitative restrictions encourage firms to upgrade their quality, unlike tariffs.

evidence that these policies impact the departure of price above marginal cost. These trade policy results provide some of the only evidence of which we are aware that confirms prior theoretical literature hypothesizing that quantitative restrictions can lead to quite different pricing responses by domestic firms (Bhagwati, 1965), and perhaps even facilitate collusion (e.g., Krishna, 1989). To the extent that market power is a significant potential inefficiency, it suggests that the WTO's stance against quantitative restrictions in favor of tariffs is an important one on these grounds.

We also find significant differences in market power for mini-mill products versus integrated products. Significant markups over cost are initially observed at the beginning of our sample for steel products that mini-mills ultimately dominate by the end of our sample. However, markups in these products gradually erode over the sample as mini-mill shares increase, becoming statistically insignificant from zero by the 1990s. This suggests that mini-mill technology may indeed be a significant reason for market power loss in the industry. For other products that are largely the domain of integrated producers, we find little evidence of market power throughout the sample with the exception of the VRA period. In fact, we find that the comprehensive VRA period was only beneficial to these "integrated" steel products in terms of increasing their ability to price marginal costs for their products, not for mini-mill products.

The remainder of the paper proceeds as follows. In the next section, we briefly describe the US steel industry and its substantial history of trade protection. Section 3 takes a first look at the data to understand the effect of trade policies on import penetration and industry profitability before describing our formal model and empirical specification in section 4, and our empirical results in section 5.

II. US Steel Industry and Its History of Trade Policies

A. US Steel Producers

The US steel industry is composed of two major types of producers: integrated mills and mini-mills. Integrated mills use large blast furnaces to make pig iron from iron and coke, which is then melted into raw steel in basic oxygen furnaces. Until recently, integrated mills accounted for the majority of steel production in the United States. Their production process is relatively capital- and energy-intensive and, thus, characterized by large plant-level scale economies. Integrated mills often include on-site or nearby finishing and rolling mills that further finish the semi-finished steel forms, such as ingots, slabs, and billets, into finished products, such as bars and sheets. Over time, a process of "continuous casting", whereby molten steel is formed directly into finished products has spread throughout the industry. Examples of integrated steel companies include US Steel and Bethlehem Steel.

The past three decades have also seen an ever-increasing share of steel production due to mini-mill steel plants which melt recycled steel scrap with electric arc furnaces (EAFs) into raw steel and steel products.[6] There are a number of cost efficiencies possible from mini-mill production, particularly in the much smaller plant size and hence, capital costs, required for an EAF. Historically, mini-mill producers have primarily produced lower-quality steel products, such as wire rods and steel bar products, because of the greater impurities in steel made from recycled scrap steel, rather than iron ore. However, over time, technologies have been developed that have begun to allow mini-mill producers to break into higher-quality steel markets, such as plate and sheet products. While Nucor is the well-known example of a mini-mill-based steel company, there are scores of smaller mini-mill steel plants across the United States.

B. Brief History of US Steel Trade Policies

Prior to the 1960s, the US steel industry was far more concerned with fending off anti-trust charges than securing trade relief from the federal government.[7] A string of factors, however, led to the industry's permanent shift from dominant world exporter to net importer.[8] In reaction to pressure from the large, integrated steel producers and the United Steel Workers Union (USW), President Johnson negotiated the industry's first VRA with Japan and the European Community (EC) in 1969. While the VRA expired in 1974, a surge of imports in 1977 led to renewed calls for quantitative restrictions as well as AD and CVD petitions. In order to avoid either outcome, President Carter implemented the Trigger Price Mechanism (TPM) in 1977. Under the TPM the domestic industry agreed to refrain from filing AD and CVD petitions as long as import prices did not fall below Japanese production costs (the world's lowest-cost industry) plus an 8 percent profit margin.

The TPM was renewed in 1980, but the industry was convinced that the policy was failing to provide sufficient protection from subsidized European imports and began filing petitions for AD and CVD protection. This, in turn, led to a suspension of the TPM program for much of the period after 1980, and which culminated in the filing of over one hundred AD and CVD petitions primarily against European producers in January of 1982. In order to avoid trade frictions that would result from significant AD and CVDs, President Reagan negotiated VRA agreements across a wide range of steel products with the EC in October of 1982.

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[6] Data from various issues of the American Iron and Steel Institute's *Annual Statistical Yearbook* show that percent of US domestic steel produced by using EAFs has increased from about 15% in 1970 to around 50% today.
[7] This confrontation even led to President Truman's unsuccessful attempt to nationalize the industry in 1952.
[8] These factors included: 1) a crippling strike in 1959 that required downstream users to seek non-domestic sources, 2) increasingly efficient, subsidized European and Japanese operations, 3) the discovery of large iron ore deposits outside the US, and 4) a strong dollar. As such, between 1960 and 1968, US import penetration climbed from 4.7 percent to 16.7 percent of total US steel consumption. See Moore (1996) for a more detailed discussion of the history of steel trade protection in the US through the early 1990s.

Although European steel imports were not permitted to exceed 5.5 percent of the US market, overall import penetration remained high due to a strong dollar and import diversions to non-EC sources. This likely contributed to the industry filing a large set of AD and CVD petitions in early 1984 and ultimately filing a safeguard petition (historically known as a Section 201 Escape Clause action in the US) in 1984. These trade protection actions led to the negotiation of a comprehensive VRA for all finished steel products and limiting total import market share to 18.4 percent in the last couple months of 1984. The VRAs were put into place for a roughly five-year period to end in October of 1989.

In late 1989, citing the industry's strong performance, President George H. Bush decided to renew the VRAs for only two-and-a-half additional years, rather than the full five years requested by the industry. When the VRAs ended in early 1992, the steel industry immediately filed a large number of AD and CVD petitions once again. While many industry observers expected intervention by the administration, President Bush instead allowed the cases to reach their completion. In July of 1993, affirmative AD and CVD determinations were ruled in favor of the domestic industry in only about a half of the value of imports under review. In several instances, competition from mini-mills, rather than imports, were seen as the real cause of injury by the US International Trade Commission. The ruling was perceived as a major defeat for the industry and was cited by Moore (1996) as an indication of the industry's loss of political clout.

Through the rest of the 1990s, steel producers used AD and CVD actions targeted at a limited number of specific products to secure trade relief. One possible reason for such limited action was the strong economy and modernized US operations. For the first time in decades, integrated producers were globally competitive, touted by some experts as an industry that had survived its austere, rationalization period and which was now enjoying a much-deserved "renaissance." (Ahlbrandt, Fruehan, Giarratani, 1996) Unfortunately, a string of unexpected shocks in 1998 brought this period quickly to an end. Most notable were currency crises in East Asia and Russia which led to import surges and subsequent AD and CVD filings in the late 1990s. By the early 2000s, about one-third of the industry had fallen into bankruptcy, leading President George W. Bush to implement another safeguard action on behalf of the US steel industry in March of 2002, which placed tariffs ranging from 8-30% on many major steel products in the first year. However, a number of major import sources were excluded including Canada and Mexico, as well as less-developed countries. Secondly, downstream industries successfully lobbied for exceptions over the ensuing safeguard period further watering down the amount of affected imports. Finally, the safeguard tariffs were terminated prematurely in early 2004 due to a WTO dispute panel ruling against the US safeguard action.

Our purpose is to examine the effects of policy on pricing power in the industry. To do so, we next turn to an analysis of the impact of these trade policies on the US steel industry's fortunes, first with a descriptive time series analysis, and then with formal estimation of their impact on the US industry's ability to price above marginal cost.

