Are All Trade Protection Policies Created Equal? Empirical Evidence for Nonequivalent Market Power Effects of Tariffs and Quotas

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Abstract

Over the past decades, the steel industry has been protected by a wide variety of trade policies, both tariff- and quota-based. This wide heterogeneity in trade protection provides the opportunity to examine the well-established theoretical literature predicting nonequivalent effects of tariffs and quotas on domestic firms' market power. Robust to a variety of empirical specifications with U.S. Census data on all U.S. steel plants from 1977-2002, we find strong evidence for significant market power effects for quota-based protection, but not for tariff-based protection. There is also some evidence that antidumping protection also significantly increases market power.

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1. Introduction

There is an extensive literature that extends back to at least Bhagwati (1965) that demonstrates a number of ways in which a tariff and a quota set to limit imports in an identical way may nonetheless have nonequivalent effects on economic behavior and outcomes. The presence of imperfect competition and market power is almost invariably a necessary condition for non-equivalence results. One of the most well-known examples of non-equivalence are provided by Harris (1985) and Krishna (1989) which show that these two forms of trade protection can have quite different effects on the degree of market power exercised by domestic and foreign firms.[1] These papers examine oligopoly settings where a foreign and a domestic firm compete for the domestic market. The key result is that the strict quantitative limit set by a quota restricts the foreign firm's best response in a systematic way that facilitates collusive pricing by the firms, therefore raising prices, market power and profits. In contrast, tariffs do not impose any binding constraints on prices and quantities and, thus, have no predicted effects on market power.

Despite this theoretical literature establishing the nonequivalent market-power effects of quotas vis-à-vis tariffs, there has been virtually no work to examine this hypothesis empirically.[2] A number of studies, including Berry, Levinsohn, and Pakes (1999) and Goldberg and Verboven (2001), have estimated significant market impacts of quantitative restrictions on exports of automobiles in U.S. and European markets, but they do not examine whether tariffs have equivalent effects. Winkelmann and Winkelmann (1998) use the experience of a large trade protection liberalization event in New Zealand to estimate significant negative terms-of-trade

[1] A related literature (see Falvey , 1979, Rodriguez, 1979, and Feenstra,1988), theoretically demonstrates and empirically confirms that quotas, unlike tariffs, can provide incentives for firms to upgrade the quality of their products. We do not explore this non-equivalence result, but note that evidence for this effect in imported US steel products is found in Boorstein and Feenstra (1991).

effects to New Zealand for products that were formerly protected by quotas, but no such effects for those that were tariff-protected. However, since the authors do not have cost data and identify estimates off of primarily cross-sectional variation, it is difficult to connect their results to market power effects. Kim (2000) estimates the impact of trade protection programs on productivity, market power, and scale efficiency for the Korean industrial sectors from 1966 through 1988. The analysis finds that quotas have a statistically significant impact on market power, whereas price forms of protection do not, but cannot conclude that their impacts are different due to the size of the standard errors.

In this paper, we directly examine the hypothesis of nonequivalent market-power effects of quotas and tariffs using a detailed panel census of U.S steel plants from 1977 through 2002. The US steel industry has been the recipient of practically every form of trade protection over this time period (see Table 1 for a timeline of events). In fact, the steel industry accounts 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 enjoyed quotas or safeguard remedies. In addition, there has been significant heterogeneity in trade protection across various steel products and at different points in time, providing a rich variation to identify our estimates. Our plant-level data includes detailed measures of inputs, production, and prices, allowing us to use well-established techniques to estimate market power, and the panel nature of the data allow us to control for unobserved plant-level fixed effects.

While a primary focus of our analysis is the difference in market-power effects of tariffs and quotas, our data allow us to also estimate market power effects of a variety of other trade

[2] A predecessor paper to this one by a subset of the authors (Blonigen, Liebman and Wilson, 2007) also considers these issues, but with industry-level data that does not allow the precision and robustness of this paper's results using highly detailed plant-level data.

protection programs, including antidumping (AD) duties and countervailing duties (CVD).[3] Staiger and Wolak (1989), Prusa (1994), and Veugelers and Vandenbussche (1999) provide models that indicate that the structure of AD investigations and duty determination can facilitate collusion amongst domestic and foreign firms serving a domestic market and, thus, also raise market power of these firms. Konings and Vandenbussche (2005) analyze a firm-level data set of European firms who petitioned and received AD protection in the 1990s and find that there was a significant increase in market power of firms after the imposition of AD duties. In contrast, 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.

