How Large Are Double Markups?

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Because prices exceed marginal costs in many upstream and downstream industries, downstream prices often reflect a double markup. This paper is the first to estimate the size of double markups across many industries taking account of direct and indirect upstream markups. The double markups in many U.S. manufacturing industries are large both because of large upstream and downstream markups and increasing returns to scale. (*JEL* D22, D24, D43, D57, L13, L60)

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If upstream and downstream industries set their prices above their marginal costs, downstream prices reflect a double markup. An upstream industry with market power affects the price of a downstream industry that it supplies directly or indirectly by supplying other industries that provide inputs to the downstream industry. This paper is the first to systematically estimate the size of double markups across many industries taking account of these direct and indirect effects. It compares estimates of the double markup based on two methods of estimating market power. It also demonstrates that the estimated double markups are magnified by increasing returns to scale.

Our analysis uses a multimarket (incomplete general equilibrium) model for two-digit manufacturing industries and for the mining and utility industries, which supply downstream manufacturing industries. Unfortunately, we cannot calculate the complete general equilibrium effects because we lack the data needed to estimate markups in all industries and a complete demand system across all goods.

A plethora of theoretical articles, dating from the 1950s, discuss the implications of double markups (see the summaries of the literature in Perry 1989, Carlton and Perloff 2005, and Riordan 2008). Some of these papers discuss how vertical integration may eliminate the double markup (Spengler 1950, Warren-Boulton 1974, and Riordan 2008).

However, no empirical studies have systematically estimated how important double markups are across industries, and few articles pay explicit attention to the role of returns to scale. Empirical articles typically focus on the marketing channel for a single downstream industry, typically between an industry's manufacturers (or wholesalers) and retailers. For example, Bresnahan and Reiss (1985) looked at the relationship between an automobile manufacturer and its dealers. Kadiyali, Chintagunta and Vilcassim (2000) estimated the shares of retailer and manufacturer profits. Chintagunta, Bonfrer, and Song (2002) investigated how the introduction of a private label by one retailer affects the relative market power of the retailer and the manufacturers. J. Miguel Villas-Boas and Zhao (2005) examined the ketchup market in a single city. Sofia Berto Villas-Boas (2007) examined double marginalization between wholesalers and retailers in yogurt supply chains. Gayle (2013) examined double marginalization when unaffiliated airlines independently determine the prices for various segments of a trip. Crawford et al. (2018) studied the welfare effects of vertical integration in multichannel television markets, where one potential effect is the elimination of a double markup.

Baqaee and Farhi (forthcoming) addressed the role of market power on productivity and misallocation across supply chains in many industries. However, they do not explicitly estimate double markups. Our paper differs from theirs because we calculate the price effects from eliminating double markups. Also, we use estimated returns to scale, which are increasing; whereas, they assumed non-increasing returns to scale.

In the first section, we briefly discuss supply chains in manufacturing. In the next section, we develop the theory needed to calculate double markups in the presences of returns to scale. The third section covers the literature on estimating market power and returns to scale, two methods to estimate market power, the data, and our markup and production function estimates. Section 4 presents our results on the price and consumer surplus effects from eliminating double markups and all markups. Section 5 concludes.

1. Supply Chains in Manufacturing

We want to measure how upstream markups affect downstream prices in manufacturing industries. To do so, we investigate the channels by which inputs flow from mining, utilities, and upstream manufacturing industries into downstream manufacturing industries.

To examine how upstream markups affect downstream prices in manufacturing industries, we need to know each downstream industry’s share of upstream manufacturing, mining, and utilities inputs. We calculate input flows using data from the 2000 Bureau of Economic Analysis (BEA) input-output tables and BEA and Bureau of Labor Statistics (BLS) total cost information.

We examine only flows between industries that exceed 6% of total cost. Smaller flows are, of course, of relatively little importance. This restriction simplifies our analysis greatly. Were we to examine smaller flows, we would see many pairs of industries that supply each other. However, all these major flows go in only one direction: If Industry 1 supplies Industry 2, Industry 2 does not also supply Industry 1.

As a result of this restriction, we have two non-overlapping vertical supply chains. One supply chain "starts" with the mining industry, while the other "starts" with the chemical industry.

Figure 1 shows the vertical supply chain that start with mining (though the computer and electronics industry in this figure is not linked to mining). The percentages on the directional arrows are the value of the upstream input divided by the downstream industry's total cost. For example, mining's input is 78.08% of petroleum and coal's total cost.

The figure illustrates how an upstream industry may supply a downstream industry directly or indirectly. For example, inputs from the mining industry flow directly into the primary metal industry. In addition, mining supplies utilities, which in turn supplies primary metal. Thus, mining provides inputs to primary metal directly and indirectly through utilities.

Figure 2 shows the vertical supply chain that starts with chemicals (though wood is not linked to chemicals). We use the relationships and input shares that Figures 1 and 2 show to calculate the direct and indirect effects of upstream markups on downstream prices.

2. Theory

Although the theory behind the double markup is well-known, the role of returns to scale and the downstream price effects with complicated supply chains have rarely been discussed. In this section, we start by illustrating the role of returns to scale in determining a double markup with a downstream monopoly that buys its only input from a single upstream industry. Next, we describe the effects on the price of a downstream monopoly that buys from many upstream monopolies along a complex supply chain. Throughout, we assume that industries face constant elasticity demand functions, have Cobb-Douglas production functions, and are monopolies.[1]

A. One Upstream Industry

Suppose initially that a downstream monopoly buys its sole input from a competitive upstream industry. The downstream monopoly faces a constant elasticity demand function $X_d =$

[1] We assume industries are monopolized both because doing so greatly simplifies our analysis and because this assumption underlies the Diewert and Fox (2008) method of estimating market power, which is one of the two approaches we use.

p_d^{ε} (or $p_d = X_d^{1/\varepsilon}$), where ε is the constant elasticity of demand, p_d is the price of the output X_d, and the subscript d indicates "downstream." Its cost function is $C(X_d)$.

The monopoly chooses X_d to maximize its profit,

$$\pi_d = p_d X_d - C(X_d) = X_d^{1+\frac{1}{\varepsilon}} - C(X_d).$$

Its first-order condition is

$$\left(1 + \frac{1}{\varepsilon}\right) p_d - \frac{\partial C}{\partial X_d} = 0.$$

Thus, the markup, M, of price over marginal cost, $MC = \partial C/\partial X_d$, is $M = p_d/MC = 1/(1 + 1/\varepsilon)$. The markup depends solely on the constant elasticity of demand.

Now, suppose the downstream monopoly buys its input from an upstream monopoly with nonconstant returns to scale. The upstream monopoly uses a single input X, which it purchases at price m. It produces its output X_u using the production process is $X_u = X^{a_u}$, where a_u is the returns to scale, and the subscript u indicates the upstream industry. The production process exhibits increasing returns to scale if $a_u > 1$, constant returns to scale if $a_u = 1$, and decreasing returns to scale if $a_u < 1$.