III. A First Look at the Data

One of the most striking characteristics of the US steel industry over the past decades is the large drop in employment in the sector. As show in Figure 1, employment in the steel sector has fallen from close to 600,000 employees in 1960 to less than 100,000 by the 2000s.[9] A significant portion of this decline occurred in the first half of the 1980s, when industry lobbying for protection led to comprehensive VRAs. The 1990s then saw a much more gradual decline in the number of employees.

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[9] Data used in this section come from issues of the *Annual Statistical Yearbook* of the American Iron and Steel Institute, with the exception of the Industrial Production Index which comes from statistical tables in the *Economic Report of the President*.

It is quite informative, however, to match this trend with the associated trends in US domestic production of steel, which has been relatively constant over the four-decade period. There is a decline in output in the early 1980s as well, but it is much smaller in magnitude than the decline in employment and had leveled off and begun to increase by 1983, whereas employment continued to decline until 1987 before leveling off. In fact, the correlations between output and employment both before and after 1980 are slightly negative and insignificant, suggesting that other factors (such as technological advances) are extremely important for understanding economic outcomes in this industry.

The effect of trade protection programs on domestic employment and production are not clear from Figure 1 either. The period of the TPM was the period of greatest decline in both. The ensuing VRA periods may have led to leveling off of the variables. However, the TPM period was the beginning of a substantial recession in the United States, and the VRA period was one of recovery.

Figure 2 provides a snapshot over the same period of some variables that get closer to the heart of our statistical analysis, graphing out a measure of the steel industry's annual profitability (net income as a percent of sales), import penetration (the value of imports as a percent of apparent supply to the US market), and an index of industrial production (1997=100). Over the four decades import penetration has risen from around 5% in the early 1960s to between 25-30% in the early 2000s. It is hard to argue that any of the trade protection programs affected this import market share except for the comprehensive VRA period from the mid-1980s through the early 1990s, when import shares decreased from about 25% to less than 20%. Interestingly, profitability of steel firms during this period is not clearly helped by falling import shares and actually is negative on average. Pair-wise correlations indicate a strong negative correlation between import share and profitability of US firms before 1980 (-0.61), but an essentially zero correlation after 1980. Taken at face value, this evidence suggests that in the post-1980 period, even if trade protection programs effectively limit imports, profitability of US firms is unaffected. However, these simple trends cannot uncover the independent effect of trade policies from the effect of many other market forces on the steel firms' performance, including changes in exchange rates, technological progress, demand preferences and input prices. Thus, we next turn to our econometric analysis that more formally examines the effect of trade policy on US steel firms' market power.

IV. Methodology and Data

A. Theory and Empirical Specification

Our approach is to estimate an econometric model of the industry that allows an examination of the effects of various trade policy regimes, while controlling for demand, cost and technology considerations.[10] We model US firms as a dominant firm that competes with a competitive fringe. The fringe is composed of foreign-country exporters to the US. Evaluation of the structure of imports suggests that these foreign firms can be modeled as a set of price-taking suppliers. Specifically, while the market share of imports in the US steel market has ranged from 15-25% since the mid-1970s (see Figure 2), the market shares of even individual foreign countries (much less individual foreign firms) are very small and makes the assumption of a fringe import supply quite reasonable. Table 2 provides market share of the top foreign-country import sources for the US steel market in 1980, 1990, and 2000. The largest foreign-country source is Canada with less than 5% of the market (spread across multiple steel firms),

[10] Generally, studies using this methodology estimate price-cost margins use firm-level data. We choose industry-level data for our analysis because there are very few US steel firms that provide publicly available data over the length of time period we wish to consider. For example, Nieberding's (1999) study over the 1978 to 1989 period was able to find only three steel companies "with enough available historical data to allow for the implementation of the market power test." (p. 79) Our study covers a much longer period, including one that saw many bankruptcies in the industry (early 2000s) which leads to unusable data for estimating market power at the firm level.

while very few countries have even 0.5% of the US market. Varying efficiencies across these foreign import sources, as well as capacity constraints, means that we expect an upward-sloping supply function in response to US steel prices, a relationship we estimate in our empirical specification. Importantly, we note that the market structure features we observe across all imports are generally true for each of our twenty products as well. Indeed, for seventeen of the twenty products, more than half of the top twenty US import source countries ship the product in an average year. Fifteen of the twenty products have a total import share (across all sources) of 25% or less in an average year. Finally, the results reported below are qualitatively identical when we eliminate the products that have both high import market shares (25% or above) and relatively few import source countries out of the top twenty (less than 12).[11]

Given our market structure assumptions, our focus is on the ability of the US steel firms to price above marginal cost and how this ability varies with trade policy changes and technological changes. Thus, our model of the US steel market consists of a US demand equation, an import fringe supply equation, and a domestic pricing equation[12]:

$$\begin{aligned} Q^{D} &= Q^{D}(P, X^{D}) \\ Q_{IMP} &= Q_{IMP}(P, X^{S}) \\ P &= MC_{US}(Q^{D} - Q_{IMP}, X^{C}) - \left(\frac{1}{\frac{\partial Q^{D}(P, X^{D})}{\partial P} - \frac{\partial Q_{IMP}(P, X^{S})}{\partial P}} \right) (Q^{D} - Q_{IMP})\theta, \end{aligned} \qquad \textbf{(1)}$$

where P is the US domestic price of steel; $Q^{D}(P,X^{D})$ is the domestic market demand function with associated shifters, X^{D}; $Q_{IMP}(P,X^{IMP})$ is the import supply with associated shifters, X^{IMP}; $MC_{US}(Q_{US} - Q_{IMP}, X^{C})$ is the marginal cost equation for the US producing $Q^{D} - Q_{IMP}$ with cost shifters X^{C} ; and θ represents an index of the degree to which prices depart from marginal costs. We note that the bracketed term is the slope of the residual demand function used for pricing

[11] These products are black plate, rails, tool steel, and wire-drawn.

decisions by US firms, and that as either the market demand and/or import fringe supply functions become more responsive to price changes, it dampens the departure of price from marginal costs.

The parameter, θ, indicates the degree to which US firms in the industry are able to set prices above marginal cost is usually thought to range in values from 0 to 1. If θ is equal to 0, the market yields no ability to price above marginal cost. As θ increase in values, the aggregate ability of the industry to price above marginal cost increases up to a possible markup of 100%. We note that, as is common in this literature (e.g., Bresnahan (1989), marginal costs are not observed and are accounted for with other measurable variables. Further, our focus is on whether or not θ is statistically important or not and, if important, whether it is affected by policy and other variables.

We begin by assuming linear forms for the demand, import supply, and marginal cost relationships and estimate the three equations as a system using 3-Stage Least Squares regression techniques to control for potential endogeneity and correlation of error terms. However, as discussed by Bresnahan (1982), identification of θ rests on interactions in the demand equation. Alternatively, Gallet (1997) achieves identification of θ in a similar empirical specification by assuming non-linearity in the marginal cost function and interacting the factor price terms. We employ both sets of interactions for identification, as statistical tests always strongly support inclusion of both in our specification. Below we describe our matrix of exogenous regressors for each equation.

Before proceeding, there is one final issue we address. Corts (1999) levels a major criticism at the new empirical industrial organization (NEIO) approach to estimating market power – an approach we generally follow here. Specifically, he argues that the NEIO approach

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[12] The median US export volume for a steel product category in our data is less than 5% of US production in the

is estimating marginal changes in market power, not the level of market power, which need not correspond to each other if the inherent strategic market game is dynamic. However, recent work examining the inherent bias in estimating market power in the NEIO framework for industries where one has precise estimates of marginal cost, and can therefore calculate market power directly, finds that the bias from estimating market power in an NEIO framework is often not large.[13] In addition, the focus of our paper will not be on the magnitude of market power *per se*, but whether market power exists or not. Our main results are characterized by little evidence of market power in the steel industry for virtually the entire sample period, with the exception of a very large and discrete jump in estimated market power to collusive levels during the height of the VRA period. It seems unlikely that such a large, discrete, and temporary jump in market power would be due to some other unobserved change in the underlying dynamic strategic game between firms.