There are no studies (of which we are aware) that suggest CVDs would increase market power. CVDs are designed to countervail subsidization by a foreign government and, therefore, the calculation of the CVD is unaffected by firm behavior. In contrast, the calculation of AD duties are directly affected by foreign firm pricing behavior, and it is these well known rules by which AD duties adjust to foreign firm pricing that allows the domestic and foreign firms to potentially coordinate collusive pricing. Given this, we propose a second related nonequivalence hypothesis that AD duties increase market power of domestic firms, whereas CVDs do not.

[3] There is a literature that has analyzed the impacts of various trade protection programs in the steel industry, though the frequent focus is to analyze just one type of trade protection program, rather than compare effects across trade protection programs. 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. Lenway, Rehbein and Starks (1990) and Lenway, Morck, and Yeung (1996) provide event study analysis evidence that steel firms' profitability was increased by the announcement of voluntary restraint agreements (VRAs) in 1982 and 1984. 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. 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 do not explore differing effects of trade protection programs.

Our analysis will be able to directly examine whether there are any differential market-power effects of AD duties and CVDs, as well as the extent to which these trade protection programs differ in their effects from tariffs and quotas.

Our paper's econometric results provide a number of important results. First, we find significant support for nonequivalent effects of quotas and tariffs as theory would suggest, though the decisiveness of these results depends a bit on the approach one uses to estimate market power effects. These results are strongest for the minimill and integrated steel plants which produce their own steel in our sample, whereas our estimates suggest that the market power of processing steel plants that use purchased steel for further fabrication are unaffected by any trade protection policies. There is some evidence that antidumping duties affect market power, but this is sensitive to specification.

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 describes our empirical methodology and data, section 4 presents our empirical results, and section 5 concludes.

2. US Steel Industry and Its History of Trade Policies

2.1. 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.[4] 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.

In addition to these steel producing plants, there are also steel processing plants that do not produce raw steel, but do produce many of the same basic steel products as the integrated and minimill plants using purchased steel. Such products include various steel pipes and tubes, as well as wire and related wire products.

Since trade policies do not discriminate on the type of plant producing these products, we include all three types of steel plants in our analysis. However, there are certainly economic reasons to suggest that the effect of trade policies may differ across these types of plants. This is particularly true of the processors, since steel trade policies may not only raise import protection on their final good, but also their main input. After presenting full sample results, we will also explore heterogeneity in trade policy impacts across these three types of steel plants.

2.2. 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.[5] A string of factors, however, led to the industry's permanent shift from dominant world exporter to net importer.[6]
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 in January of 1982 which terminated the TPM program. 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.

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

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[4] 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.
[5] This confrontation even led to President Truman's unsuccessful attempt to nationalize the industry in 1952.
[6] 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.

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)

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.

3. Methodology and Data

3.1. Empirical Specification

Our focus in this paper is on the ability of the US steel plants to price above marginal cost and how this ability varies with trade policy changes.[7] There are a couple standard ways in which the previous literature estimates market power using plant- or firm-level data (Tybout, 2003) and which we employ here.

The first method stems back to Hall (1988), which was then extended by Roeger (1995) to overcome an endogeneity issue. Konings and Vandenbussche (2005) use this Roeger methodology in their estimation of the effect of AD duties on mark-ups and we use their notation here to sketch out the model and resulting estimating equation.

Assume that each plant *i* producing product *j* in year *t* has a production function, $F(N_{ijt}, K_{ijt}, M_{ijt})$, that is linear homogeneous in three factors – labor (N_{ijt}), capital (K_{ijt}), and materials (M_{ijt}) – and that output (Q_{ijt}) for a plant is given by

$$Q_{ijt} = \Theta_{ijt} F(N_{ijt}, K_{ijt}, M_{ijt}), \qquad \textbf{(1)}$$

where Θ_{ijt} is a plant- and year-specific productivity shock.

From this set-up, Hall (1988) derives the Solow residual for plant *i* in product *j* in year *t* (SR_{ijt}) as

$$SR_{ijt} = \hat{Q}_{ijt} - \alpha_{N_{ijt}} \hat{N}_{ijt} - \alpha_{M_{ijt}} \hat{M}_{ijt} - (1 - \alpha_{N_{ijt}} - \alpha_{M_{ijt}}) \hat{K}_{ijt} = \beta_{ijt} (\hat{Q}_{ijt} - \hat{K}_{ijt}) + (1 - \beta_{ijt}) \hat{\Theta}_{ijt}, \qquad \textbf{(2)}$$

where the cavats denote growth rates, α's are the associated factor shares of total revenues, and $\beta_{ijt} = 1 - (1/\mu_{ijt})$. The variable $\mu_{ijt} = P_{ijt} / c_{ijt}$, where P_{ijt} is the price and c_{ijt} is the marginal cost, and thus measures the price-cost markup for plant *i* in product *j* in year *t*. As in Hall (1988), one can estimate equation (2), though much care needs to be taken to control for potential endogeneity, as the productivity shock term may be at least partly composed of anticipated shocks that affect the plant's choice of inputs.