The upstream monopoly sells X_u to the downstream monopoly at a price of p_u. The downstream monopoly uses X_u as its sole input to produce its output X_d. Its production function is $X_d = X_u^{a_d}$, where a_d is the returns to scale.

The downstream firm's objective is to maximize its profit through its choice of X_d:

$$\max_{X_d} \pi_d = p_d X_d - p_u X_u = X_d^{1+\frac{1}{\varepsilon}} - p_u X_d^{\frac{1}{a_d}}. \tag{1}$$

Its first-order condition is

$$\left(1 + \frac{1}{\varepsilon}\right) X_d^{\frac{1}{\varepsilon}} - \frac{p_u}{a_d} X_d^{\frac{1}{a_d} - 1} = 0. \tag{2}$$

We can rewrite Equation 2 as

$$X_d^{\frac{1}{M} - \frac{1}{a_d}} = \frac{M}{a_d} p_u, \tag{3}$$

where, again, $M = 1/(1 + 1/\varepsilon)$ is the downstream monopoly's markup of price over marginal cost.

Because $X_d = X_u^{a_d}$, $X_d^{\frac{1}{M} - \frac{1}{a_d}} = \left(X_u^{a_d}\right)^{\frac{1}{M} - \frac{1}{a_d}} = X_u^{\frac{a_d}{M} - 1}$. Substituting this expression into Equation 3 and rearranging terms, we obtain the upstream monopoly's inverse demand function,

$$p_u = \frac{a_d}{M} X_u^{\frac{a_d}{M} - 1}. \tag{4}$$

Using Equation 4, the upstream monopoly's profit-maximizing objective is

$$\max_{X_d} \ \pi_u = p_u X_u - mX = \frac{a_d}{M} X_u^{\frac{a_d}{M}} - mX_u^{\frac{1}{a_u}}. \tag{5}$$

Its first-order condition is

$$\left(\frac{a_d}{M}\right)^2 X_u^{\frac{a_d}{M}-1} - \frac{m}{a_u} X_u^{\frac{1}{a_u}-1} = 0. \tag{6}$$

Substituting Equation 4 into Equation 6, and rearranging terms, we learn that its profit-maximizing price is

$$p_u = \frac{Mm}{a_d a_u} X_u^{\frac{1}{a_u}-1}. \tag{7}$$

Using Equation 4, the downstream demand function, and some algebra, we obtain the downstream price equation[2]

$$p_d = \left[\frac{M^2 m}{a_d^2 a_u}\right]^{\frac{M a_d a_u}{\varepsilon(a_d a_u - M)}}. \tag{8}$$

Thus, the downstream price depends on the upstream firm's input price, *m*, the returns to scale parameters, a_d and a_u, and the demand elasticity, ε (because *M* depends solely on ε).

With constant returns to scale both downstream and upstream, a_d = a_u = 1, the downstream markup, Equation 8, simplifies to

$$p_d = M^2 m. \tag{9}$$

Both the upstream and downstream demand functions have the same constant elasticity of demand, ε, so they both have the same markup, *M*, over marginal cost.[3] Thus, with constant returns to scale, the downstream markup, M^2, is the classic double markup. With nonconstant returns to scale, the double markup is implicit in the relatively ugly expression in Equation 8.

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[2] Substituting Equation 7 into Equation 3, we obtain $X_d^{1/M - 1/a_d} = [M^2 m/(a_d^2 a_u)] X_u^{\frac{1}{a_u}-1}$. Because $X_u = X_d^{1/a_d}$, we can rewrite this expression as $X_d^{1/M - 1/(a_d a_u)} = M^2 m/(a_d^2 a_u)$. Using the downstream demand curve $X_d = p_d^{\varepsilon}$ and some algebra, we obtain Equation 8.

[3] If a_d =1, then $X_u = X_d$, so Equation 4.2 implies that $X_d^{1/\varepsilon} = p_u/(1 + 1/\varepsilon) = Mp_u$. With constant returns to scale downstream, a_u = 1, $p_u = X_d^{1/\varepsilon}/M$, so the inverse demand elasticity, 1/ε, is the same upstream and downstream. As a result, the upstream markup is also *M*.

B. Many Upstream Industries

Our goal is to determine how much upstream markups affect downstream prices across many industries, each of which is assumed to be a monopoly. To do so, we need to generalize our one upstream and one downstream firm model in two ways. First, the downstream industry now uses inputs from several upstream industries. Second, some of the upstream suppliers may buy inputs from industries further upstream.

Our generalized model differs from our initial two monopolies example in one other key way. In the simpler model, we were able to fully analyze the double markup because, with a single input, we could derive the upstream demand function explicitly from the downstream demand function. In our more general model, we cannot derive the upstream demand functions as useful expressions.

To conduct a full general equilibrium analysis, we would need a complete set of cross-elasticities of demand, which is not available. Here, we calculate the effect on downstream prices of reducing upstream prices, ignoring any possible downstream substitutions that would affect the upstream demand function.

In our general model, a downstream monopoly in Industry d produces a single output X_d, which it sells at price p_d. The monopoly uses inputs, $\mathbf{X} = (X_1, X_2, \ldots, X_U)$, generated by U upstream industries. The corresponding input prices are $\mathbf{p} = (p_1, p_2, \ldots, p_U)$. Each downstream monopoly has a Cobb-Douglas production function, $X_d = \prod_{u=1}^{U} X_u^{a_{du}}$, where u indexes each of the U upstream industries.

As before, the downstream monopoly faces a constant elasticity of demand function, $X_d = p_d^{\varepsilon_d}$, so its profit-maximizing markup is $M_d = 1/(1 + 1/\varepsilon_d)$. The downstream firm's objective is to maximize its profit:

$$\max_{\boldsymbol{X}} \pi_d = p_d X_d - \mathbf{pX} = \left[\prod_{u=1}^{U} X_u^{a_{du}}\right]^{1+\frac{1}{\varepsilon_d}} - \mathbf{pX}. \tag{10}$$

Its U first-order conditions are

$$a_{du}\left(1 + \frac{1}{\varepsilon_d}\right) X_u^{a_{du}\left(1+\frac{1}{\varepsilon_d}\right)-1} \prod_{j=1, j\neq u}^{U} X_j^{a_{dj}\left(1+\frac{1}{\varepsilon_d}\right)} - p_u = 0, \tag{11}$$

where $u = 1, \ldots, U$. Rearranging Equations 11, we can express X_u in terms of the input prices:

$$X_u = \left[{M_d}^{M_d} \left[\frac{p_u}{a_{du}}\right]^{M_d - \sum_{j=1, j\neq u}^{U} a_{dj}} \prod_{j=1, j\neq u}^{U} \left[\frac{p_j}{a_{dj}}\right]^{a_{dj}} \right]^{\frac{1}{\sum_{u=1}^{U} a_{du} - M_d}}. \tag{12}$$

Substituting for X_u from Equation (12) in the Cobb-Douglas production function, we find that the downstream quantity is

$$X_d = \left[M_d^{a_d} \prod_{u=1}^{U} \left[\frac{p_u}{a_u}\right]^{a_{du}} \right]^{\phi_d}. \tag{13}$$

Consequently, the downstream price is a function of the upstream input prices, the returns to scale parameters, and the elasticity of demand:

$$p_d = \left[M_d^{a_d} \prod_{u=1}^{U} \left[\frac{p_u}{a_u}\right]^{a_{du}} \right]^{\frac{\phi_d}{\varepsilon_d}}. \tag{14}$$

where $a_d = \sum_{u=1}^{U} a_{du}$ is the downstream industry's returns to scale and $\phi_d = M_d/(a_d - M_d)$. With constant returns to scale, $a_d = 1$ and $\phi_d/\varepsilon_d = 1$.