B. Variables and Data

Our data set consists of annual observations of a panel of 20 major steel products covering the years 1980 through 2006. Exploiting cross-product variation has rarely been employed in previous studies of the steel industry, but the significant variation in how trade policies, technological change, and other market forces impact these various products over time allows us to more cleanly identify the impacts of focus variables. A full list of the steel products we include in our sample appears in the data appendix. It includes all major categories, such as plate, hot-rolled and cold-rolled sheet, wire rod, various types of bars, and drawn wire. While

category, and thus we do not model export behavior.

[13] These examples include sugar (Genesove and Mullin, 1998), whiskey (Clay and Troesken, 2003), and electricity (Puller, 2007).

our data appendix also describes construction of variables and data sources in detail, this section briefly discusses the variables, beginning with our endogenous price and quantity variables.

The main data limitation that prevents us from going back farther with our sample than 1980 is due to data issues with our main endogenous variable, the US steel price. Crucial issues in accurately measuring market steel prices are, first, the difference between listed and actual trade prices and, second, the complication of agreed-upon contractual prices that may run out many months or even longer than a year. While the US Bureau of Labor Statistics has historical price series that go back well before 1980, these are often based on listed prices by steel firms which may have little relationship with actual transaction prices (see Crandall 1981).[14] As a result, Crandall (1981) uses unit prices derived from *Current Industrial Reports* for the steel industry published by the US Census. These data are problematic for two reasons. First, the prices reflect revenues derived on sales that may be bound by prior contractual arrangements, not current market conditions. Second, this publication is quick to censor data for confidentiality problems and, thus, missing values begin to accumulate quickly, especially toward the end of our sample as the number of US steel firms declined. The price data we use come from Purchasing Magazine, which surveys monthly US spot prices of major steel products. These data more likely reflect current market conditions for a given period, but have the limitation that they only first began in January of 1980.[15] We note that we construct a real US price by deflating by the US GDP deflator. Our domestic and import steel quantity variables, the other endogenous variables in our empirical specification, are measured in tons and these data come from annual yearbooks of the American Iron and Steel Institute.

[14] Our own correspondence with staff of the US Bureau of Labor Statistics suggests that this methodology has ultimately been changed to better reflect market prices, but that this change began well after our sample begins in 1980.

[15] In practical terms, we find that the BLS prices give us qualitatively similar answers to those reported in the paper that use the Purchasing Magazine data. Price data constructed as unit values from the US Census' *Current*

Exogenous variables in our US demand equation include the real price of a common substitute for steel, aluminum, as well as an index of industrial production because steel is an important intermediate input for so many industrial sectors in the economy. We expect the coefficient on both of these terms to be positive. As mentioned earlier, we also include interaction terms between these exogenous variables and the US steel price variable, which also appears as a regressor on the right-hand side of the US demand equation.

Exogenous variables in the import fringe supply equation include the real exchange rate (expressed in terms of US dollar per foreign currency), rest-of-world (i.e., non-US) real GDP, real world input prices (including iron ore, oil, and coal), and trade policies. Our trade policies include, first, a dummy variable indicating the years of the VRAs on steel products from 1983 through 1991. We also include trade-weighted average antidumping and countervailing duties, which vary by product and year, as well as product-specific *ad valorem* tariffs. Finally, we include a dummy variable for the recent safeguard period from 2002 and 2003. We expect an increase in the real exchange rate measure (depreciation of the dollar) to increase US imports of steel. Rest-of-world real GDP and US imports are expected to be negatively correlated if excess capacity effects are present.[16] Increases in world prices of steel production inputs are expected to decrease the supply of steel products to the US market from the rest of the world. Finally, US trade policies are expected to restrict US imports with an obvious interest in how large these trade policy effects are, ceteris paribus.

Exogenous variables in the final equation begin with real factor prices, including wages, iron ore, scrap steel, electricity and coal. We also include interaction terms between these factor prices to aid identification of our market conduct parameter, as discussed earlier. These factor

Industrial Reports generally perform quite poorly with coefficient signs on the price term often reversed from that predicted by theory.

[16] See Blonigen and Wilson (2005) for a more detailed analysis of this issue with respect to US imports of steel.

prices are expected to be positively correlated with marginal costs of the firms in the industry and, hence, the real price of steel.

We also include an exogenous variable in the pricing equation that captures important technological factors in the steel industry, namely, a measure of the percent of US steel that is being "continuously-cast". Continuous casting is a process that allows molten steel to be directly shaped into semi-finished steel products. Prior to continuous casting, the metal was poured into standing casts to form ingots, which then required many more steps of reheating and working the metal to produce steel products. Over the time period of our sample, the amount of steel produced through continuous casting increases from around 15% to over 95%. Wider prevalence of this technology is expected to decrease real US steel prices, ceteris paribus. The other obvious technological change in the industry has been the rise of mini-mill production. Below we discuss some specific mini-mill technology events that we can use to examine the effect of mini-mill technology on the industry's ability to price above marginal cost.

The final variables on the right-hand side of the pricing equation are domestic production of steel ($Q_{US} - Q_{IMP}$) and a term that interacts the domestic production of steel with the inverse of the difference in the slopes between the demand equation and the import fringe supply equation.[17] The coefficient on the first term indicates the extent to which marginal costs vary with increasing production in the industry. The coefficient on the latter term, which we will refer to as the "weighted domestic quantity" term identifies the parameter θ, which indicates the ability of firms in the industry to price above marginal cost. Finally, we note that we include an annual trend term and product fixed effects in all three equations.

The above fully describes our base specification. From this base specification our analysis below proceeds by examining how various policy and market forces affect the US steel industry's ability to price above marginal cost. These analyses break down into two main categories: trade policies and the impact of mini-mill production. With respect to trade policies, we analyze the separate impact of various VRA periods, antidumping and countervailing duties, standard import tariffs, and the 2002-2003 safeguard period. With respect to mini-mill versus integrated steel producers, we investigate whether the ability to price above marginal costs varies across products that are traditionally produced by integrated producers versus those produced by mini-mills, as well as whether trade policies had differential impacts on these two sets of products/producers.

V. Empirical Results

Column 1 of Table 3 displays three-stage least-squares estimates for our benchmark three-equation system using our annual panel of 20 products and the years 1980-2006. The model fits the data quite well, with R^2 statistics fairly high for each of the three equations (0.92, 0.73, and 0.85, respectively) and chi-squared statistics (not reported) easily rejecting the null hypothesis of that the coefficients are jointly zero. We do not report the coefficient estimates on the product fixed effects or factor price interaction terms, but note that the chi-squared tests strongly support their inclusion throughout our analysis.

Most of the coefficients in our benchmark model are of expected sign and many are statistically significant as well. The price terms in both our domestic demand and import fringe supply equations are estimated with correct sign and are statistically significant; domestic demand is inversely related to the market price, while fringe supply increases when the market price increases. Industrial production and price of the substitute good (aluminum) have correct sign in the demand equation, though not statistically significant. However, we note that these

[17] The slopes in the construction of this variable are simultaneously estimated in the prior two equations, generating cross-equation restrictions in our parameters.

variables are connected with interaction terms, which can affect their sign and significance. Importantly, the coefficient on the interaction term between industrial production and steel price is statistically significant, which is important for identification of the market power parameter, as discussed above.