Due to the difficulty of finding appropriate instruments to control for this endogeneity issue, Roeger (1995) derives an equation to estimate the markup that is free from this source of endogeneity. The methodology is to simply derive a dual Solow residual and difference the primal and dual expressions for the Solow residual to eliminate the common productivity shock term in each. In particular, the dual Solow residual (DSR_{ijt}) can be derived as

$$DSR_{ijt} = \alpha_{N_{ijt}} \hat{P}_{N\,ijt} - \alpha_{M_{ijt}} \hat{P}_{M\,ijt} - (1 - \alpha_{N_{ijt}} - \alpha_{M_{ijt}}) \hat{R}_{ijt} - \hat{P}_{ijt} = -\beta_{ijt} (\hat{P}_{ijt} - \hat{R}_{ijt}) + (1 - \beta_{ijt}) \hat{\Theta}_{ijt}, \qquad \textbf{(3)}$$

where $P_{M\,ijt}$, $P_{N\,ijt}$, and R_{ijt} are the factor prices for materials, labor, and capital, respectively. Differencing equations (2) and (3) and re-arranging yields

$$(\hat{Q}_{ijt} + \hat{P}_{ijt}) - (\hat{K}_{ijt} - \hat{R}_{ijt}) = \mu_{ijt} \{ \alpha_{N_{ijt}} [(\hat{N}_{ijt} + \hat{P}_{N\,ijt}) - (\hat{K}_{ijt} - \hat{R}_{ijt})] + \alpha_{M_{ijt}} [(\hat{M}_{ijt} + \hat{P}_{M\,ijt} - (\hat{K}_{ijt} - \hat{R}_{ijt})]) \}, \qquad \textbf{(4)}$$

[7] While the theory also suggests that trade policy may affect foreign firms' market power, we do not examine this because we do not have the data to do so.

This equation can easily be estimated using our plant-level data and has a number of nice properties. First, the productivity shock term has been differenced away and, thus, is no longer a source of endogeneity bias. Second, assuming a mean-zero error term, it is easily interpretable as the regression of sales growth on weighted factor expenditure growth after netting out capital expenditure growth from both sides, with the regression coefficient a direct estimate of the price-cost markup.

Our hypotheses in this paper concern the differential impacts that trade protection policies imposed on foreign competitors of the plants in our sample can have on a plant's ability to price above marginal cost. To empirically examine this, we propose a varying-coefficients model where the estimated markup parameter in equation (4) is a function of an intercept and a linear combination of *K* product-specific trade policies (TP_{jt}^{k}),

$$\mu_{ijt} = \theta_0 + \sum_{k=1}^{K} \theta_k TP_{jt}^{k}, \qquad \textbf{(5)}$$

where the θ's are parameters to be estimated. Given our earlier discussions, we would expect both quotas and AD duties to significantly increase the markup parameter, μ_{ijt} , while tariffs and CVDs have no significant effect. An important feature of the theoretical analysis proposing nonequivalence between tariffs and quota is that these types of protection programs have different effects on market power for the same level of import penetration. Thus, we also include an import penetration measure (IM_{jt}) on the righthand side of equation (5) so that we can estimate the impact of various trade protection programs on markups controlling for the level of import penetration.[8] We expect the coefficient on import penetration to be negative. A final additional variable that we add to the righthand side of equation (5) is a measure of downstream demand

[8] There is a related literature that looks at imports as "market discipline," in that greater import penetration likely correlates with a more competitive market, lower markups for all firms/plants (e.g., see Kee and Hoekman, 2007).

growth (GR_{jt}). Gallet (1997) finds that markups in the steel industry can vary with the business cycle and Konings and Vandenbussche (2005) also finds this is an important control variable for their estimation.