C. Effects of Eliminating Double Markups

To calculate the effect of eliminating double markups, we determine how the downstream price would change if all upstream markups were eliminated—that is, setting M_u equal to one in all relevant industries. To make such a calculation, we not only have to eliminate all upstream markups, but we also need to take into account that some upstream suppliers buy inputs from other industries even further upstream.

To illustrate the issues that arise, consider the supply chain in Figure 3. Each downstream industry d is supplied by a different set of upstream industries. Each industry may be upstream of some industries and downstream of others. In Figure 3, Industry 2 is a downstream industry for Industry 1 and an upstream industry for Industries 3 and 4. (This example corresponds to the actual relationship in Figure 1, where mining is Industry 1, utilities is Industry 2, primary metals is Industry 3, and fabricated metal is Industry 4.)

In Figure 3, Industry 3 buys directly from Industries 1 and 2. However, Industry 1 also supplies Industry 2, which directly supplies Industry 3. Thus, Industry 1 has both a direct and an indirect effect on Industry 3. Given that input flows go in only one direction, we can calculate such indirect effects, which we refer to as second and higher-order effects.

First, suppose that we eliminate market power in a single upstream industry that *directly* supplies an input to a downstream industry. For example, consider the effect of eliminating the markup in Industry 2, M_2, on the downstream price in Industry 3, p_3.

Before eliminating the markup, the price of Industry 2's output, X_2, is $p_2 = M_2 m_2$, where m_2, is the marginal cost of X_2. Using Equation 13, the price of the downstream monopoly in Industry 3 is

$$p_3 = \left[M_3^{a_3}\left[\frac{p_1}{a_{31}}\right]^{a_{31}}\left[\frac{M_2 m_2}{a_{32}}\right]^{a_{32}}\right]^{\frac{\phi_3}{\varepsilon_3}}. \tag{15}$$

where $\phi_3 = M_3/(a_3 - M_3)$. If we eliminate the upstream markup in Industry 2 by setting M_2 equal to one, the downstream price becomes

$$p_3^* = \left[M_3^{a_3}\left[\frac{p_1}{a_{31}}\right]^{a_{31}}\left[\frac{m_2}{a_{32}}\right]^{a_{32}}\right]^{\frac{\phi_3}{\varepsilon_3}}. \tag{16}$$

Thus, the percentage changes of the downstream price from eliminating market power in Industry 2 is

$$\frac{p_3^* - p_3}{p_3} = \left[M_2^{-a_{32}}\right]^{\frac{\phi_3}{\varepsilon_3}} - 1. \tag{17}$$

With constant returns to scale, $(p_3^* - p_3)/p_3 = \left[M_2^{-a_{32}}\right] - 1$.

More generally, suppose that we eliminate market power in all the upstream industries, u, that *directly* supply inputs to the downstream Industry d. Before eliminating the market power, the price of the output in each upstream industry u is $p_u = M_u m_u$. If we eliminate all these markups, setting $M_u = 1$ for all u, the change in the downstream price is

$$\frac{p_d^* - p_d}{p_d} = \left[\prod_{u=1}^{U} M_u^{-a_{du}}\right]^{\frac{\phi_d}{\varepsilon_d}} - 1. \tag{18}$$

Equation 18 shows only the direct effect of reducing all upstream markups. For example, eliminating the markup in Industry 1 in Figure 3 has both direct and indirect effects on price p_3 in downstream Industry 3. The change in the downstream price is

$$\frac{p_3^* - p_3}{p_3} = \left[M_1^{-\left(a_{31} + a_{32} a_{21}\frac{\phi_2}{\varepsilon_2}\right)}\right]^{\frac{\phi_3}{\varepsilon_3}} - 1, \tag{19}$$

where p_3^* is the price of X_3 when the markup in Industry 1 equals one.

Equation 19 shows that the effect of eliminating the markup in Industry 1 on the price p_3 depends on the exponent of the term in brackets, ϕ_3/ε_3, which in turn depends solely on the downstream markup, M_3; returns to scale, a_3; and demand elasticity, ε_3. The exponent on the M_1 term reflects the direct and indirect effects of eliminating the markup in Industry 1. The direct effect stems from the direct flow between Industry 1 and Industry 3, which is captured by a_{31}. Eliminating the markup in Industry 1 reduces price p_3 indirectly through reducing the price p_2. This indirect effect depends on the flow between Industry 2 and Industry 3, which is captured by a_{32}, on the flow between Industry 1 and Industry 2, which is captured by a_{21}, and the price effect on p_2, which depends ϕ_2/ε_2, which in turn depend on only M_2, a_2, and ε_2.

Similarly, we can calculate higher-order effects for longer channels. For instance, the effect of setting all upstream markups equal to one on the downstream price p_4 is

$$\frac{p_4^* - p_4}{p_4} = \left[M_1^{-(a_{43}a_{31}\frac{\phi_3}{\varepsilon_3} + a_{43}a_{32}a_{21}\frac{\phi_2\phi_3}{\varepsilon_2\,\varepsilon_3})} M_2^{-a_{43}a_{32}\frac{\phi_3}{\varepsilon_3}} M_3^{-a_{43}} \right]^{\frac{\phi_4}{\varepsilon_4}} - 1. \tag{20}$$

where p_4^* is the price of X_4 when all upstream markups are set equal to one ($M_1 = M_2 = M_3 = 1$).

In general, the change in the downstream price p_d from eliminating all upstream markups is

$$\frac{p_d^* - p_d}{p_d} = \left[\prod_{u=1}^{U} M_u^{-(\alpha_{du} + \sum \alpha_{dh}\alpha_{hu}\frac{\phi_h}{\varepsilon_h} + \sum \alpha_{di}\alpha_{ih}\alpha_{hu}\frac{\phi_i\phi_h}{\varepsilon_i\,\varepsilon_h} + \cdots)} \right]^{\frac{\phi_d}{\varepsilon_d}} - 1, \tag{21}$$

where h and i are intermediate industries.

D. Consumer Surplus

Because the upstream markups increase the downstream price, they decrease downstream consumer surplus (and welfare more generally). We calculate this effect for each downstream industry.