Control variables in the import fringe supply equation are generally of expected sign as well, with many statistically significant. The exchange rate and rest-of-world GDP variables are highly significant, suggesting that imports increase when the US dollar appreciates and when foreign countries economies see reduced demand in their own markets. The various trade policies, with the exception of countervailing duties, all are estimated to decrease import supply of steel. The poor performance of the countervailing duty variable is not surprising in light of the fact that such duties are almost always applied simultaneously with antidumping duties on the same products and import sources for US steel cases, and that these countervailing duties are invariably much smaller in magnitude than antidumping duties.

Control variables are often of correct sign in the pricing equation as well, though we note that the interaction terms we include amongst all the factor price terms (electricity, ore, scrap steel, coal, and wage prices) can easily affect sign and significance of the coefficient on that factor price. The marginal effects of these factor prices, including the direct and interacted effects, are generally of correct sign and statistically significant. The coefficient estimates on the interaction terms, though not reported to save space, are jointly statistically significant. Thus, they are likely quite important for identifying the departure of price from marginal cost, θ. Our estimates also show that the industry is characterized by economies of scale, with a statistically significant negative coefficient on the quantity variable. As expected, we find that greater use of continuous-cast technology has a significant effect in reducing costs and, hence, domestic prices.

Finally, our base model estimates a positive coefficient for the weighted domestic quantity variable in the domestic pricing equation; in other words, our estimate of θ. While this coefficient is of expected sign, it is also statistically insignificant, indicating that we cannot reject (perfectly) competitive pricing. We can also show that the magnitude of the implied markup associated with this estimated coefficient is small. In particular, we can use the estimated coefficients from our model (including θ) to generate an estimated price-cost margin. Recalling that the domestic pricing relation is $P = MC_{Dom} - \theta \cdot P'(Q_{Dom})Q_{Dom}$, we can reorganize and divide both sides by price, to obtain the markup solution:

$$Markup \equiv \frac{P - MC_{Dom}}{P} = \frac{-\theta P'(Q_{Dom})Q_{Dom}}{P}, \qquad \textbf{(2)}$$

where $P'(Q_{Dom})$ is defined as the term in large brackets of the last equation in (1).[18] Using our estimated coefficients, as well as sample mean values of domestic steel output, steel prices, industrial production, and the aluminum price, we calculate the average markup for our sample as 0.5%. Thus, the magnitude and statistical significance of the markup in our base model argues against any ability by the US steel industry to price above marginal cost.

A. Effects of Trade Policies on Market Power

We next explore how various trade policies affect market power. As we can see in the benchmark estimates, all of the trade policies are estimated to decrease imports, with the exception of countervailing duties. In column 2 of Table 3, we re-estimate our system of equations and interact the trade policy variables with the weighted domestic quantity variable in the domestic pricing equation, so that we can estimate how these trade policies may structurally affect the domestic industry's ability to price above marginal cost. Panel A of Table 4 provides markup calculations for these various trade policies based on our estimates in column 2 of Table 3. The estimated markups are noteworthy in that there is a strong increase in the domestic industry's ability to price above marginal cost during the VRA period from 1982 through 1991, but no evidence of effects on markups by any other trade policy. In fact, we cannot reject a mark-up of 100% during the VRA period, which would indicate collusive pricing by the US steel industry. While these results are quite dramatic in terms of differences in the industry's ability to price above marginal costs, they are consistent with prior theoretical literature showing that quantitative restrictions can lead to significant market power for domestic firms (Bhagwati, 1965) and even facilitate collusion (e.g., Krishna, 1989), since the VRA period saw quotas as the main form of protection, whereas the other trade policies we examine were characterized by *ad valorem* duties. In fact, this is the most direct evidence for this well-established theoretical literature of which we are aware.

It may be surprising that we do not find some evidence that AD duties can affect market power, given that Konings and Vandenbussche (2005) find evidence that AD duties positively affect market power in their sample of European firms enjoying AD protection. However, as Konings and Vandenbussche point out, we may expect AD duties to be less likely to affect market power in the US due to previous findings of significant trade diversion of imports from targeted products to alternative import sources in US AD cases (Prusa, 1997). Such trade diversion can substantially weaken the effects of the trade policy. Unlike the US situation, Konings et al. (2001) document quite limited trade diversion effects in European AD cases.

In column 3 of Table 3 we take a closer look at the ability of the domestic industry to price above marginal cost during the VRA period by splitting these years into three periods. The

[18] In particular, from our benchmark model, we calculate $P'(Q_{Dom})$ = 1/(-6.164 + 0.078*Industrial Production - 0.0005*Aluminum Price - 1.626), where we use the sample mean values for the Industrial Production and Aluminum Price variables.

first couple years of this period (1983-1984) saw VRAs only with European Community members, with allegations by the steel industry of significant trade diversion to other import sources.[19] Comprehensive VRAs on virtually all import sources and steel products did not occur until 1985 after further trade protection petitions by the industry. These "comprehensive" VRAs lasted until late 1989, at which point they were only renewed through 1991. In this latter period (1990-1991), there is evidence that many of the quotas were no longer binding as the economy slid into the recession of the early 1990s. (Crandall, 1996) Thus, we hypothesize that the industry's ability to price above marginal cost was greatest from 1985-1989, when comprehensive VRAs were in place.

Our estimates in Column 3 of Table 3 and the associated markup calculations in Panel B of Table 4 show that the VRAs effects on market power were different across these three VRA periods. We estimate statistically significant markups around 100% for both the EC VRA period from 1983-1984 and for the comprehensive VRA period from 1985 to 1989. The latter VRA period (1990-1991) is associated with a fairly small markup estimate of less than 30% and is statistically insignificant. This last result is consistent with Crandall's (1996) assessment that market conditions were such that the quantitative restrictions were not binding towards the end of the VRA period.

One potential issue with our VRA variables is that they are simply dummy variables for a given time period. Are we picking up some spurious correlation or is the effect simply being driven by other market factors during this particular time period? We are fairly confident that it is not simply a spurious correlation. Table 5 shows our estimates of θ for every possible continuous three-year of our sample, beginning with 1980-1982, and using the same

[19] While these initial VRAs only involved EC countries, they covered a wide range of steel products. Thus, we continue to proxy this period's effects with a dummy variable taking the value of "1" during this period for all products in our sample.

specification we employ in Column 2 of Table 3. The only three-year period that displays a statistically significant estimate of θ is the 1987-1989 period, the height of the VRA period. The market power estimate associated with the estimated θ for 1987-1989 is 92.7%, which is in line with the large magnitude we estimate above for the VRA period. There is always the possibility that there is some factor driving our VRA estimate for which we have not accounted, though we have been careful to control for many market factors, including exchange rates, technology, and demand shocks.

B. Differential Market Power for Mini-mill and Integrated Products

As discussed earlier, integrated and mini-mill steel producers are quite different in their production processes, plant-level scale economies, and the types of products they typically produce. In this section, we examine whether there are differing markup abilities across these producers, by interacting relevant variables with an indicator variable for whether the product is primarily produced by mini-mill producers. These products are reinforcing bar, hot-rolled bar, bar and light structural shapes under three inches, and heavy structural shapes.

In Panel C of Table 4, we report estimated markups for both mini-mill and integrated product during the entire sample and for the VRA period from 1983 through 1991.[20] Recall that in the first section we found a significant effect of VRAs on markups. Panel C's results show that while we cannot reject a baseline estimate of no ability to price above marginal costs for both sets of products, the positive impact of the VRAs is limited to the integrated products, where we estimate a statistically significant markup over marginal cost of 76.5%. In contrast, we estimate a markup of -21.8% markup for mini-mill products during the VRA period that is not statistically different from zero. There are a number of possible explanations for this difference.