Denoting the lefthandside of equation (4) as ΔY_{ijt}, the term in brackets on the righthand side of equation (4) as ΔX_{ijt}, a mean-zero error term as ε_{ijt}, and incorporating our varying coefficients modeling of the effects of trade policies, import penetration and downstream demand growth, we get the final Roeger-style estimating equation that we will take to the data:

$$\Delta Y_{ijt} = \theta_0 \Delta X_{ijt} + \sum_{k=1}^{K} \theta_k (TP_{jt}^k \times \Delta X_{ijt}) + \theta_{k+1} (IM_{jt} \times \Delta X_{ijt}) + \theta_{k+2} (GR_{jt} \times \Delta X_{ijt}) + \eta_i + \varepsilon_{ijt}. \quad \textbf{(6)}$$

The estimated parameter, θ_0, provides a baseline estimate of the price-cost markup by plants in our sample, while the other estimated θ parameters measure how much these other variables (trade policies, import penetration, and downstream demand growth) increase or decrease a plant's baseline markup. We also include plant-level fixed effects, η_i.

One limitation of the Roeger derivation is an assumption of constant returns to scale. Klette (1999) provides an extension to the approach of Hall and Roeger to relax this assumption. However, when we implement Klette's specification with our sample, our estimates cannot reject constant returns to scale. Thus, we follow the simpler Roeger specification for our analysis.

An alternative specification to the Hall/Roeger approach to estimate the effect of various factors on a firm's or plant's markup (and perhaps even more common in the literature) is to simply construct a proxy for the markup using observable accounting data and regress this on explanatory factors. Following previous studies we construct the price-cost markup proxy

(PCM_{ijt}) as total revenues minus variable costs over sales and estimate the following PCM regression equation[9]:

$$PCM_{ijt} = \gamma_0 + \sum_{k=1}^{K} \gamma_k TP_{ijt}^k + \gamma_{k+1} IM_{ijt} + \gamma_{k+2} GR_{ijt} + \gamma_{k+3} (K_{ijt} / P_{ijt} Q_{ijt}) + \rho_i + v_{ijt} \qquad \textbf{(7)}$$

where ρ_i are estimated plant-level fixed effects and v_{ijt} is an assumed mean-zero error term. The inclusion of a lagged dependent variable controls for any dynamic adjustment in markups over time, such as mean-reversion behavior.

3.2. Variables and Data

We rely on the U.S. Census Bureau's Census of Manufactures (CM) for the data used in this analysis. The CM is conducted every five years and collects plant-level data for all U.S. manufacturers[10] including the total value of shipments, book value of capital, raw material usage and employment. In addition, the CM tracks the full set of products produced by each plant, which allows us to identify the plants producing steel products that received trade protection. Our panel dataset includes CM data from 1972, 1977, 1982, 1987, 1992, 1997 and 2002. We limit our sample to U.S. steel plants producing products in SIC 331 (Steel Works, Blast Furnaces, and Rolling and Finishing Mills).

We then match trade policy and other control variables to the plants' 5-digit SIC product codes within SIC 331. A few of the wire-related products also have associated SIC 349 (Miscellaneous Fabricated Steel Products) product codes when the product is produced by a steel processor, rather than a steel-producing plant. For example, wire cloth produced by a steel-

[9] See, for example, equation 13.2 and related discussion in Tybout (2003) and equation 8 and related discussion in Konings and Vandenbussche (2005).

[10] The CM collects limited data for small manufacturers, which are referred to as "administrative records." Because output and input data may be imputed for these plants, however, they are excluded from this analysis, as is standard in research utilizing the CM.

producing plant is coded as SIC 33157, whereas wire cloth produced by a steel-processor plant is coded as SIC 34964. This distinction is what allows us to identify steel processors from steel producers in our data.

There are five different types of protection programs that were applied to steel products in our database over our sample period that we examine. The first program we examine are standard *ad valorem* tariffs ($Tariff_{jt}$), which were in place for the majority of the sample, though some had fallen to zero by the last year of the sample. The relevant data were collected from the NBER Trade Database (www.nber.org/data/) and tariff duties were calculated by dividing duties collected by the customs value of the imports for the associated product codes.[11] Tariffs by import product codes (Tariff Schedule of the United States of America (TSUSA) or Harmonized System (HS)) were aggregated to SIC 5 categories using concordances in various issues of *Current Industrial Reports: Steel Mill Products*, published by the U.S. Census Bureau of the U.S. Department of Commerce.