Let the original downstream equilibrium be (X, p). If we eliminate all upstream (and possibly the downstream) markups, the new downstream equilibrium is (X^*, p^*). The change in consumer surplus in the downstream industry is

$$\int_{p^*}^{p} p^{\varepsilon}\, dp = \frac{p^{\varepsilon+1}}{\varepsilon+1}\Big|_{p^*}^{p} = \frac{p^{\varepsilon+1} - p^{*\varepsilon+1}}{\varepsilon+1} = \frac{pX - p^*X^*}{\varepsilon+1}, \tag{22}$$

because $p^{\varepsilon+1} = pX$. We can rewrite this change in consumer surplus as

$$\int_{p^*}^{p} p^{\varepsilon}\, dp = \frac{pX}{\varepsilon+1}\left(-\left(\frac{p^*-p}{p}\right)-\left(\frac{X^*-X}{X}\right)-\left(\frac{p^*-p}{p}\right)\left(\frac{X^*-X}{X}\right)\right). \tag{23}$$

Given that we have $\left(\frac{p^*-p}{p}\right)$ from Equation 21 and that the demand function is $X = p^{\varepsilon}$, then we can calculate

$$\left(\frac{X^*-X}{X}\right) = \left[\left(\frac{p^*-p}{p}\right)+1\right]^{\varepsilon} - 1. \tag{24}$$

Thus, we can use Equations 21, 23 and 24, revenue (*pX*) from our data set, and our estimates of ε_d to calculate the change in consumer surplus.

3. Estimation

To determine the size of double markups, we use (1) input flows between industries based on input-output and cost data; (2) estimates of markups and returns to scale in two-digit manufacturing industries and two other major industries that supply them; and (3) estimates of the Cobb-Douglas production functions.

We have already discussed the input flows. We start this section by discussing various methods of estimating market power and returns to scale, data and period issues, and our estimates. Then we discuss the production function estimates.

A. Methods for Estimating Market Power and Returns to Scale

The size of double markups depends critically on the estimates of markups and returns to scale at each stage of the supply chain. As the estimates from the literature vary, we consider several methods.

Many articles estimate industry markups. In his classic paper, Harberger (1954) calculated market power using the limited aggregate data on profits available at the time. He concluded that the U.S. economy had virtually no market power distortions: “Nothing to see here. Move along folks.”

More recent, new empirical industrial organization (NEIO) papers used advances in theory, econometrics, and computing power as well as better data sets to estimate the degree of market power using sophisticated reduced-form and structural models (see the survey in Perloff, Karp, and Golan, 2007). Many of these papers found substantial market power.

Until the last few years, these NEIO studies focused on a single industry. However, a number of recent papers systematic test for or estimate market power across industries, such as Hall (1988), Roeger (1995), Diewert and Fox (2008), De Loecker and Warzynski (2012), De Loecker et al. (2016), De Loecker, Eeckhout, and Unger (2020), and Hall (2018). See Basu (2019) for a review and comparison of several recent methods.

To study the importance of double markups and returns to scale, we need estimates of industry markups and returns to scale for all relevant industries. Although the various papers De Loecker wrote with colleagues are excellent, they used firm-level data or non-U.S. data, so that they do not provide industry-level estimates for U.S. manufacturing. Thus, we focus on the Diewert and Fox (2008) and Hall (2018) methods to obtain our estimates using U.S. industry-level data.[4]

Diewert and Fox (2008) estimated markups and returns to scale. They assumed that each industry functions as a monopoly. They used a nonconstant returns to scale translog cost function with neutral technical change, decomposing productivity growth into contributions from returns to scale and to technological progress. Treating input prices as given, they estimated their model using ordinary least squares. They argued that likely productivity shocks show up primarily in output variables, most likely instruments are not completely exogenous, and these instruments are weakly correlated with some inputs for some industries.

Hall (2018) estimated markups by determining marginal costs as the ratio of the observed change in cost to the observed change in output. He did not explicitly assume constant returns to scale. However, he did so implicitly when he uses the Solow residual based on BLS data, which imposes constant returns to scale to derive its cost of capital.[5] He estimated his model using five instruments: military purchases of equipment, military purchases of ships, military purchases of software, military expenditures on R&D, and the oil price.

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[4] The older Hall (1988) paper and Roeger (1995) are possible alternative. Hall (1988) is a seminal article on the estimation of markups across industries. Roeger (1995) and others built upon Hall's original approach to estimate markups. As Hall prefers his more recent approach, we follow his lead. Roeger's paper produces market power estimates that are of comparable size to Diewert and Fox and Hall's more recent papers, though the time periods differ.

[5] Hall argues that his estimates are not biased in the presences of increasing returns to scale. Thus, although we henceforth say that Hall assumes constant returns to scale, it might be more accurate to describe him as being agnostic about the returns to scale.

B. Data

We want to compare the double markups implied by estimates of the Diewert-Fox and Hall models. To make this comparison clear, we use a single data set to estimate both models.

Diewert and Fox (2008) used data for the two-digit manufacturing industries. Hall (2018) examined most one-digit industries, including mining, utilities, and manufacturing among others. Because we think looking at supply chains at the two-digit level makes more sense than at the one-digit level, we concentrate on two-digit manufacturing industries plus mining and utilities, which supply those industry. (We ignore agriculture because it is competitive.)

The primary data set in both Diewert-Fox and Hall is the U.S. Bureau of Labor Statistics (BLS) industry-level output and input quantity Törnqvist indexes for output and inputs. The BLS provides information about capital, labor, and intermediate input costs. However, the BLS calculates the cost of capital by assuming that costs equal revenue, which implies constant returns to scale. Because they want to estimate returns to scale, Diewert and Fox used the U.S Bureau of Economic Analysis (BEA) cost of capital information (Table 3.45, Current Cost Depreciation of Private Structures by Industry). The BLS does not provide industry-level output and input quantity Törnqvist indexes for mining and utilities, so we used BEA data to calculate the Törnqvist indexes for these two industries.

C. Period of Study and Instruments

To make the Diewert-Fox and Hall estimates comparable, we estimate both models for the same period. We also have to decide on whether to estimate the models using instruments or not.

Diewert and Fox (2008) used 1949–2000 data; whereas, Hall (2018) used 1987–2015 data. Several studies including De Loecker, Eeckhout, and Unger (2020) and Hall (2018) argued that markups have been increasing over time and provided various explanations. An examination of both BLS and BEA data between 1949 and 2016 indicates a clear structural shift starting around 2000. Figure A1 in the Appendix shows that a pronounced plunge in input and output indexes occurred in many industries at that time. Given this major change in trends, the larger variability, and the limited number of years in the post-2000 period, we use the Diewert and Fox period, 1949–2000, to estimate both models.[6]

Diewert and Fox, after arguing against using instruments, estimated their model employing ordinary least squares (OLS). Although Hall (2018) used instruments for a later period, we estimate his model for this earlier period using OLS for three reasons. First, not all of his instruments are available for some of the earlier years. Second, several of the remaining instruments are weak for at least some industries (see Duran-Micco 2019). Third, these instruments may not be exogenous to all macroeconomic fluctuations (see Hall 1988 and Roeger 1995).