First, unionized workers are probably better able to organize lobbying efforts for trade protection that covers the products they specifically produce and integrated mills were typically unionized, whereas most mini-mills were not. Second, the mini-mill sector is characterized by many smaller firms relative to the integrated sector. Thus, the integrated firms may have been better able to lobby for stronger trade protection for their products and/or better able to achieve and maintain tacit collusion once the VRAs were in place.

A final issue that we are able to explore, at least indirectly, is the extent to whether mini-mill competition has eroded integrated firms profitability over time. A direct way to estimate this would be if we had data on mini-mill market shares by product over time. These data are unavailable. However, we have some indirect pieces of evidence. First, we know that overall mini-mill market shares have steadily increased over time in the industry and the products where this mini-mill market share has increased to take over the majority of market share by the end of our sample – hot-rolled bar, cold-rolled bar, reinforcing bar, light bars and shapes, and structural shapes.[21] In Panel D of Table 4 we examine the evolution of estimated market power in the two types of products by interacting relevant terms by a trend variable.[22] The results show that products mainly dominated by integrated producers throughout the sample have actually shown little market power even from the beginning of the sample with a negative, but insignificant, change in market power over time. In contrast, products that have seen a large rise in mini-mill production initially display significant market power at the beginning of the sample (56.7%), but see it significantly eroded over the sample with an annual decline of 1.6%. By the 1990s, our estimates cannot reject the hypothesis that market power was zero for these products as well.

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[20] For the sake of brevity, we do not report the parameter estimates that we base our markup calculations on in this section. These estimates are available upon request.

[21] This information comes from US Census' *Current Industrial Reports: MA331B – Steel Mill Products*, which began to report such data toward the end of our sample.

This suggests that mini-mills broke into more lucrative steel products and quickly eroded profits for the steel industry in these products over time.

VI. Conclusion

This paper estimates a model of the US steel market that allows analysis of the effect of various trade policy programs on imports and market power in a comprehensive fashion for the first time. Using a panel data set of 20 major steel products from 1980 through 2006, we find substantial differences in the effects of various trade programs. While most protection programs have had at least moderate impacts on reducing imports, only the comprehensive VRAs during the latter half of the 1980s had any significant impact on the ability of the US steel industry to price above marginal cost. Moreover, the impact of these VRAs was large and we cannot reject the hypothesis that the industry was able to perfectly collude during this period. To our knowledge, this is the most direct confirmatory evidence of the well-established theoretical literature showing that a significant difference between quantitative restrictions and tariff (price) policies are the ability of quantitative restrictions to allow firms to the ability to price above marginal cost. Interestingly, we find that the market power effects of the VRAs occurred only with steel products that were mainly produced by integrated steel producers. Steel products for which mini-mill producers had a significant market share saw no discernible changes in market power during the VRA period, though we also find that these "mini-mill" products see gradual erosion of market power over time.

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[22] Specifically, we interact our "weighted domestic quantity" variable in the domestic pricing equation with 1) a dummy variable indicating whether the product was mainly produced by mini-mills (bar products and structural shapes), 2) a trend term, and 3) a trend term multiplied by the mini-mill product dummy.

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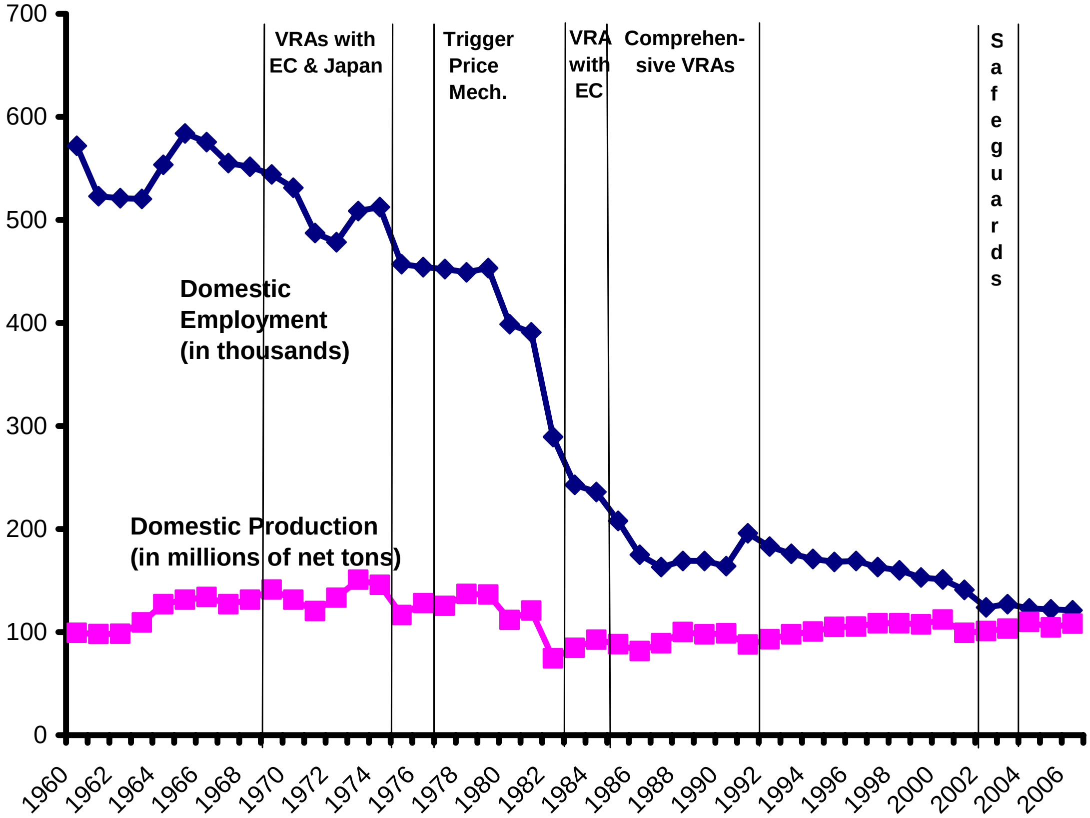
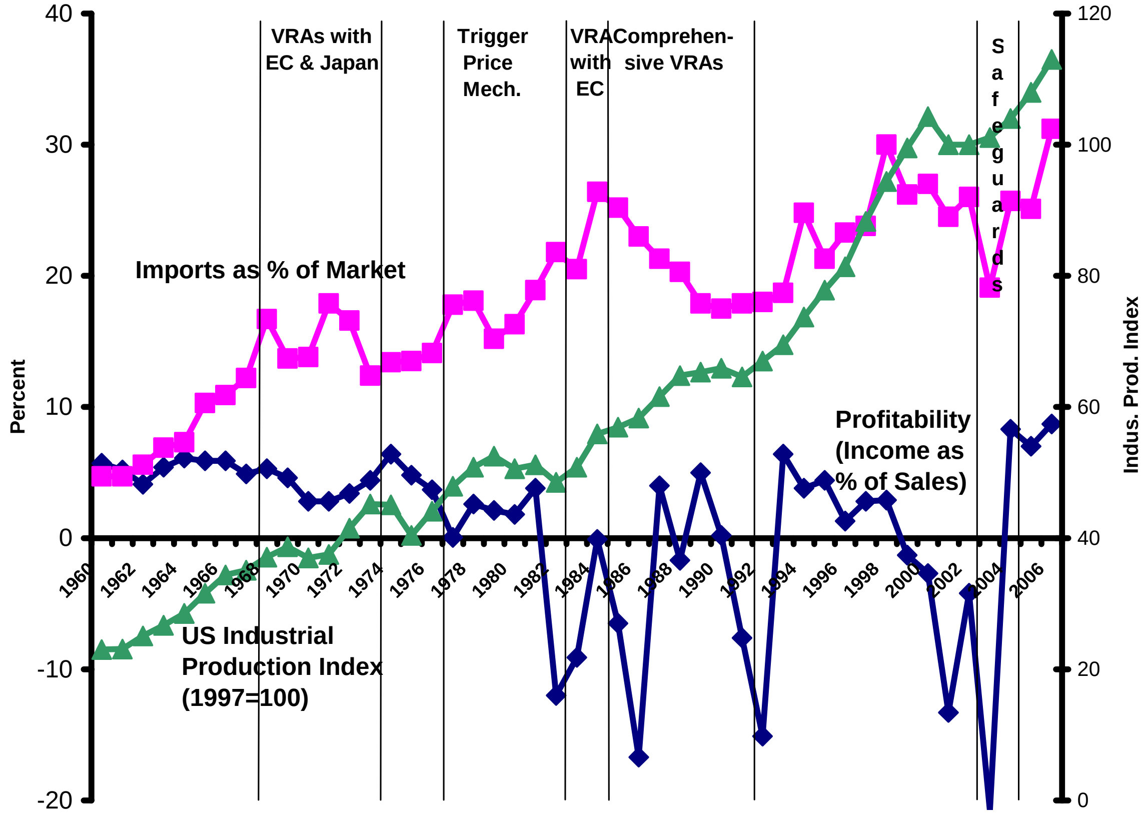
Figure 1
US Domestic Steel Output and Employment, 1960-2006