Second, are voluntary restraint agreements or quotas (VRA_{jt}), which were in place on many products in the steel industry from the end of 1984 to early 1992.[12] Only one year of our sample fully overlaps with this period, 1987, and, thus, we create a "1" for any product subject to a VRA in 1987 and a "0" otherwise. As discussed in Moore (1996), the "fill rates" of the VRAs across products were essentially at their peak in 1987, suggesting that they were most likely binding during this period. Since a key condition for the theoretical result of the nonequivalence between tariffs and quotas with respect to market power is that the quota truly constrains (or binds) the total quantity imported, 1987 is the year for which we should see a nonequivalent effect

[11] The NBER Trade Database currently only goes through the year 2001, and so we rely on purchased official merchandise import data from the Foreign Trade Division of the U.S. Census for the year 2002.
[12] Products covered under the VRAs are listed in the U.S. International Trade Commission (USITC) publication 1729 (August 1985), *Annual Survey Concerning Competitive Conditions in the Steel Industry and Industry Efforts to Adjust and Modernize*.

between quotas and tariffs if it exists. Moore (1996) also provides calculations of "fill rates" of quotas by product which we concord into our product codes. Thus, we will also examine below our estimates of market power effects for alternative VRA dummy variables that only take the value of "1" if the fill rate is above 90%, or if the fill rate is above 95%.

The third and fourth types of protection programs were antidumping (AD_{jt}) and countervailing duties (CVD_{jt}). Information on these investigations and duties were gathered from relevant *Federal Register* notices. In particular, we gather information on affected import product codes (TSUSA or HS), foreign country source, applied duty rates and length of time these duties were in place, and then construct average trade-weighted AD and CVD duty rates for our SIC5 sectors using the import volume of the affected product and country source in the year prior to the case available from the NBER Trade Database and the concordance between import product codes and SIC5 products available in *Current Industrial Reports: Steel Mill Products*, mentioned above.

The fifth trade protection program during our sample that we examine is the steel safeguard tariffs ($SafeTariffs_{jt}$) that were put into place in March 2002; i.e., early in the last year of our sample. Steel safeguard tariff rates are reported and available from the U.S. Department of Commerce at http://www.ita.doc.gov/media/FactSheet/0303/fs_steel_ex_032103.html. We constructed trade-weighted average safeguard tariffs for our SIC5 products in the same fashion as our AD and CVD duties, being sure to taking into account the imports from country sources that were exempt from the safeguard remedy, such as the North American Free Trade Agreement partner countries.

There are a few trade protection programs applied to the steel industry during our sample years that we do not include in our reported regression estimates. The TPM ran from January 1978 to January 1982, and thus does not overlap with any of our sample's closest years – 1977 or

1982. Second, there were two special safeguard actions that led to trade protection in the form of tariff-rate quotas on wire rods and circular welded line pipe from March 2000 to March 2003. These programs overlap with our last sample year, 2002. However, they also pertain to very specific products that comprise only a small share of one of our SIC5 products, particularly circular welded line pipe. Not surprisingly, when we include dummy variables indicating the affected SIC5 products in 2002, we estimate statistically insignificant effects on markups and none of our other variables are qualitatively affected. Thus, we do not present results from specifications with these variables in our empirical tables below.

Beyond the trade protection variables, we rely on two main control variables. The first is a measure of import penetration for a product in a given year (IM_{jt}), which we construct as the share of imports in the sum of imports plus domestic shipments. We rely on data from various annual yearbooks of the American Iron and Steel Institute for products where there is a direct correspondence to our SIC5 products. For a handful of our products (particularly wire-related products), there is not a clear correspondence, and so we use data on imports from the NBER Trade Database for imports and *Current Industrial Reports: Steel Mill Products* for domestic shipment data.

The second control variable is a real demand growth measure which we calculate as the weighted average of real GDP growth by downstream sectors. We gather real GDP growth by sector and year from table B-13 of the *Economic Report of the President*, 2006, and then weight by the share of total shipments purchased by the downstream sector as reported in the 1992 U.S. input-output tables. The product codes in the input-output tables are not as detailed as our SIC5 products, so we often have to apply the same demand growth values across multiple SIC 5 product codes. We construct changes in growth over the prior year, but also report estimation results below when we calculate growth over the prior 5 years. Table 2 provides a list of the steel products covered in our sample and average trade policy coverage by product and trade policy.

4. Empirical Results

4.1. Roeger-style estimates

Column 1 of Table 3 presents results from estimating equation (6) – which we term our "base model" of estimates from the Roeger specification. The data fit the model well, with an R^2 statistic of 0.91 and an F-statistic that easily rejects the null hypotheses of jointly zero coefficients. The coefficient on the ΔX_{ijt} variable is highly statistically significant and also statistically greater than 1.0, suggesting that the steel plants in our sample enjoy the ability to price about 14.9% above cost on average.