How do these decisions about the time period and instruments affect our estimates? Duran-Micco (2019) estimated the Diewert and Fox (2008) and Hall (2018) models for several periods, with and without instruments.[7] She found that the returns to scale and markup estimates are sensitive to each of these choices. Using Hall's instruments that are available for the earlier period (oil price and military purchases of equipment, intellectual property products, and research and development) for both Diewert and Fox's and Hall's methods produces very imprecise estimates. Moreover, for several industries the point estimates of the markup are implausibly negative.

D. Estimated Markups and Return to Scale Estimates

We report OLS estimates for both models in Table 1. Although the table does not show hypothesis tests for Diewert and Fox's market power estimates, these estimates are a transformation of their returns to scale estimates, so the hypothesis tests corresponds to the returns to scale tests. In the table, the null hypothesis is that the coefficient equals one: either constant returns to scale or no market power.

The estimates for the Diewert and Fox method replicate their results for the manufacturing industries because we are using their time period and estimation method. Because

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[6] Because we use this earlier period, our industry definitions are based on the Standard Industrial Classification. More recently, the BLS switched to the North American Industry Classification System (NAICS), but it did not reclassify its older data using this system.
[7] She also found that the results using BLS and BEA data were qualitatively comparable, but the BEA estimates of market power were generally smaller than those using the BLS data.

Hall did not look at this earlier period and did not provide estimates for two-digit manufacturing industries, we cannot compare our results to his.

Despite having different underlying theories, Hall (2018) and Diewert and Fox (2008) estimated the same regression equation (see Duran-Micco, 2019). However, they interpret the parameters of the equation differently. Hall estimated the price markup conditional on assuming constant returns to scale. The Diewert and Fox estimates of returns to scale are the same as Hall's estimates of the price markup (as the first two columns of Table 1 show). Diewert and Fox then use the estimated returns to scale to determine the price markup. For example, Hall's estimated markup for mining is 1.320. Diewert and Fox's estimated returns to scale estimate is 1.320, and their estimated price markup is 1.601. The markup estimates are systematically smaller using Hall's method than Diewert and Fox's method.

Using either set of estimates, we cannot reject the hypothesis that the markup is one in the apparel, textile, utilities, and wood industries at the 5% level. Nonetheless, in the following analyses, we use the (nearly one) point estimates for these industries.

Given that the markup in a monopoly industry is $M = 1/(1 + 1/\varepsilon)$, we can use the estimated markups to infer the elasticities of demand: $\varepsilon = M/(1 - M)$. Thus, in our calculations of the double markups, the demand elasticities vary with the method we use to estimate the markups.

E. Estimated Cobb-Douglas Production Functions

We use a two-step procedure to estimate our Cobb Douglas production-function coefficients. For downstream Industry d, s_{du} is the share of total cost, $C(X_d)$ spent on input X_u:

$$s_{du} = \frac{p_u X_u}{C(X_d)}.$$

We calculate these input shares using BEA input-output and total costs data. By construction, these input shares sum to one: $\sum_u s_{du} = 1$.

With the Diewert and Fox approach, we use their estimates of the downstream industry's returns to scale a_d. With the Hall method, we assume constant returns to scale, $a_d = 1$. Using the values for s_{du} and a_d, we calculate the Cobb-Douglas production function parameters for the downstream industry as $a_{du} = a_d s_{du}$. Consequently,

$$a_d = \sum_u a_{du}.$$

4. Price and Consumer Surplus Effects from Eliminating Market Power

To measure the size of double markups, we calculate how eliminating market power upstream would lower downstream prices. First, we calculate the downstream price effects of eliminating market power in a single upstream market, by setting its markup equal to one. Second, we calculate the impact on downstream prices from eliminating all upstream markups. Third, we calculate the effects from eliminating all upstream and downstream markups on downstream prices. Finally, we calculate the consumer surplus effects.

F. The Price Effects from Eliminating One Upstream Markup

We start by calculating the downstream effects of eliminating one upstream markup. Figures 1 and 2 show that the mining and chemical industries are upstream from virtually all the other manufacturing industries. Thus, we start by calculating the downstream price effects of eliminating the markup in each of these industries.

Table 2 shows the price effects for all the industries that are downstream from mining. Table 3 shows these effects for industries that are downstream from the chemical industry.

To illustrate the role of both markups and returns to scale, we present calculations using approaches. The first column of each table uses Diewert-Fox markups and jointly estimated returns to scale, which we refer to as DF-IRS because all the estimated returns to scale exhibit increasing returns to scale (IRS). The second column uses the Diewert-Fox estimated markup, which were jointly estimated with nonconstant returns to scale, and then sets the returns to scale parameters equal one (constant returns to scale, CRS). We refer to this method as DF-CRS. The final column uses Hall's method, which implicitly assume CRS.

The mining markup is a moderate 1.32 using Hall's method and 1.60 using Diewert and Fox's method. By comparing the DF-IRS estimates to the DF-CRS or Hall calculation in Table 2, we see that double markups are substantially larger with increasing returns to scale than with constant returns to scale. For example, eliminating the markup in mining reduces the downstream price in primary metals by 4.16% using DF-CRS or 2.47% using Hall, but would reduce the downstream price by 20.48% accounting for increasing returns to scale using DF-IRS. The double markup is large in all downstream sectors given increasing returns to scale, and relatively large in petroleum and coal and utilities even with constant returns to scale.

Eliminating the mining markup has a very large price effect on petroleum and coal for two reasons. First, mining inputs are 78% of petroleum and coal total cost (see Figure 1). Second, petroleum and coal has a moderately large returns to scale, 1.344.

The chemical markup is large: 2.176 (Hall) or 2.692 (Diwert-Fox). Again, we see that eliminating this markup has much larger downstream price effects given increasing returns to scale in Table 3. The double markup is large in all markets given increasing returns to scale, and large in plastic and textiles even with constant returns to scale.

G. The Price Effects from Eliminating All Double Markups

We used Equation 21 to calculate the effects of eliminating double markups by eliminating all upstream markups, so that only downstream markups remain. Table 4 shows the percentage change in downstream prices from eliminating all upstream markups. The table does not include the chemical, computer and electronics, mining, or wood industries because they are not downstream from any of our other industries.

The DF-IRS method in the first column shows very large reductions in downstream prices from eliminating the double markups. The decrease in price is larger than 50% for three industries: plastic (73%), petroleum and coal (70%), and printing (63%).

The price reductions from eliminating double markups impacts are substantially lower given constant returns to scale (in the second and third columns). For instance, the price reduction in petroleum and coal with the DF-IRS method of 70% falls to 31% if we impose constant returns to scale (DF-CRS) or 19% using Hall's method. Indeed no double markup exceeds 31% with the DF-CRS method or 21% with Hall's. Using the Diewert-Fox markup estimates, imposing constant returns to scale cuts the double markup at least in half in all industries except textiles and utilities, and often cuts the double markup by much more, sometimes to nearly one-eighth.

With the Diewert and Fox approach, eliminating double markups would reduce downstream prices by between 10% and 73% across 13 industries, with prices falling by more than 25% in 10 industries and by more than 40% in 6 industries. With the Hall approach, downstream prices would fall by between 3% and 21%, with prices falling by more than 15% in 3 industries.

Because the Diewert-Fox estimated markups are larger than Hall's, both the DF-IRS and DF-CRS price reductions from eliminating the double markup exceed the Hall price reductions.

Printing is a good example of the role of the role of direct and indirect effects. The chemical industry supplies the paper industry, which in turn supplies the printing industry. Table 3 shows that eliminating market power only in the chemical industry reduces the price in paper by 44.82%, and in printing by 33.18% (DF-IRS). Table 4 shows that printing falls by 62.57% if we eliminate the markup in both the chemical industry and in the paper industry.

H. The Price Effects from Eliminating Upstream and Downstream Markups

Of course, the price effects is greater if all upstream and downstream markups are eliminated, as Table 5 shows.

Allowing for increasing returns to scale (DF-IRS in the first column), eliminating all markups would cause a price reduction of 50% or more in nine industries, compared to only three in Table 4, which shows the effects of eliminating only the double markup. Given constant returns to scale in the DF-CRS and Hall estimates, the price decreases are smaller, but still substantial. Only one industry (apparel) had its price drop by less than one-fifth with the DF-CRS estimates, and only three did with the Hall estimates.

What part of the total price reduction of eliminating market power is due to upstream effects only? Table 6 shows the percentage share of the total downstream price reduction that is due to eliminating only the upstream markup. This share is at least 50% for all industries except stone, clay & glass and utilities with the DF-IRS model. It is over 80% for four industries and is 92% for plastic. These shares are much higher for this method than for the other two methods, textiles and utilities aside. However, four industries have a share greater than 50% with both the DF-CRS and Hall approaches. Thus, according to any of these approaches, double markups are important in many industries.

I. Consumer Surplus Effects from Eliminating All Upstream Markups

Obviously, these price reductions from eliminating market power would have consumer surplus benefits. To illustrate the magnitude of the double markup on consumer surplus, we ask how much consumer surplus would rise if we reduced all upstream markups by 1%. Table 7 shows the resulting change in consumer surplus as a percentage of industry revenue in 2000. With constant returns to scale, the consumer surplus gain would be less than one percent in all downstream industries. However, with increasing returns to scale, the consumer surplus gain would significantly exceed 1% in fabricated metal, furniture, petroleum and coal, plastic, and transportation.

Conclusion

This study is the first to systematically estimate the price effects of double markups across two-digit manufacturing industries. Because the results are sensitive to the estimated markup in each industry, we compare the estimation methods of Diewert and Fox (2008) and Hall (2018).

The Diewert and Fox approach provides estimates of markups and returns to scale. The Hall markup estimates implicitly assume constant returns to scale. The Diewert and Fox markup estimates are larger than the Hall estimates, so our estimates of the double markup effects would be larger with the Diewert and Fox estimates for that reason alone. However, our estimates of the double markup are even larger with the Diewert and Fox approach because their method produces estimates of increasing returns to scale in all industry, which substantial increases our estimates of the double markup's effects. Eliminating upstream markups—that is, the double markups—would reduce downstream prices by between 10% and 73% across the 13 industries using the Diewert and Fox approach, but by only 3% to 21% with the Hall method.

Eliminating all markups including the downstream markups would have very large price effects with both approaches. The downstream prices fall by between 25% and 81% with the Diewert and Fox approach and between 9% and 53% with the Hall method.

Much of the total downstream markup is due to upstream markups; that is, double markups. Were we to eliminate all upstream and downstream markups, upstream markups would account for between 26% and 92% of the downstream price reduction using the Diewert-Fox method and between 7% and 91% using Hall's method.

The sizeable price decreases from eliminating market power would increase consumer surplus. Given increasing returns to scale, a 1% reduction in upstream markups would increase consumer surplus by much more than 1% in fabricated metal, furniture, petroleum and coal, plastic, and transportation.

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Appendix

Starting about 2000, Bureau of Labor Statistics (BLS) input and output indexes for many manufacturing industries exhibit pronounced changes in trends. The left column in Figure A1 shows the input index and the right column shows the corresponding output index for several industries (see Duran-Micco 2019 for figures for all manufacturing industries).

Traditionally, the BLS used the Standard Industrial Classification (SIC) to define industries. In 1997, a new classification, the North American Industry Classification System (NAICS) was introduced. The NAICS increased coverage of the service sector, relative to SIC, but it did have some effects on manufacturing industry definitions. In the figure, the blue dots reflect the BLS data for 1948–2000 based on the SIC. The red dots correspond to BLS data for 1987–2016 based on the NAICS.

Although part of the change may be due to the change in the classification definitions. Pierce and Schott (2016) and Baily and Bosworth (2014) attribute this change in trend to the granting of permanent normal trade relations to China in 2000. In addition, both output and input indexes cratered around 2007 in most industries due to the Great Recession.

Figure A1: BLS Input and Output Indexes for Various Manufacturing Industries

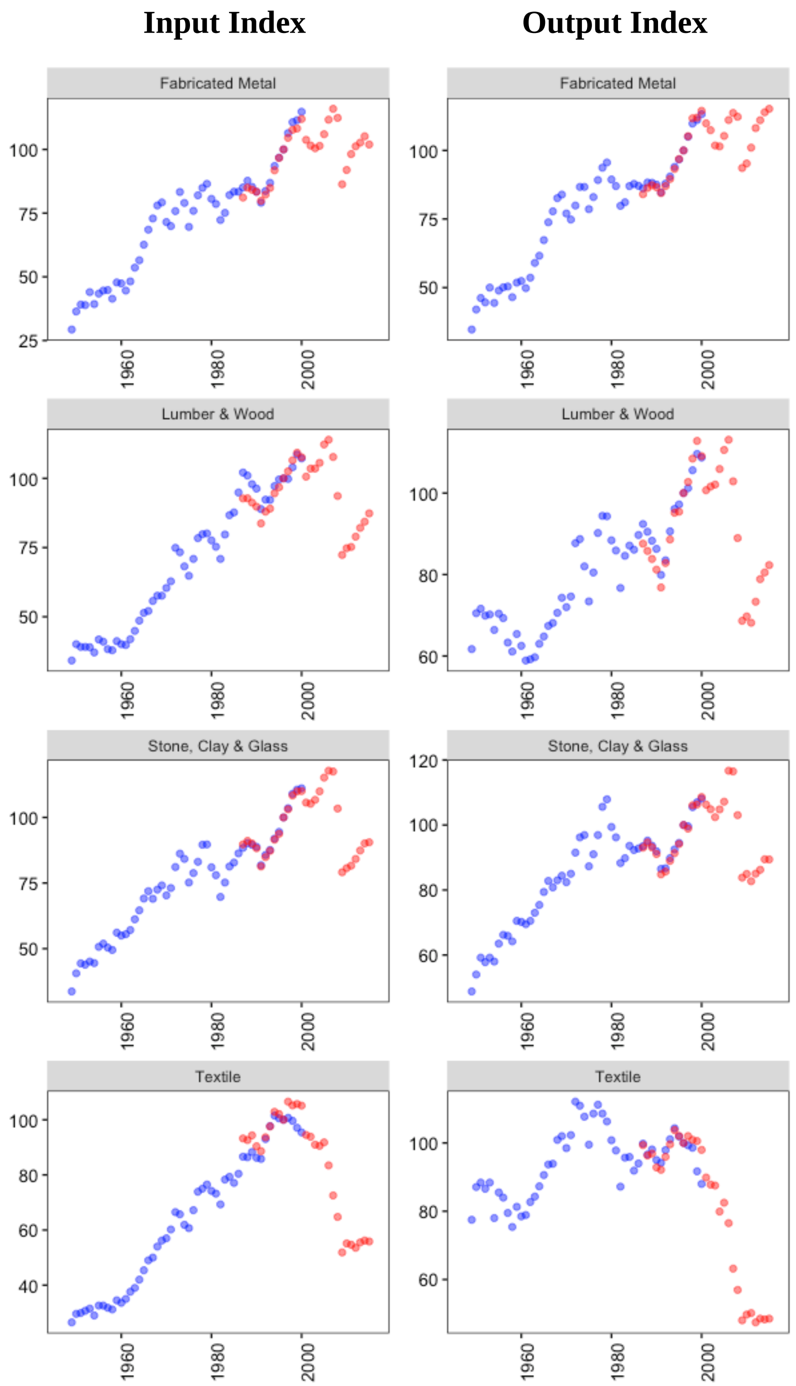

Figure 1

The Vertical Supply Chain that Starts with Mining

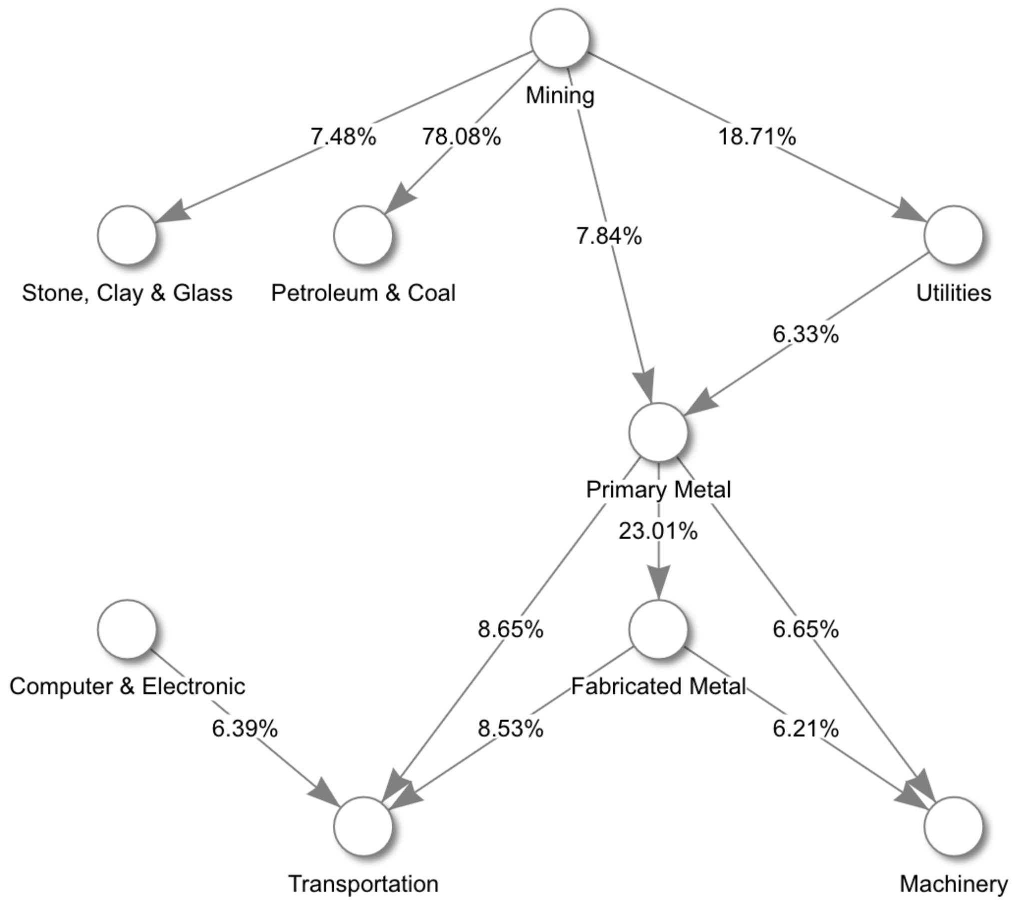

Figure 2

The Vertical Supply Chain that Starts with Chemicals

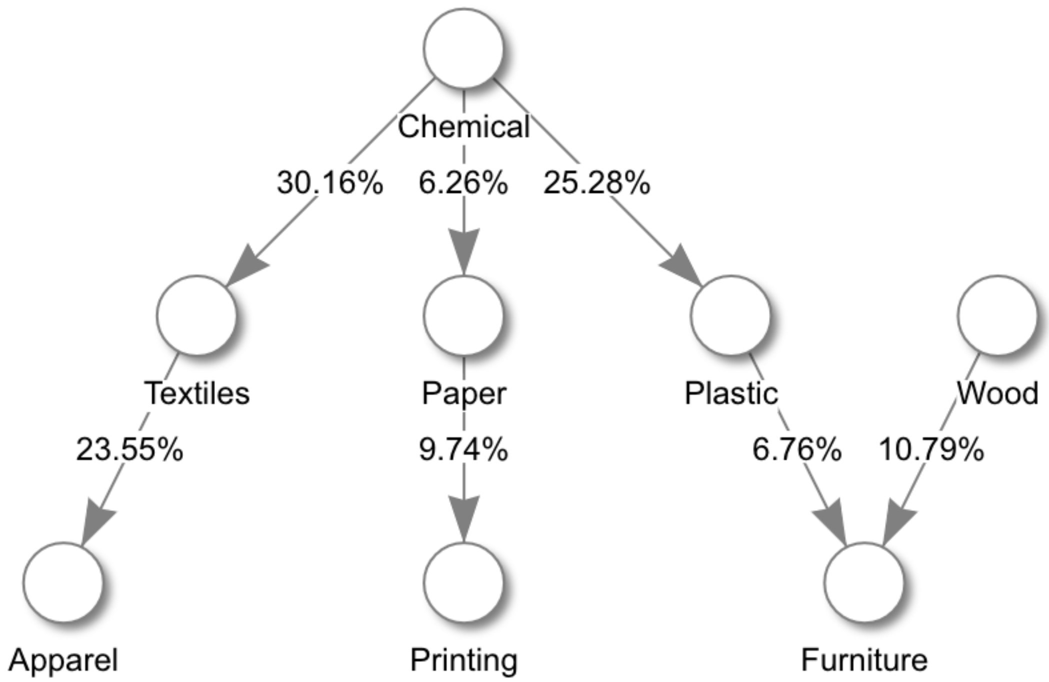

Figure 3

A Supply Chain Example

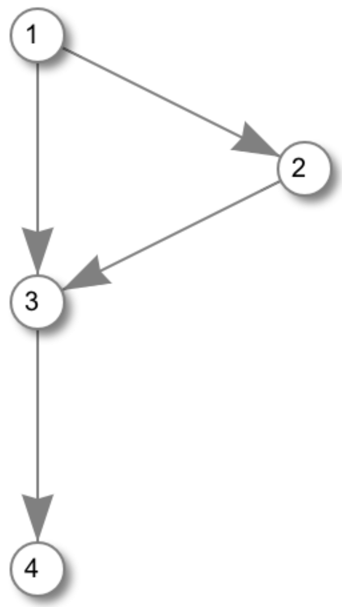

Table 1

Estimates of Price Markups and Returns to Scale

	Hall	Diewert and Fox	
	Markup	**Returns to Scale**	**Markup**
Apparel	1.038	1.038	1.100
Chemical	2.176***	2.176***	2.692
Computer & Electronic	1.389***	1.389***	1.593
Fabricated Metal	1.163***	1.163***	1.271
Furniture	1.213***	1.213***	1.288
Machinery	1.304***	1.304***	1.452
Mining	1.320***	1.320***	1.601
Paper	2.060***	2.060***	2.350
Petroleum & Coal	1.344***	1.344***	1.579
Plastic	1.258***	1.258***	1.339
Primary Metals	1.311***	1.311***	1.414
Printing	1.620***	1.620***	1.808
Stone, Clay & Glass	1.405***	1.405***	1.561
Textiles	1.028	1.028	1.103
Transportation	1.273***	1.273***	1.380
Utilities	1.051	1.051	1.460
Wood	1.153*	1.153*	1.330

Notes: Estimates using Hall (2018) and Diewert and Fox (2008) methods for 1949–2000.
*** Reject the null hypothesis that the coefficient equals one at the 1 percent level.
** Reject the null hypothesis at the 5 percent level.
* Reject the null hypothesis at the 10 percent level.
Although the table does not show hypothesis tests for Diewert and Fox's market power estimates, these estimates are a transformation of their returns to scale estimates, so the hypothesis tests corresponds to the returns to scale tests.

Table 2

The Percentage Change in Downstream Prices from Eliminating the Mining Markup

	Diewert-Fox		Hall
	Estimated returns to scale	CRS	CRS
Fabricated Metal	–14.26	–0.97	–0.57
Machinery	–9.40	–0.34	–0.20
Petroleum & Coal	–70.38	–30.75	–19.49
Primary Metals	–20.48	–4.16	–2.47
Stone, Clay & Glass	–16.29	–3.46	–2.06
Transportation	–13.84	–0.45	–0.27
Utilities	–9.89	–8.43	–5.06

Table 3

The Percentage Change in Downstream Prices from Eliminating the Chemical Markup

	Diewert-Fox		Hall
	Estimated returns to scale	CRS	CRS
Apparel	–15.32	–6.79	–5.37
Furniture	–33.97	–1.68	–1.32
Paper	–44.82	–6.01	–4.75
Plastic	–73.23	–22.15	–17.84
Printing	–33.18	–0.60	–0.47
Textiles	–34.40	–25.82	–20.90

Table 4

The Percentage Change in Downstream Prices from Eliminating all Upstream Markups

	Diewert-Fox		Hall
	Estimated returns to scale	CRS	CRS
Apparel	–18.53	–8.92	–5.99
Fabricated Metal	–37.58	–9.06	–6.65
Furniture	–47.81	–6.52	–4.32
Machinery	–27.37	–4.64	–3.29
Paper	–44.82	–6.01	–4.75
Petroleum & Coal	–70.38	–30.75	–19.49
Plastic	–73.23	–22.15	–17.84
Primary Metals	–29.91	–6.43	–2.78
Printing	–62.57	–8.54	–7.24
Stone, Clay & Glass	–16.29	–3.46	–2.06
Textiles	–34.40	–25.82	–20.90
Transportation	–46.09	–8.89	–6.34
Utilities	–9.86	–8.43	–5.06

Table 5

The Percentage Change in Downstream Prices from Eliminating all Upstream and Downstream Markups

	Diewert-Fox		Hall
	Estimated returns to scale	CRS	CRS
Apparel	–25.93	–17.20	–9.43
Computer & Electronics	–37.22	–37.23	–28.01
Fabricated Metal	–50.89	–28.45	–19.73
Furniture	–59.48	–27.42	–21.12
Machinery	–49.98	–34.33	–25.84
Paper	–76.52	–60.00	–53.76
Petroleum & Coal	–81.24	–56.14	–40.10
Plastic	–80.01	–41.86	–34.69
Primary Metals	–50.43	–33.82	–25.84
Printing	–79.29	–49.41	–42.74
Stone, Clay & Glass	–46.38	–38.15	–30.29
Textiles	–40.53	–32.75	–23.06
Transportation	–60.93	–33.98	–26.42
Utilities	–38.28	–37.28	–9.67
Wood	–24.81	–24.81	–13.27

Table 6

The Percentage Share of the Total Downstream Price Reduction Due to Eliminating the Double Markup

	Diewert-Fox		Hall
	Estimated returns to scale	CRS	CRS
Apparel	71	52	64
Fabricated Metal	74	32	34
Furniture	80	24	20
Machinery	55	14	13
Paper	59	10	9
Petroleum & Coal	87	55	49
Plastic	92	53	51
Primary Metals	59	19	11
Printing	79	17	17
Stone, Clay & Glass	35	9	7
Textiles	85	79	91
Transportation	76	26	24
Utilities	26	23	52

Table 7

The Change in Consumer Surplus from a One Percent Reduction of all Upstream Markups

(Percentage of Revenue in 2000)

	Diewert-Fox		Hall
	Estimated returns to scale	CRS	CRS
Apparel	0.58	0.31	0.32
Fabricated Metal	1.26	0.27	0.27
Furniture	1.27	0.19	0.19
Machinery	0.94	0.15	0.15
Paper	0.60	0.06	0.06
Petroleum & Coal	2.66	0.79	0.79
Plastic	1.36	0.26	0.26
Primary Metals	0.83	0.15	0.15
Printing	1.10	0.10	0.10
Stone, Clay & Glass	0.38	0.08	0.08
Textiles	0.44	0.31	0.32
Transportation	1.73	0.27	0.27
Utilities	0.22	0.19	0.19