Notes: Data come from *Annual Statistical Yearbook*, American Iron and Steel Institute, various issues.

Figure 2
Steel Industry Profitability, Steel Import Penetration and US Industrial Production, 1960-2006



Notes: Import share and profitability data come from *Annual Statistical Yearbook*, American Iron and Steel Institute, various issues. The US industrial production index comes from Table B-51 of the most recent issues of the *Economic Report of the President*.

Table 1: US Steel Trade Protection Events

1969-1974	Voluntary Restraint Agreements (VRAs) with Japan and the EC.
1977-1981	Trigger Price Mechanism applied to all imports.
1982	Antidumping (AD) and countervailing duty (CVD) cases filed against EC countries. Subsequently terminated for VRAs on EC imports.
1984	AD and CVD cases filed against non-EC countries. Subsequently terminated for comprehensive VRAs.
1984-1989	Comprehensive VRAs with all significant import sources.
1989-1992	Extension of VRAs.
1992-1993	AD and CVD cases filed against significant import sources after VRAs expire. AD and CVD remedies applied to only subset of products.
1998-2000	Multiple AD and CVD cases against Japan and other Asian countries.
2002-2003	Safeguard remedies in form of tariffs placed on steel imports, excluding FTA partners and developing countries.

Table 2: Share of US Steel Market by Top Foreign Country Import Source for Selected Years

	US Market Share (in percent)		
Countries	**1985**	**1995**	**2005**
Japan	6.2	2.2	1.1
Canada	3.0	4.0	4.9
Germany	2.5	1.4	1.2
Korea	2.0	1.2	1.5
Brazil	1.8	1.9	2.1
France	1.7	0.8	0.5
Belgium-Luxembourg	1.1	0.3	0.5
Sweden	0.7	0.2	0.3
United Kingdom	0.6	0.6	0.6
Italy	0.6	0.3	0.4
Netherlands	0.6	1.0	0.5
Spain	0.6	0.3	0.3
Mexico	0.3	2.0	3.4
China	0.1	0.4	2.0
Russia	0.0	1.3	1.3
Turkey	0.0	0.4	1.1
India	0.0	0.0	0.6

Notes: Market shares calculated as foreign country's imports of semi-finished and finished steel mill products (in tons) as a percent of US apparent supply (shipments by domestic firms minus exports plus imports) of steel mill products (in tons). We list any countries that were one of the top ten import sources for any of the three reported years and order by the largest import sources in 1985.
Source: *Annual Statistical Report of the American Iron and Steel Institute* (various issues). New York, NY: The American Iron and Steel Institute

Table 3: Three-stage Least Squares Estimates of a Three-Equation Model of the US Steel Market (Demand, Import Supply, and Domestic Pricing): The Effects of Various Trade Policies

	Predicted Sign	Base Model	Effect of Various Trade Policies	Effect of Various VRA Periods
Equation 1: Domestic Demand				
Steel Price	-	-6.164***	-6.767***	-6.667**
		(1.637)	(1.535)	(1.585)
Industrial Production	+	17.639	25.058*	26.081*
		(13.567)	(13.481)	(13.950)
Aluminum Price	+	0.498*	0.340	0.345
		(0.272)	(0.242)	(0.274)
Steel Price * Industrial Production	?	0.078***	0.080***	0.082***
		(0.019)	(0.016)	(0.018)
Steel Price * Aluminum Price	?	-0.0005	-0.0003	-0.0004
		(0.0003)	(0.0003)	(0.0003)
Trend	?	-24.427	-48.449	-56.172
		(54.850)	(53.183)	(55.234)
Equation 2: Import Fringe Supply				
Steel Price	+	1.626**	1.719**	1.916**
		(0.809)	(0.734)	(0.811)
Real Exchange Rate	+	22.047***	22.417***	23.350***
		(5.378)	(5.120)	(5.282)
Rest-of-World Real GDP	-	-263.652***	-270.212***	-245.077***
		(78.187)	(73.403)	(76.91)
Foreign Ore Price	-	3.698	3.807	7.609
		(3.100)	(3.014)	(3.678)
Foreign Oil Price	-	-1.235	-1.005	-2.219
		(1.473)	(1.441)	(1.573)
Foreign Coal Price	-	-2.283	-2.584	-5.487*
		(2.448)	(2.386)	(2.924)
Tariff Rate	-	-48.668*	-47.367*	-54.861**
		(26.067)	(26.295)	(26.442)
Antidumping Duty Rate	-	-20.078***	-20.342***	-20.080***
		(3.618)	(3.607)	(3.640)
Countervailing Duty Rate	-	5.212	6.725	5.716
		(4.646)	(4.693)	(4.688)
Safeguard Tariffs	-	-19.179***	-17.448***	-16.991***
		(6.064)	(6.144)	(6.173)

VRA Period, 1983-1991	-	-179.883	-203.343**	
		(115.8)	(112.9)	
VRA Period, 1983-1984	-			-167.293
				(146.5)
VRA Period, 1985-1989	-			-360.554**
				(145.9)
VRA Period, 1990-1991	-			-238.465*
				(142.4)
Trend	?	186.769***	189.451***	158.558***
		(43.812)	(41.815)	(45.338)
<u>Equation 3: Domestic Pricing</u>				
Electricity Price	+	438.095	552.735	577.249**
		(229.8)	(272.6)	(255.6)
Ore Price	+	-9.800	-1.289	-1.052
		(25.111)	(27.089)	(26.721)
Scrap Price	+	3.924*	3.586	2.648
		(2.381)	(2.717)	(2.687)
Coal Price	+	-95.952	-128.297	-133.236
		(75.497)	(85.508)	(81.983)
Steel Wage	+	28.301***	24.901***	22.793**
		(10.239)	(9.321)	(10.350)
Continuous Cast	-	-4.575***	-3.992**	-3.839**
		(1.701)	(1.907)	(1.932)
Trend	?	0.653	3.027	3.127
		(6.536)	(3.985)	(6.426)
Domestic Quantity	?	-0.029***	-0.019***	-0.020**
		(0.006)	(0.004)	(0.008)
Weighted Domestic Quantity	+	0.0003	0.0015	0.0007
		(0.0007)	(0.0010)	(0.0015)
Weighted Domestic Quantity × Tariff	+		-0.0006	
			(0.0007)	
Weighted Domestic Quantity × AD Duty	+		0.00004	
			(0.00004)	
Weighted Domestic Quantity × CVD Duty	+		-0.0010*	
			(0.0005)	
Weighted Domestic Quantity × Safeguard Tariffs	+		-0.00003	
			(0.00007)	
Weighted Domestic Quantity × VRA Period (1982-1991)	+		0.0332**	
			(0.0150)	