The next set of regressors listed in Table 3 are our main focus in this paper – the trade policy variables. As discussed above, prior theory suggests that the VRA and AD duties will have a positive impact on plants' market power, while strictly tariff-based trade policy programs – tariffs, CVDs, and safeguard tariffs – to show no effects on market power. Our estimated coefficients in our Roeger base model follow this exact pattern. Both the VRA and AD duties variables show positive, statistically significant coefficients, while the estimated coefficients on the other trade policy variables are not statistically different from zero. The estimated effects of VRAs and AD duties are also economically significant. The imposition of a VRA is estimated to increase market power by 21.5 percentage points, while a 10 percentage point increase in the AD duty is estimated to raise the price-cost markup by about 8 percentage points. In summary, these results provide significant evidence for the non-equivalent effects of quotas and tariffs on market power, as well as the similar effects that AD duties can have on market power to that of quotas.

The final regressors listed in Table 3 control for import penetration and the downstream demand growth. While import penetration is correct sign, it is statistically insignificant from zero. The coefficient on downstream demand is surprisingly negative and statistically significant. This runs counter to Gallet (1997) that finds that market power goes up in periods of greater demand. To explore this more, we tried alternative measures of real demand growth, including a 5-year change in our downstream demand variable (rather than a one-year change) and get qualitatively identical estimates.

An interesting issue is whether products with VRAs that are more likely binding provide evidence of greater market power effects. The fill rates for products in our sample range form 78% to 102%, but the point at which the fill rate is high enough to mean the quota is binding in the marketplace is clearly ambiguous. In column 3 of Table 3 we re-estimate our Roeger specification where we replace our VRA variable with a dummy variable for any product that has a VRA fill rate at 90% or higher. However, the estimated coefficient is a bit lower, though not statistically different than that estimated in column 2. This suggests that the fill rates are all high enough to have significant impacts on market power.

A final issue we examine with these base Roeger-style estimates before turning to the PCM base results is the issue of heterogenous effects across types of steel plants. Particularly in the beginning of our sample, the large integrated steel producers were often the only type of firms publicly instigating petitions for trade protection. While this may suggest they were the ones most likely to gain from trade protection, it may also be due to their relatively large size in the industry and incentives for smaller minimill plants to free ride even though the benefits from trade protection were proportionally as large as for the integrated plants. As mentioned, processing plants are quite different from the other two because they purchase basic steel rather than produce it on-site. With trade protection often applied simultaneously across a number of steel products, the processing plants reliance on purchased steel may translate into different market power effects as well.

Column 3 of Table 3 shows our results when we interact our trade policy and control variable interactive terms with dummies for minimill and processing plants.[13] Thus, by omission, our coefficient estimates in column 3 capture the effects for integrated mills only. As one can see, the coefficient estimates are very similar to the previous columns, though standard errors increase.

The top half of Table 4 combines our reported estimates in column 3 of Table 3 with the coefficient estimates on the minimill and processing plant interactions to show the effects of trade policies by type of steel plant. The effects of the VRA and AD duties on market power are sharpest with minimill plants, while the tariff-based protection programs (tariffs, CVDs, and safeguard tariffs) for all three types of plants show no sign of statistically significant effects on market power. Thus, these results provide fairly strong evidence of nonequivalent market power effects between quotas and AD duties versus tariff-based trade policies.

4.2. PCM estimates

We next turn to estimating market powers effects using a PCM specification as presented in equation (7) above. Table 5 presents results in analogous fashion to Table 2; Column 1 presents base results, column 2 presents estimates when we indicate the presence of a VRA only for products where reported fill rates are 90% or greater, and column 3 results present estimates when we include minimill and processor plant interactions. The evidence of nonequivalence between quotas and tariffs is fairly similar in these estimates, though perhaps not quite as compelling. Similar to the Roeger estimates, the effect of the VRA on market power is significantly positive, and tariff-based protection programs, CVDs and safeguard tariffs, are insignificant or the wrong sign. However, unlike the Roeger estimates, standard tariffs in this

[13] Minimill plants are not explicitly identified in the CM data. However, production capacities of minimill plants are significantly smaller than for integrated plants – a fact that is well documented and can be seen in the bi-modal nature of capacities in our sample's distribution of plant capacities. We use this feature of the data to identify minimill plants.

specification are estimated to have an effect on market power that is sometimes marginally statistically significant. The estimated market power effects in the PCM specification are generally smaller in magnitude as well, though still economically significant. The effect of VRAs is to increase the price-cost markup by 5-6 percentage points, whereas each percentage point increase in the tariff increases the price-cost margin by 0.5 percentage points. With tariffs falling an average of roughly 8 percentage points over our sample, this would suggest cumulative tariff effects on the price-cost margin of about 4 percentage points – which would rival the magnitude of the VRA. Taken as a whole though, the estimate market-power effect of the quantitative restriction is large and highly statistically significant in these PCM estimates, while only one of the three tariff-based measures has correct sign and is only marginally significant. One clear difference between the Roeger and PCM estimates, however, is that AD duties are not estimated to have any impact on market power with the PCM estimates, unlike the Roeger estimates that suggested modest support for significant positive AD duty impacts.

The bottom half of Table 4 provides estimated effects across different types of steel plants. The effects of the VRA on market power are equally strong across integrated and minimill steel plants, and much weaker, but still marginally significant for steel processing plants. In contrast, market power effects of tariff-based protection are generally statistically insignificant, as is consistent with the theory of nonequivalence of quotas and tariffs. One exception is the positive effect estimated for tariffs on minimill plants. The other exception is the estimate on safeguard tariffs on integrated plants, which is significant, but wrong sign.

A possible explanation for the negative sign on safeguard tariffs for integrated plants is endogeneity bias. Firms of plants are more likely to petition for trade protection in periods when their profitability (and market power) is low. This would lead to a downward bias in the effect of trade protection on market power. Our use of 5-year intervals can substantially mitigate this if changes in trade protection programs are made in years that do not correspond to our years of observation. For example, the VRA appears in our 5-year data in 1987, while the quotas came in place at the end of 1984. This inherent lag can largely eliminate an endogeneity bias. Similar lags in implementation of trade policies relative to our years of observation are also likely substantially reducing endogeneity bias of our estimates for the other trade protection programs as well. The exception is likely the safeguard tariffs that came in place in the same year as the relevant year of observation – 2002. And the poor performance of the integrated mills was likely the driving force behind the imposition of the safeguard tariffs; hence there is likely a large downward bias in this estimated coefficient. Future versions of this paper intend to address issues of endogeneity more directly.

5. Conclusion

This paper provides the first analysis of which we are aware to directly compare the effects of trade protection programs on a common set of products and analyze the hypothesis of nonequivalent market power effects of tariffs and quotas. We use detailed plant-level Census data to examine changes in market power of U.S. steel plants as they were buffeted by a wide variety of trade protection policies from 1977 through 2002. We find that the only trade program to consistently show significant effects on market power in our various estimates is the quantitative restrictions, which is consistent with the prior theory that quotas, unlike tariffs, can facilitate collusive pricing by domestic and foreign firms. These results are hold for the steel-producing plants in our sample, not steel-processing plants that rely on purchased steel for inputs. We find much weaker evidence that AD duties have positive effects on market power as has been suggested by prior literature.

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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: Average Values of Trade Policy Variables Over Sample by Steel Product

SIC5	Product	Tariff Rate (ad valorem)	AD Duty (ad valorem)	CVD (ad valorem)	VRA	Safeguard Tariffs (ad valorem)
33122	Ingot, blooms, slabs, etc	4.06	0.00	0.00	0.17	0.00
33126 & 33170	Steel pipe and tubes	3.66	4.61	0.04	0.17	0.98
33123	Hot-rolled sheet and strip	5.18	5.14	0.18	0.17	2.57
33124	Hot-rolled steel products	3.16	6.80	0.83	0.17	1.54
33125 & 33155	Wire	4.48	0.00	0.00	0.17	0.02
33127 & 33167	Cold-rolled sheet and strip	6.10	6.56	0.55	0.17	3.18
33128 & 33168	Cold-formed bars	5.25	2.31	0.09	0.17	2.62
3312C	Rails	0.40	6.74	21.19	0.17	0.00
33151 & 34961	Wire rope, cable, and strand	3.66	0.58	0.00	0.17	0.00
33152	Nails and staples	0.51	3.71	0.00	0.17	0.00
33156 & 34966	Fencing and gates	0.23	0.00	0.00	0.17	0.00
33157 & 34964	Wire cloth	4.92	0.00	0.00	0.00	0.00

Table 3: Roeger-style Estimation of the Effects of Various Trade Policies on Steel Plant Markups