Weighted Domestic Quantity × VRA Period (1982-1984)	+			0.0438^{*}
				(0.0236)
Weighted Domestic Quantity × VRA Period (1985-1989)	+			0.0417^{**}
				(0.0208)
Weighted Domestic Quantity × VRA Period (1990-1991)	+			0.0104
				(0.0159)
Factor-price Interactions in Equation 3		Yes	Yes	Yes
Product Fixed Effects in Each Equation		Yes	Yes	Yes
Observations		540	540	540
R^2 - Domestic Demand		0.92	0.92	0.92
R^2 - Import Fringe Supply		0.73	0.73	0.73
R^2 - Domestic Pricing		0.85	0.85	0.86

Notes: Data sample is panel of annual observations across 20 major steel products from 1980 through 2006. Product fixed effects are included in each equation and as part of the instrument set. The dependent variable for the first equation is total steel products demanded for a given product-year combination in the US market in tons; the dependent variable for the second equation is total imports of a product-year combination in tons; the dependent variable for the third equation is the price for a product-year combination in US dollars per ton. The data appendix provides details on data construction and sources. Standard errors are in parentheses and ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively. Chi-squared statistics are not reported in the table, but easily reject the null hypothesis of jointly insignificant coefficients for all equations across all specifications. Fixed-effects coefficient estimates for the twenty steel products are jointly statistically significant in each of the three equations, but not displayed in order to save space. Likewise, the cost interaction terms in the pricing equation are jointly significant in all specifications, but not displayed to save space.

Table 4: Estimated Mark-ups from Various Regression Specifications

A. Mark-ups for Various Trade Policies Effects Estimates from Column 2 of Table 3	
Baseline	3.4%
Tariff - For Each Percentage Point Increase	-1.0%
AD Duty - For Each Percentage Point Increase	0.1%
CVD Duty - For Each Percentage Point Increase	-1.7%*
Safeguard Tariff - For Each Percentage Point Increase	-0.1%
VRA Period from 1983-1991	82.8%**
B Mark-ups for Various VRA Periods Using Estimates from Column 3 of Table 3	
Baseline	1.1%
VRA Period from 1983-1984	111.6%*
VRA Period from 1985-1989	98.0%**
VRA Period from 1990-1991	27.1%
C. Mark-ups during the VRA Period: Integrated versus Minimill Products	
Integrated Products	
Baseline	0.6%
VRA, 1983-1991	76.5%**
Minimill Products	
Baseline	-0.4%
VRA, 1983-1991	-24.2%
D. Evolution of Mark-ups Over Time: Integrated versus Minimill Products	
Integrated Products, Controlling for VRA Period Effects	
Baseline – 1980	16.8%
Annual Change in Market Power after 1980	-0.6%
Minimill Products, Controlling for VRA Period Effects	
Baseline - 1980	56.7%**
Annual Change in Market Power after 1980	-1.6%**

Notes: ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively.

Table 5: Estimates of θ Over Three-Year Windows

Three-Year Period	θ	P-Value of θ Estimate
1980 - 1983	-0.0347	0.321
1981 - 1984	-0.0235	0.215
1982 - 1984	0.0216	0.184
1983 - 1985	0.0123	0.375
1984 - 1986	0.0071	0.577
1985 - 1987	-0.0036	0.793
1986 - 1988	0.0098	0.383
1987 - 1989	**0.0356**	**0.030**
1988 - 1990	0.0189	0.276
1989 - 1991	0.0121	0.323
1990 - 1992	-0.0138	0.285
1991 - 1993	-0.0010	0.904
1992 - 1994	0.0086	0.282
1993 - 1995	0.0046	0.538
1994 - 1996	-0.0002	0.964
1995 - 1997	-0.0053	0.202
1996 - 1998	-0.0020	0.609
1997 - 1999	0.0006	0.672
1998 - 2000	0.0013	0.238
1999 - 2001	0.0009	0.189
2000 - 2002	0.0007	0.389
2001 - 2003	-0.0004	0.482
2002 - 2004	-0.0009	0.125
2003 - 2005	-0.0018	0.207
2004 - 2006	0.0135	0.218

Notes: These estimates are of our market power parameter (θ) over all continuous three-year periods in our sample using the same specification as that in Column 2 of Table 3.

Data Appendix

In this appendix, we first describe data construction and sources for the respective dependent variables in our three-equation system, and then provide similar details for the control variables in each equation in the order they are listed in Table 3 of the paper. At the end of the section, we provide a table of basic descriptive statistics for each variable.

Dependent variables

1) Domestic Demand Equation: US market quantity. *Annual Statistical Report***,** American Iron and Steel Institute, various issues. To get total shipments by domestic US steel producers, we record "Net Shipments" for each product-year observation which is "Gross Shipments" by US steel plants minus "shipments from one reporting company to another reporting company for conversion, further processing or resale." We then add imports (discussed next) and subtract export shipments using data from the same publication to get total domestic quantity sold in the US measured in thousands of tons.

2) Import Fringe Supply Equation: Import quantity. *Annual Statistical Report***,** American Iron and Steel Institute, various issues. Galvanized and Other Metal Coated sheets were combined figures from 1980-1982. We use the 1983 percent (88% is Galvanized) to estimate separate quantities for these two products over the 1980-1982 period. This variable is measured in thousands of tons.

3) Domestic Markup Equation: US steel price. For a variety of reasons described in the text, we rely on steel prices provided by Purchasing Magazine, available for a fee at http://www.purchasingdata.com/. These data provide monthly spot prices for a number of specific steel products (in US dollars per ton) back to January 1980. Table A.1 shows the concordance between the steel products in our data sample and the price series used from Purchasing Magazine. Where there was not an exact match, we used the price series that had the largest correlation between the two products in another price series discussed in the text – unit values from *Current Industrial Reports*. These correlations were always above 0.8. We took the simple average of the monthly price series to create annual prices and deflated by the US GDP deflator available from the *Economic Report of the President*, Table B-3, to convert into real US dollars per ton.

Table A.1: Concordance for our product-level US price data

Product Categories in our Data	Purchasing Magazine Series Used
Wire Rods	Wire Rod
Plates	Hot Rolled Plate (coiled)
Hot-rolled Sheet and Strip	Hot Rolled Sheet
Cold-rolled Sheet and Strip	Cold Rolled Sheet
Sheet & strip - Galvanized	Hot Dipped Galvanized Sheet
Tin Plate	Cold Rolled Sheet
Bars - Hot-rolled	Wide Flange Beams
Bars - Light structurals (under 3")	Reinforcing Bar
Bars - Reinforcing	Reinforcing Bar
Bars - Cold finished	Cold Finished Bar

Black plate	Hot Rolled Plate (coiled)
Ingots, Blooms, Billets, Slabs, etc	Wire Rod
Rails (Standard and Other)	Hot Rolled Plate (coiled)
Sheet piling	Wide Flange Beams
Sheets & Strip - Metallic Coated	Cold Rolled Sheet
Sheets & Strip - Electrical	Cold Rolled Sheet
Structural Shapes - Heavy	Wide Flange Beams
Tin Free Steel	Cold Rolled Sheet
Tool Steel	Reinforcing Bar
Wire - Drawn	Cold Rolled Sheet

Explanatory variables – Domestic Demand Equation

Our measure of US production is the production index for the manufacturing sector reported in the *Economic Report of the President*, Table B-51. Data on US aluminum prices through 2004 come from the US Geological Survey, which are available online at http://minerals.usgs.gov/ds/2005/140/#steelscrap. All prices are expressed in terms of 1998 dollars per ton. We then used price data from recent volumes of the US Geological Survey's *Minerals Yearbook* to construct prices in 1998 dollars per ton for years 2005 and 2006. The trend term in all three equations is constructed as the year minus 1979, the year prior to the start of our sample.

Explanatory variables – Import Fringe Supply Equation

Our measure of the US real exchange rate is the "Broad Index of Real Exchange Rate of the US Dollar" from US Federal Reserve Board official statistics. Monthly data were averaged to generate yearly observations. These data are available at http://www.federalreserve.gov/releases/h10/summary/. Real world GDP measured in constant 2000 US trillions of dollars and taken from the World Bank's *World Development Indicators*. Data on world iron ore, oil, and coal prices comes from the International Monetary Fund's *International Financial Statistics* data on world commodity prices. The iron ore price is an index of North Brazilian port prices, coal is an index of Australian prices, and oil is an average index of three spot prices – Dubai Fateh, U.K. Brent and West Texas Intermediate. These prices are deflated using the US GDP deflator to express them in real terms. Steel tariffs are measured as trade-weighted import tariffs and calculated from official US Census trade statistics on US 7-digit Tariff System of the United States (prior to 1989) and 10-digit Harmonized System product codes. Various issues of the US Census's *Current Industrial Reports: Steel Mill Products* were used to concord import product codes into consistent classifications over the sample. US antidumping and countervailing duties are constructed as trade-weighted averages across import sources for a given steel product. Data for these came from Blonigen and Wilson (2005). The VRA and safeguard measures are dummy variables that take the value of "1" for the years noted in the tables.

Explanatory variables – Import Fringe Supply Equation

Our measure of the US real exchange rate is the "Broad Index of Real Exchange Rate of the US Dollar" from US Federal Reserve Board official statistics. Monthly data were averaged to generate yearly observations. These data are available at http://www.federalreserve.gov/releases/h10/summary/. Real world GDP measured in

constant 2000 US trillions of dollars and taken from the World Bank's *World Development Indicators*. Data on world iron ore, oil, and coal prices comes from the International Monetary Fund's *International Financial Statistics* data on world commodity prices. The iron ore price is an index of North Brazilian port prices, coal is an index of Australian prices, and oil is an average index of three spot prices – Dubai Fateh, U.K. Brent and West Texas Intermediate. These prices are deflated using the US GDP deflator to express them in real terms. Steel tariffs are measured as trade-weighted import tariffs and calculated from official US Census trade statistics on US 7-digit Tariff System of the United States (prior to 1989) and 10-digit Harmonized System product codes. Various issues of the US Census's *Current Industrial Reports: Steel Mill Products* were used to concord import product codes into consistent classifications over the sample. US antidumping and countervailing duties are constructed as trade-weighted averages across import sources for a given steel product. Data for these came from Blonigen and Wilson (2005). The VRA and safeguard measures are dummy variables that take the value of "1" for the years noted in the tables.

Explanatory variables – Domestic Markup Equation

Measures of electricity and coal prices come from the US Energy Information Administration. Real prices of electricity for industrial purposes are available at http://www.eia.doe.gov/emeu/aer/elect.html as the "Industrial – Real" column of Table 8.10. Coal prices are available at http://www.eia.doe.gov/emeu/aer/coal.html, and are expressed in terms of 1998 dollars per ton. Data on US iron ore and scrap steel prices through 2004 come from the US Geological Survey, which are available online at http://minerals.usgs.gov/ds/2005/140/#steelscrap. All prices are expressed in terms of 1998 dollars per ton. We then used price data from recent volumes of the US Geological Survey's *Minerals Yearbook* to construct prices in 1998 dollars per ton for years 2005 and 2006. Wages for the steel industry come from various issues of the *Annual Statistical Report*, American Iron and Steel Institute, various issues. We use "Total Employment Cost per Hour" as reported in Table 6 of most recent issues and deflated by the US GDP deflator to convert into real terms. Data on the percent of all products produced with continuous casting methods are available from the *Annual Statistical Report*, American Iron and Steel Institute, various issues. The domestic quantity variable comes from *Annual Statistical Report* of the American Iron and Steel Institute, various issues. To get total shipments by domestic US steel producers, we record "Net Shipments" for each product-year observation which is "Gross Shipments" by US steel plants minus "shipments from one reporting company to another reporting company for conversion, further processing or resale." The weighted domestic quantity variable is the domestic quantity weighted by the inverse of the partial derivative of the US market quantity with respect to the steel price (from the domestic demand equation) minus the partial derivative of the import quantity with respect to the steel price (from the import fringe supply equation) as noted in the text. We constrain the coefficients in estimation of the domestic demand and import fringe supply to be the same as those used in constructing the partial derivatives for this weighted domestic quantity variable.

In table A.2 we provide (in order) descriptive statistics for all the variables appearing in column 1 of table 3, our base model. We don't report the weighted domestic quantity variable in the last equation, since it depends on estimated parameters.

Table A.2. Basic Descriptive Statistics of Variables Used for Estimation

Variable |	Mean	Standard Deviation	Minimum	Maximum
<u>Domestic Demand Equation</u>				
US Steel Market Quantity	5155.57	5863.91	43.00	26283.00
Steel Price	486.06	147.88	221.76	948.93
Industrial Production	76.90	20.53	48.50	113.00
Aluminum Price	2470.53	1305.84	1215.43	6476.33
Steel Price * Industrial Production	36084.40	11425.53	16749.74	85012.94
Steel Price * Aluminum Price	1315896.78	1104371.94	323895.10	6041762.35
Trend	14.00	7.80	1.00	27.00
<u>Import Fringe Supply Equation</u>				
Import Quantity	1096.54	1509.94	1.00	9320.00
Steel Price	486.06	147.88	221.76	948.93
Real Exchange Rate	99.14	9.50	86.67	122.59
Rest-of-World Real GDP	18.42	4.09	12.56	26.46
Foreign Ore Price	131.52	33.37	97.79	231.04
Foreign Oil Price	108.90	49.89	48.00	234.02
Foreign Coal Price	177.84	58.05	100.00	310.27
Tariff Rate	3.21	2.53	0.00	10.14
Antidumping Duty Rate	7.03	13.07	0.00	52.40
Countervailing Duty Rate	2.17	9.53	0.00	56.17
VRA Period, 1983-1991	0.33	0.47	0.00	1.00
Safeguard Tariffs	0.69	4.43	0.00	30.00
Trend	14.00	7.80	1.00	27.00
<u>Domestic Markup Equation</u>				
Steel Price	486.06	147.88	221.76	948.93
Electricity Price	7.20	2.84	4.39	12.77
Ore Price	52.13	31.65	22.07	126.20
Scrap Price	155.51	55.50	67.29	334.55
Coal Price	34.08	19.83	15.77	84.40
Steel Wage	36.09	2.66	32.25	41.52
Continuous Cast	73.14	26.15	20.30	97.30
Domestic Quantity	4256.27	5097.45	18.00	22767.00
Trend	14.00	7.80	1.00	27.00