	Predicted Sign	OLS Base Model	OLS 90% Binding VRAs	OLS - With Processor and Minimill Interactions
ΔX_{ijt}	+	1.149^{***}	1.159^{***}	1.152^{***}
		(0.047)	(0.055)	(0.080)
Trade Policy Effects				
$Tariff_{jt} \times \Delta X_{ijt}$	0	-0.003	-0.001	-0.002
		(0.012)	(0.011)	(0.023)
$VRA_{jt} \times \Delta X_{ijt}$	+	0.215^{**}		0.215
		(0.096)		(0.160)
$VRA\_90Fill_{jt} \times \Delta X_{ijt}$	+		0.150^{*}	
			(0.078)	
$ADDuty_{jt} \times \Delta X_{ijt}$	+	0.008^{**}	0.006^{**}	0.008
		(0.003)	(0.003)	(0.008)
$CVDuty_{jt} \times \Delta X_{ijt}$	0	0.001	0.002	-0.008
		(0.001)	(0.001)	(0.009)
$Safeguard_{jt} \times \Delta X_{ijt}$	0	-0.005	-0.004	-0.005
		(0.005)	(0.005)	(0.009)
Other Controls				
$IM_{jt} \times \Delta X_{ijt}$	-	-0.000	-0.000	0.000
		(0.001)	(0.001)	(0.001)
$GR_{jt} \times \Delta X_{ijt}$	+	-0.015^{***}	-0.013^{***}	-0.021^{***}
		(0.002)	(0.003)	(0.009)
Minimill Interactions		No	No	Yes
Processor Interactions		No	No	Yes
R^2		0.91	0.91	0.91
F-Test (or Chi-Squared)		2781.04^{***}	2700.51^{***}	421.93^{***}
Observations		3669	3669	3669

Notes: All regressions include plant-specific fixed effects. Standard errors are in parentheses and ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively.

Table 4: Trade Policy Effects on Market Power: Variation in Integrated, Minimill and Processor Effects

Variable	Integrated	Minimills	Processors
Roeger Specification			
$Tariff_{jt}$	**-0.002**	**-0.001**	**0.001**
	(0.875)	(0.968)	(0.925)
VRA_{jt}	**0.215**	**0.417*****	**0.079**
	(0.179)	(0.004)	(0.309)
$ADDuty_{jt}$	**0.008**	**0.010***	**0.007**
	(0.316)	(0.098)	(0.354)
$CVDuty_{jt}$	**-0.008**	**0.004**	**-0.003**
	(0.384)	(0.337)	(0.976)
$Safeguard_{jt}$	**-0.005**	**0.006**	**-0.005**
	(0.591)	(0.479)	(0.362)
PCM Specification			
$Tariff_{jt}$	**0.005**	**0.009****	**0.003**
	(0.231)	(0.022)	(0.380)
VRA_{jt}	**0.055*****	**0.059*****	**0.020***
	(0.001)	(0.000)	(0.063)
$ADDuty_{jt}$	**-0.000**	**0.000**	**0.002**
	(0.989)	(0.814)	(0.166)
$CVDuty_{jt}$	**-0.002**	**0.000**	**-0.021**
	(0.518)	(0.860)	(0.263)
$Safeguard_{jt}$	**-0.004****	**-0.003**	**0.001**
	(0.048)	(0.422)	(0.458)

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

Table 5: Price-Cost Margin (PCM) Estimation of the Effects of Various Trade Policies on Steel Plant Markups.

	Predicted Sign	OLS Base Model	OLS 90% Binding VRAs	OLS - With Processor and Minimill Interactions
Trade Policy Effects				
$Tariff_{jt}$	0	0.004^{*}	0.005^{*}	0.005
		(0.002)	(0.002)	(0.004)
VRA_{jt}	+	0.040^{***}		0.055^{***}
		(0.013)		(0.023)
VRA_90Fill_{jt}	+		0.042^{***}	
			(0.013)	
$ADDuty_{jt}$	+	0.001	0.001	-0.000
		(0.001)	(0.001)	(0.001)
$CVDuty_{jt}$	0	-0.001	-0.001	-0.002
		(0.002)	(0.002)	(0.002)
$Safeguard_{jt}$	0	-0.001	-0.001	-0.004^{**}
		(0.001)	(0.001)	(0.001)
Other Controls				
$CapInt_{ijt}$		-0.038^{***}	-0.038^{***}	-0.007
		(0.011)	(0.012)	(0.021)
IM_{jt}	-	-0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
GR_{jt}	+	-0.001	-0.001	-0.001
		(0.001)	(0.001)	(0.001)
Minimill Interactions		No	No	Yes
Processor Interactions		No	No	Yes
R^2		0.64	0.64	0.64
F-Test (or Chi-Squared Statistic)		3.98	3.33	3.58
(p-value)		(0.007)	(0.016)	(0.000)
Observations		6142	6142	6142

Notes: All regressions include plant-specific fixed effects. Standard errors are in parentheses and ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively.