Hicks-Marshall Conditions and Defining Antitrust Markets for Intermediate Goods
Economic and Legal Issues in Competition, Intellectual Property, Bankruptcy, and the Cost of Raising Children

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HICKS-MARSHALL CONDITIONS
AND DEFINING ANTITRUST
MARKETS FOR INTERMEDIATE
GOODS

James Langenfeld, Jonathan T. Tomlin,
David A. Weiskopf and Georgi Giozov

ABSTRACT

Purpose — To develop a framework for systematically defining the relevant market for intermediate goods that incorporates downstream market conditions.

Methodology/approach — We combine the well-established "Hicks-Marshall" conditions of derived demand for inputs with "critical loss/critical elasticity of demand" to yield insights into the definition of antitrust markets for intermediate goods and the competitive effects from a merger.

The opinions expressed are those of the authors, and do not necessarily represent the views of any institution.
Findings — We show that examining “Hicks-Marshall” conditions can provide a more rigorous framework for analyzing relevant markets for intermediate goods. We also show that solely examining demand substitution possibilities for direct customers of an input can lead to an incorrect market definition.

Research limitations/implications — Our framework may be difficult to apply in circumstances when several different downstream products use the input being examined and each of those downstream products has a different elasticity of demand.

Practical implications — We illustrate how reasonable ranges for key parameters relating to the ability of firms to substitute to other inputs and to adjust to downstream market conditions will often be sufficient to define antitrust markets for intermediate goods in practice.

Originality/value — Previous antitrust analysis has not systematically analyzed the impact of downstream market conditions in assessing market definition for intermediate goods. The framework we develop will be useful to future researchers attempting to define relevant markets for intermediate goods and evaluating the competitive effects of a merger.

Keywords: Market definition; intermediate goods; Hicks-Marshall; upward pricing pressure (UPP)

INTRODUCTION

Antitrust cases often concern mergers or allegedly anticompetitive practices that involve the manufacturing of intermediate goods, or “inputs” used to produce final goods. These inputs (e.g., oil, car engines, and bricks) are typically not sold directly to the ultimate consumers, but instead are combined with other inputs to produce one or more “downstream” products (gasoline, cars, and houses, respectively). Inputs can differ substantially in the number of products in which they are used, their importance in the production of downstream products, and the number of levels of production and distribution between the input and the downstream products incorporating the input. In some industries, a portion of the production of the input is sold to third party manufacturers (“merchant sales”), and the rest is used internally by vertically integrated manufacturers to produce a downstream product.

The outcomes of antitrust inquiries involving intermediate goods have often turned on the definition of the relevant markets and market power of
the firms involved. As recognized in the labor economics literature and some antitrust analyses (e.g., Higgins & Shughart, 1989; Inderst & Valletti, 2007), properly evaluating the demand for an input often involves examining market conditions downstream from that input. However, in general, antitrust analysis has not systematically analyzed the impact of downstream conditions in assessing market definition and market power for inputs. This is unfortunate because not only can a systematic analysis of downstream conditions help inform the assessment of market definition and market power for inputs, failure to examine these conditions can lead to incorrect conclusions.2

This paper demonstrates how the well-established “Hicks-Marshall” conditions of derived demand can be used in conjunction with (1) typical market definition analyses (such as critical loss/critical elasticity of demand analysis) to properly define antitrust markets for inputs, and (2) with other analyses (such as diversion ratios) to predict or estimate the competitive effects of mergers. Our analyses have several important implications for the economic evaluation of a merger or alleged anticompetitive action.

First, solely examining demand substitution of direct customers of an input — often the primary focus of antitrust relevant market inquiries — can lead to wrong conclusions about the relevant markets for inputs. In fact, the relevant antitrust market can be larger than a specific input, even when the downstream firm purchasing that input cannot substitute a different input for it.

Second, critical loss analysis that takes into consideration the Hicks-Marshall conditions can use information on technical production substitutability and downstream market conditions to provide useful information on the contours of the relevant market, particularly when direct estimates of the elasticity of demand of the input are unavailable or inexact. Using reasonable ranges for key parameters, as opposed to precise estimations, can be sufficient to define relevant markets for inputs in practice. For example, if an input accounts for more than 50% of the cost of a downstream final product, has an incremental profit margin of over 50%, and there is a 0.5 or greater elasticity of substitution, then input and downstream substitution would make the relevant product market broader than just the input.

Third, applying the Hicks-Marshall conditions with diversion ratios can provide important insights about whether a merger or potentially anticompetitive act that harms a competitor would create an incentive to raise prices. In particular, diversion ratio and “upward pricing pressure” (UPP) analyses of competitive effects can be made more exact by taking into account the Hicks-Marshall conditions, which explicitly include input and downstream substitution effects.
Fourth, at a minimum, using information on downstream market conditions in the specific tests derived here can also often serve as a "reality check" on other market definition and competitive effects analyses.

Section "Market Definition and Intermediate Goods" below explains the market definition exercise and provides examples of how relevant markets have been defined in some antitrust cases involving intermediate goods. Section "Hicks-Marshall Conditions" describes the Hicks-Marshall conditions of derived demand that link the demand for an input with the demand for downstream products. Section "Market Definition for Inputs Using Hicks-Marshall Conditions" combines the Hicks-Marshall conditions with critical loss/critical elasticity of demand analysis in the context of defining relevant markets for intermediate goods. As we show, downstream conditions can be important in market definition for inputs, and overlooking these conditions can lead to an incorrect definition of the relevant antitrust market. Section "Competitive Effects Using Hicks-Marshall Conditions" discusses the relevance of the Hicks-Marshall conditions in the assessment of competitive effects under upward pricing pressure ("UPP") analysis. In particular, if the analysis of the Hicks-Marshall conditions indicates sufficient downstream substitution, UPP measures calculated using shares and diversions at the input market level can overstate the true upward pricing pressure. Section "Conclusions" summarizes our primary conclusions.

MARKET DEFINITION AND INTERMEDIATE GOODS

Market definition remains an important part of evaluating most competition matters both in the United States and the European Union (Shapiro, 2010). The economics of the U.S. Department of Justice and Federal Trade Commission Horizontal Merger Guideline's (2010) (Merger Guidelines) approach for market definition focuses initially on buyers' demand and the products or services over which a "hypothetical monopolist" could profitably raise prices to customers. This approach asks whether a small but significant and non-transitory price increase over existing levels by all firms in the proposed market would be profitable. One key element of this approach is determining the degree to which customers would switch to other products if prices of the products in a proposed market were raised. If buyers can relatively easily substitute other products — i.e., there is a high elasticity of demand — then the hypothetical market
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needs to be expanded to take into account other substitute products. If substitution to other products is very limited in the face of a relative price increase — i.e., the elasticity of demand is low in absolute value — then the proposed market would be a relevant antitrust market. With regard to inputs, the Merger Guidelines state that the applicable agency will take into account “the influence of downstream competition faced by customers in their output markets.” This approach to market definition can and is also used in non-merger settings, as is recognized by the European Union, although there can be issues in applying this type of test to monopolization and conspiracy cases (White, 2008).

As part of market definition analysis, economists often consider indicia similar to those discussed by the Supreme Court in Brown Shoe Co. v. United States (1962), including “industry or public recognition of ... the product’s peculiar characteristics and uses including a consideration of functional and economic substitutability, unique production facilities, distinct customers, distinct prices, sensitivity to price changes, and specialized vendors.” This evidence typically comes from a variety of sources (e.g., Keyte, 1995; Werden, 1998, pp. 363—414), and can be used to provide some general parameters for the factors that go into market definition.

Relevant market definition has been an issue for many antitrust matters involving intermediate goods such as coal (Federal Trade Commission, 2004), crude oil (Hayes, Shapiro, & Town, 2001), lead (RSR Corp. v. FTC, 1979), steel (United States v. Mittal Steel Company, 2006), and chemicals (Associated Octel Company Ltd., 1998). However, antitrust analyses in these litigations have differed on whether explicit consideration should be given to downstream conditions in assessing relevant markets for inputs and addressing the critical issue of market power. Many court decisions address the relevant market for an input without any mention of downstream conditions (Federal Trade Commission, 2004). On the other hand, at least a few decisions demonstrate a consideration of downstream conditions (Brookins et al., 2000). None of these cases discuss in detail how the different Hicks-Marshall conditions interact, and instead treat them more as a checklist than as part of an integrated analysis yielding specific testable hypotheses about the appropriate market definitions.

In their analysis of two mergers involving the chemical polyvinyl chloride (“PVC”), the Federal Trade Commission (“FTC”) took into account three of the four “Hicks-Marshall” conditions of derived demand that we discuss in detail in the next section. PVC is a thermoplastic resin combined with other additives to produce finished vinyl products (such as pipe and siding). In evaluating the elasticity of demand for PVC in determining the
competitive effects of the merger between B.F. Goodrich and Diamond Shamrock, the FTC noted that "price elasticities increase as (1) the degree to which other inputs can be substituted for them increases; (2) the proportion of total costs for which each accounts increases; and (3) the price elasticity of demand for PVC end products and PVC resin — the products for which they are, respectively, used — increases" (In the matter of B.F. Goodrich Company, 1988). After assessing these three conditions, the FTC concluded that the PVC was characterized by inelastic demand.

In later considering the elasticity of demand of PVC in the acquisition by Occidental Chemical Corporation ("Octel") of the PVC business of Tenneco Polymers, the FTC also referred to these three Hicks-Marshall conditions. Similar to Goodrich, no mention is made of a fourth Hicks-Marshall condition — the elasticity of supply of other inputs (Occidental Petroleum Corp., 1992).

In Associated Octel, the FTC challenged a series of agreements among manufacturers of lead antiknock compounds for leaded gasoline (Associated Octel Company Ltd., 1998). The FTC argued that lead antiknock compounds constituted a relevant product market, and this opinion relied upon the reasoning of the Hicks-Marshall conditions. First, the FTC found that the downstream demand for high octane fuels was relatively inelastic because consumers of high octane fuels could not easily switch to other, lower octane fuels, such as general automotive gasoline. Second, the cost of the additive was relatively small compared to the total cost of the high octane fuels. Third, there was limited ability to substitute other types of inputs for the lead antiknock compounds in production. Refiners could not easily or inexpensively switch away from the lead compounds to other octane enhancing additives, such as methyl tertiary-butyl ether. Determining whether the demand for lead antiknock compounds was sufficiently inelastic to constitute a relevant product market required a thorough understanding of the production technology of the immediate customers (the refiners) and demand by final end users (owners of prop planes and racing cars).

These cases appear to have relied on a checklist of qualitative weighing of the Hicks-Marshall conditions, rather than an integrated quantitative analysis that often is used in critical loss/critical elasticity of demand. A more formal economic analysis that takes into account observable information on how they interact can provide more accuracy and consistency, and could have led to different conclusions than reached by the FTC and courts. As shown below, a more systematic analysis can be done even if the key Hicks-Marshall parameters cannot be precisely estimated.
**HICKS-MARSHALL CONDITIONS**

The demand for an input is a "derived demand" in that its demand is directly linked to the demand for the ultimate product for which it is an input. Absent demand for a downstream product, there would be no demand for the input. Market conditions "downstream" from an input help determine the elasticity of demand for that input and, therefore, the relevant market for the input.

In labor economics, the elasticity of demand for an input has long been evaluated using conditions originally developed by Marshall (1923, pp. 518–538) and revised by Hicks (1966, pp. 241–247), commonly referred to as the "Hicks-Marshall" conditions of derived demand. In their simplest form, these conditions evaluate the elasticity of demand for an input under the assumption of two inputs (typically capital and labor), constant returns to scale, and perfect competition downstream (Layard & Walters, 1978).

The Hicks-Marshall conditions state that, ceteris paribus, the demand for an input is less elastic when:

*The elasticity of substitution between inputs is low.* The elasticity of substitution will be lower when there is relatively little change in the mix of the inputs when their relative prices change, and will be higher when the mix changes substantially with a change in the relative prices. A relatively low elasticity of substitution tends to result in a low elasticity of demand for the input in question, because a price increase relative to substitute inputs is unlikely to cause the input of interest to lose many sales to substitute inputs.

*The elasticity of demand for the downstream product is low.* If demand for the downstream product is inelastic, then any price increase caused by a higher price of the input will lead to only a small change in the quantity demanded of the downstream product and is therefore likely to lead to only a small change in the quantity demanded of the input.

*The cost of the input is a small share of the total cost of producing the downstream product.* This condition holds when the elasticity of substitution is less than the elasticity of demand for the downstream product. In this case, the increase in marginal cost of the final product would be relatively small, so passing on the higher input price to final customers would be unlikely to reduce sales to encourage much downstream substitution.

*The supply of other inputs to production is less elastic.* When the elasticity of supply of other inputs is less elastic, substitution to those inputs in response to a price increase in an input is discouraged because the increased demand for those inputs causes their prices to increase significantly. As a practical matter, this condition is important only in those instances where substitution in response to the posited input price increase would be great enough to increase prices of other inputs significantly.
Based on the Hicks-Marshall conditions, the elasticity of demand for an input can be expressed as a function of the elasticity of demand for the downstream product, the elasticity of substitution between the inputs, and the elasticity of supply of the second input as follows (with demand elasticities expressed in absolute value) (Layard & Walters, 1978, p. 267):

\[
e_i = \frac{E_f S_i + n_i [v_i E_f + (1 - v_i) S_j]}{n_i + [v_i S_i + (1 - v_i) E_f]}
\]

where \(e_i\) is the own price elasticity of demand for input \(i\), \(E_f\) is the own price elasticity of demand for the downstream product incorporating input \(i\), \(S_i\) is the elasticity of substitution between input \(i\) and a second input used in the production of downstream good \(f\), \(v_i\) is the proportion of total costs of downstream product \(f\) accounted for by input \(i\), and \(n_i\) is the elasticity of supply of the second input used to produce downstream product \(f\).

Whether the Hicks-Marshall conditions can be systematically applied in practice in defining relevant markets depends on the products or services at issue, and availability of information. For example, Hicks-Marshall conditions may be difficult to apply when several different downstream products use the input and each has a different elasticity of demand. They may also be difficult to apply when many other inputs are used in the production of the downstream product, and these inputs act as important substitutes and/or complements for the input being examined. As discussed in more detail below, the Hicks-Marshall conditions are easiest to apply when the input at issue is used primarily to produce a small number of downstream products, other inputs do not act as good substitutes for the input at issue, and the elasticity of supply of other inputs is high. For example, with a fixed factor production function, the elasticity of demand for the input is simply the proportion of total cost of the downstream product borne by that input multiplied by the elasticity of demand for the downstream product.

MARKET DEFINITION FOR INPUTS USING HICKS-MARSHALL CONDITIONS

"Critical loss" analysis has been used to help define relevant markets in many intermediate goods antitrust cases and is recognized explicitly in the Merger Guidelines, although its application has been somewhat controversial (e.g., Baker, 2007; Katz & Shapiro, 2003; Langenfeld & Li, 2001;
O’Brien & Wickelgren, 2003; Werlen, 2002). Critical loss is a direct extension of the Merger Guidelines concept that an antitrust market includes a product and a geographic area in which prices can profitably be raised. The idea of the critical loss approach is to test whether a price hike would cause sales losses from all sources (sales lost to alternative products or to producers outside the given area) that were so great that the proposed price hike would be unprofitable. The approach follows three steps: (1) estimating the hypothetical monopolist’s per unit variable profit margin before prices would be increased; (2) determining the percentage of sales this hypothetical monopolist could lose before a price increase becomes unprofitable; and (3) estimating whether this hypothetical monopolist would lose the threshold percentage of sales if it increased price. The approach is not designed to evaluate whether a particular act is anticompetitive, but rather creates a benchmark for determining whether a price increase would likely be profitable if competition within a group of products were measurably reduced.

Assuming one can get reliable measures of per unit variable profit margins, a price increase will be profitable if and only if the total variable profit at the higher price exceeds the total variable profit at the lower price, which can be shown algebraically as:

\[(P + \Delta P - MC)(Q - \Delta Q) > (P - MC)Q\]  

where \(P\) is the initial price, \(\Delta P\) is the price increase, \(MC\) is the firm’s constant marginal cost, \(Q\) is the initial quantity sold, and \(\Delta Q\) is the decline in sales caused by the price increase.

Combining terms and rearranging yields

\[\frac{\Delta P}{P + \Delta P - MC} = \frac{t}{m + t} > \frac{\Delta Q}{Q}\]  

where \(t = \Delta P/P\) is the percentage price increase; \(m = (P - MC)/P\) is the initial margin; and \(\frac{t}{m + t}\) is the “break-even” critical loss. At the break-even critical loss for a given price increase, a hypothetical monopolist will have its profits unchanged by that price increase. For the price increase to increase profits, the hypothetical monopolist would have to lose fewer sales than this break-even critical loss. Accordingly, if the hypothetical monopolist would lose less than the critical loss, then this analysis indicates that the market should be no larger than the one being analyzed.
An alternative way to implement this type of market definition analysis is to calculate a “critical elasticity of demand.” That is, critical loss can be expressed as the critical elasticity of demand facing the candidate antitrust market (Werden, 1998). Under this alternative approach, if the actual elasticity of demand is less (in absolute value) than the critical elasticity of demand, then the products and geographic area constitute a relevant antitrust market.

The final step in critical loss or critical demand analyses is to estimate how many sales would be lost for a given price increase. This is often done through econometric estimates of the elasticity of demand, natural experiments (Coleman & Langenfeld, 2008), and/or qualitative information on the industry.

Some economists have advocated examining a hypothetical profit maximizing price increase, rather than strictly applying a 5% break-even price increase test (Langenfeld & Li, 2001; Werden, 2008). It can be shown that the profit maximizing price change from the status quo is half of the break-even price change under certain circumstances. Given these circumstances, it is profit maximizing to increase price by \((0.5) \times t\) if it is more profitable than the status quo to increase price by \(t\) (e.g., Farrell & Shapiro, 2008). This suggests that a 10% price increase test for critical loss may be more appropriate than a 5% test.

Economists have disagreed on the type of evidence that should be used to evaluate whether a price increase would be profitable, and whether the critical loss formula needs to be modified to reflect how the industry has been acting. In particular, some commentators have argued that one can infer an elasticity of demand under the assumption of profit maximization from the price-variable cost margin, known as the Lerner Index (e.g., Danger & Frech, 2001, p. 349; Farrell & Shapiro, 2008). That is, \(\varepsilon = 1/m\), where \(\varepsilon\) is the elasticity of demand for the product or service in a candidate relevant market. The actual loss from a price increase based on this reasoning is approximately \(\varepsilon \times t\), or equivalently \(t/m\). Farrell and Shapiro (2008) propose that one estimate the actual loss as \(L = (1 - A)(t/m)\), where \(L\) is the actual loss due to a price increase of \(t\), and \(A\) is the Aggregate Diversion Ratio defined as the fraction of sales lost by one product or geographic area that go to other products in the candidate market when its price alone increases by \(t\).\textsuperscript{11}

There may be reasons not to infer the elasticity of demand for critical loss calculations based on calculations of the Lerner Index, such as potential measurement errors or contrary market evidence. Nevertheless, the Merger Guidelines warn that high margins (absent collusion) typically indicate each firm’s product faces demand not highly sensitive to price, which implies
higher margins should result in a smaller predicted loss. As such, higher margins should reduce the recapture percentage \(A\) necessary for a candidate market to satisfy the hypothetical monopolist test.\(^\text{12}\)

**Market Definition Using the Hicks-Marshall Conditions**

As discussed in the previous section, antitrust market definition analysis focuses at least initially on demand side substitutability for the immediate customers of the product at issue (Baker, 2007). In this regard, market definition analysis often compares an estimation of the "critical elasticity" demand to an estimate of the actual elasticity of demand. For inputs, demand side substitutability of both (1) the immediate customers of an input and (2) the indirect customers purchasing the "downstream" products can be important in defining a relevant antitrust market. Combining the "Hicks-Marshall" conditions of derived demand with critical elasticity of demand can provide important insights on relevant market definition for intermediate goods.

To make the Hicks-Marshall conditions in Eq. (1) more tractable for market definition, first recognize that in general switching to other inputs will not be substantial enough to cause an increase in the price of these other inputs. Moreover, the Merger Guidelines state that the prices of other products should be assumed to remain constant when conducting a relevant market definition exercise.\(^\text{13}\) This implies that the supply elasticity of the other input \(n_o\) is infinite. In this case, Eq. (1) can be simplified to be the sum of the elasticity of demand for the final good \(E_f\) and the elasticity of substitution \(S_i\), with the former weighted by input \(i\)'s proportion of total cost \(v_i\) and the latter being the other inputs' proportion of costs \((1 - v_i)\). This can be written as (once again, with elasticities stated in absolute value terms):

\[
e_i = v_i E_f + (1 - v_i) S_i
\]  

The "break-even" elasticity of demand below which a candidate product or set of products constitutes a relevant market (assuming linear demand (Werden, 1998)) is the inverse of the percentage incremental margin \(M\) plus the hypothesized percent price increase \(t\), or:

\[
e^*_i = \frac{t}{(M + t)}
\]
Substituting Eq. (5) into Eq. (4) and solving for the elasticity of demand for the downstream product yields a break-even elasticity for the downstream product (as opposed to that for the input itself): \[
E_f^* = \frac{S(Mv_t + t - M - t) + 1}{v_t(M + t)}
\] (6)

Product \(i\) satisfies the conditions for constituting a relevant product market under break-even analysis when the elasticity of demand for the downstream product incorporating input \(i\) falls below this level.

The equations for the "profit-maximizing" critical elasticity of demand are similar but distinct. The "profit-maximizing" critical elasticity of demand (assuming linear demand) for product \(i\) is equal to:

\[
\varepsilon_f^* = \frac{t}{(M + 2t)}
\] (7)

Substituting Eq. (7) into Eq. (4) and solving for the final elasticity of demand yields the "profit-maximizing" critical elasticity of demand for the downstream product:

\[
E_f^* = \frac{S(Mv_t + 2tv_t - M - 2t) + 1}{v_t(M + 2t)}
\] (8)

In general, the critical elasticity of demand of the downstream product (\(E_f^*\)) depends on the elasticity of substitution (\(S\)), variable profit margins (\(M\)), and the share of the input in total costs (\(v_t\)). The critical elasticity of downstream demand is a strictly decreasing function of \(M\) and \(S\). In contrast, \(E_f^*\) is decreasing in \(v_t\) only if certain conditions hold. That is, the break-even downstream elasticity of demand decreases with an increase in the share of the relevant input of total costs (\(v_t\)) only if there are relatively small values of the elasticity of substitution (\(S\)), the incremental profit margin (\(M\)), and the hypothetical price increase (\(t\)).

It is reasonable to expect that it may not be feasible for producers to switch from the input under consideration to an alternative input in some cases. For example, gasoline is produced in a relatively fixed proportion to its primary input, oil. In this case, the elasticity of substitution is zero and the price of other inputs will not change as a result of a price increase from the input at issue. In this case, Eqs. (6) and (8) simplify to:
for the break-even elasticity of demand and

\[ E^*_f = \frac{1}{v_i(M + t)} \quad (9) \]

for the profit-maximizing critical elasticity of demand. Under either of these conditions, \( E^*_f \) will be larger when \( v_i, M, \) and/or \( t \) are smaller, and it is more likely that this approach to market definition would yield a narrower market.

**Implications for Market Definition**

Combining critical loss/critical elasticity of demand analysis and the Hicks-Marshall conditions, one can define the relevant market using information about the elasticity of demand for the downstream product, even when little or no direct information is available regarding the elasticity of demand for the input. Using information from the downstream market may also provide an alternative estimate of the critical elasticity of demand, and a "reality check" on critical loss and other market definition analyses performed using information on pricing and substitution limited to the input at issue.

For example, in the context of the decisions in *Goodrich* and *Octel* involving PVC in the production of vinyl products. Further, assume there are alternative end use products that do not employ PVC, which could conceivably provide strong enough competition to prevent PVC from constituting a relevant product market. If, say, the gross margin percentage for PVC is 65%, PVC constitutes 5% of the total costs of the vinyl products, and one conservatively assumes an infinite elasticity of supply for other inputs, then the "break-even" elasticity of demand for the downstream vinyl products is very high, an absolute value of 28 using the typical 5% market test. Thus, the FTC's conclusion that the elasticity of demand for downstream vinyl products was relatively "low" without an estimation of this elasticity could be stated more accurately, perhaps, using our framework. The elasticity of
demand for downstream vinyl products would actually not need to be particularly "low" (less than 28) to be sufficient to conclude that PVC constituted a relevant product market.

In general, when the elasticity of substitution is equal to or near zero so the customer of the input has no ability to substitute away from input i (an assumption that biases the analysis towards finding smaller markets), Eqs. (9) and (10) demonstrate that an input will not necessarily constitute a relevant market even when direct customers of that input have no ability to switch to alternative inputs. As shown in Table 3, even if there was no ability to substitute another product for PVC to make vinyl products, substitution downstream would make the relevant antitrust market greater than PVC if the gross margin for PVC was 50%, its share of total cost was 70%, and the elasticity of demand for the final product was greater than 2.6. Thus, concluding that input i must necessarily constitute a relevant product market is mistaken. If the elasticity of demand for the downstream product is above the critical level, then the candidate market does not necessarily constitute a relevant product market under critical elasticity of demand analysis. Substitution by buyers downstream away from the output of the purchasers of the input in the face of an attempted price increase at the input level can make such a price increase unprofitable and therefore expand the relevant market.

Examination of the range of typical parameter values indicates that an input market may be broader than an individual input due to downstream substitution (even when there is zero elasticity of substitution) when the input at issue constitutes a fairly substantial portion of the total cost of the good incorporating that input. For example, some researchers have stated that price-cost margins are often in the range of 40%–70% (Werden, 1998, p. 390), and estimated demand elasticities for downstream products have often been below 5 in absolute value (Bijnolf, van Heerde, & Pieters, 2005). Using a 40%–70% range of price cost margins in Eq. (9), then the critical elasticity of demand for the downstream product will be over 5 and the input under consideration would likely constitute a relevant product market unless it constitutes 30% or more of the cost of the downstream product.15

Calculating a reasonable estimate of economic profits and the associated profit margin (M) and the input's proportion of total costs (v) in practice are often feasible using accounting data. In many instances, it is more difficult to estimate the elasticity of substitution and the elasticity of the final demand with precision. Nevertheless, it is possible to determine whether an input is likely to constitute a relevant market even without precise estimates of the elasticity of substitution or elasticity of final demand. For example,
assume that \( M \) is equal to 0.5 and \( v \) is equal to 0.3. If one were to estimate the elasticity of substitution at say, 0.5, then any value of the final elasticity of demand below approximately 5 in absolute value would indicate that input \( i \) constitutes a relevant market (and a value lying above this would indicate that it did not constitute a relevant market).\(^{16}\) There would be no need to precisely estimate the downstream product's elasticity; instead, all that would be required was determining whether it was above or below 5.

To further assess the conditions under which the downstream elasticity of demand can aid with the market definition for inputs, we solve for the break-even critical downstream elasticity, \( E_f^* \), that results from Eq. (6) using plausible ranges for the underlying parameters.\(^{17}\) In particular, the elasticity of substitution (\( S \)) is allowed to vary from 0 to 2,\(^{18}\) the input proportion of total cost (\( v \)) is modeled to lie between 0.001 and 0.7,\(^{19}\) and the input profit margin (\( M \)) is modeled to range from 0.1 and 0.9. We focus on providing the solutions for the break-even critical elasticity shown in Eq. (6); however, we note that deriving the profit-maximizing critical elasticity from Eq. (8) is trivial. The results are generally quite close to the values calculated for the break-even critical elasticity.

Below, we present summaries of the numerical solutions we derived for the \( E_f^* \) function. For tractability, we hold one parameter constant while letting the other two vary. Table 1, for example, displays the values for the \( E_f^* \) under plausible ranges for \( M \) and \( v \) under the assumption that \( S = 0.5 \).\(^{20}\)

Table 1 shows that under a moderate elasticity of substitution, \( E_f^* \) is very high in cases where the input's share of total cost (\( v \)) is very low, and is

<table>
<thead>
<tr>
<th>Margin (( M ))</th>
<th>0.001</th>
<th>0.01</th>
<th>0.05</th>
<th>0.1</th>
<th>0.3</th>
<th>0.5</th>
<th>0.7</th>
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<td>10%</td>
<td>6,167</td>
<td>617</td>
<td>123.83</td>
<td>62.17</td>
<td>21.06</td>
<td>12.83</td>
<td>9.31</td>
</tr>
<tr>
<td>20%</td>
<td>3,501</td>
<td>351</td>
<td>70.50</td>
<td>35.50</td>
<td>12.17</td>
<td>7.50</td>
<td>5.00</td>
</tr>
<tr>
<td>30%</td>
<td>2,358</td>
<td>236</td>
<td>47.64</td>
<td>24.07</td>
<td>8.36</td>
<td>5.21</td>
<td>3.87</td>
</tr>
<tr>
<td>40%</td>
<td>1,723</td>
<td>173</td>
<td>34.94</td>
<td>17.72</td>
<td>6.24</td>
<td>3.94</td>
<td>2.96</td>
</tr>
<tr>
<td>50%</td>
<td>1,319</td>
<td>132</td>
<td>26.86</td>
<td>13.68</td>
<td>4.89</td>
<td>3.14</td>
<td>2.38</td>
</tr>
<tr>
<td>60%</td>
<td>1,039</td>
<td>104</td>
<td>21.27</td>
<td>10.88</td>
<td>3.96</td>
<td>2.58</td>
<td>1.98</td>
</tr>
<tr>
<td>70%</td>
<td>834</td>
<td>84</td>
<td>17.17</td>
<td>8.83</td>
<td>3.28</td>
<td>2.17</td>
<td>1.69</td>
</tr>
<tr>
<td>80%</td>
<td>677</td>
<td>68</td>
<td>14.03</td>
<td>7.26</td>
<td>2.75</td>
<td>1.85</td>
<td>1.47</td>
</tr>
<tr>
<td>90%</td>
<td>553</td>
<td>56</td>
<td>11.55</td>
<td>6.03</td>
<td>2.34</td>
<td>1.61</td>
<td>1.29</td>
</tr>
</tbody>
</table>

\textit{Note:} (\(| E_f^* | < | E_f^* | \) implies input is a relevant market).
generally high in cases where the price-cost margin ($M$) is low. Those sections of Table 1 are consistent with the conclusion that the input under study constitutes a relevant market (given that the actual downstream elasticity is expected to be much lower than the critical elasticity). Conversely, the critical elasticity is relatively low under higher $v$ and $M$. In particular, when $v$ is equal or greater to 0.3 and $M$ is equal or greater to 50%, it becomes more likely that the actual downstream elasticity is higher than the critical elasticity. When this result holds, we would reject the hypothesis that the input constitutes a relevant antitrust market. For example, when $S = 0.5$, an actual final good elasticity as low as 2 can be higher than the critical elasticity if $M$ is relatively high (80%) and $v$ is equal to 0.5 (yielding a critical elasticity of 1.85).

In a similar vein, Table 2 presents the values for the $E_f^*$ under reasonable ranges for $M$ and $S$ assuming $v = 0.3$.

By keeping $v$ fixed, Table 2 demonstrates that $E_f^*$ is a decreasing function of both $S$ and $M$. It is clear that under the assumption of a moderate cost share ($v = 0.3$), higher values for $S$ may lead to a small enough critical elasticity that the hypothesis of a relevant market is rejected under a wide range of values for $M$. Of course, whether $S$ actually takes on values as high as one or two is an empirical question which will vary from one industry to another.

Finally, in Table 3 we present the values for $E_f^*$ under plausible values for $S$ and $v$ while holding the price-cost margin constant at 50%. As we have demonstrated above, the slope of $E_f^*$ function with respect to $v$ is ambiguous as it depends on the values of $M$, $S$, and the hypothetical price increase, $t$.

### Table 2. Break-Even Downstream Critical Elasticity of Demand ($E_f^*$) under Alternative Values for $S$ and $M$, $v = 0.3$.

<table>
<thead>
<tr>
<th>Elasticity of Substitution ($s$)</th>
<th>Margin ($M$)</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td></td>
<td>22.22</td>
<td>13.33</td>
<td>9.52</td>
<td>7.41</td>
<td>6.06</td>
<td>5.13</td>
<td>4.46</td>
<td>3.92</td>
<td>3.51</td>
</tr>
<tr>
<td>0.10</td>
<td></td>
<td>21.99</td>
<td>13.10</td>
<td>9.29</td>
<td>7.17</td>
<td>5.83</td>
<td>4.89</td>
<td>4.21</td>
<td>3.69</td>
<td>3.28</td>
</tr>
<tr>
<td>0.25</td>
<td></td>
<td>21.64</td>
<td>12.75</td>
<td>8.94</td>
<td>6.82</td>
<td>5.48</td>
<td>4.54</td>
<td>3.86</td>
<td>3.34</td>
<td>2.93</td>
</tr>
<tr>
<td>0.50</td>
<td></td>
<td>21.06</td>
<td>12.17</td>
<td>8.36</td>
<td>6.24</td>
<td>4.89</td>
<td>3.96</td>
<td>3.28</td>
<td>2.75</td>
<td>2.34</td>
</tr>
<tr>
<td>0.75</td>
<td></td>
<td>20.47</td>
<td>11.58</td>
<td>7.77</td>
<td>5.66</td>
<td>4.31</td>
<td>3.38</td>
<td>2.69</td>
<td>2.17</td>
<td>1.76</td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td>19.89</td>
<td>11.00</td>
<td>7.19</td>
<td>5.07</td>
<td>3.73</td>
<td>2.79</td>
<td>2.11</td>
<td>1.59</td>
<td>1.18</td>
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<tr>
<td>2.00</td>
<td></td>
<td>17.56</td>
<td>8.67</td>
<td>4.86</td>
<td>2.74</td>
<td>1.39</td>
<td>0.46</td>
<td>0.22</td>
<td>-0.75</td>
<td>-1.16</td>
</tr>
</tbody>
</table>

*Note: $|E_f| < |E_f^*|$ implies input is a relevant market.*
Table 3. Break-Even Downstream Critical Elasticity of Demand (E) under Alternative Values for S and ν, M = 50%.

<table>
<thead>
<tr>
<th>Elasticity of Substitution (s)</th>
<th>Proportion of Total Costs of Downstream Product Accounted for by Input (ν)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1,818.18 181.82 36.36 18.18 6.06 3.64 2.60</td>
</tr>
<tr>
<td>0.10</td>
<td>1,718.28 171.92 34.46 17.28 5.83 3.54 2.55</td>
</tr>
<tr>
<td>0.25</td>
<td>1,688.43 157.07 31.61 15.93 5.48 3.39 2.49</td>
</tr>
<tr>
<td>0.50</td>
<td>1,318.68 132.32 26.86 13.68 4.89 3.14 2.38</td>
</tr>
<tr>
<td>0.75</td>
<td>1,068.93 107.57 22.11 11.43 4.31 2.89 2.28</td>
</tr>
<tr>
<td>1.00</td>
<td>819.18 82.82 17.36 9.18 3.73 2.64 2.17</td>
</tr>
<tr>
<td>2.00</td>
<td>-179.82 -16.18 -1.64 0.18 1.39 1.64 1.74</td>
</tr>
</tbody>
</table>

Note: (| E | < | E | implies input is a relevant market).

The tables above illustrate that it may not be necessary to have full knowledge of and/or precisely estimate all of the parameters in order to accurately define a relevant market involving an input. There are many ranges of the parameters S, ν, and M that would assist with market definition — even in the absence of precise estimates for the demand elasticity of the downstream product.

In summary, a detailed analysis of input market definition can be done by applying the Hicks-Marshall conditions, even without exact estimates of the key parameters. Moreover, this systematic approach is likely to yield a substantially more reliable market definition analysis than the qualitative analyses that have been done in many past cases.

COMPETITIVE EFFECTS USING HICKS-MARSHALL CONDITIONS

The analyses above illustrate how taking into account the Hicks-Marshall conditions can be used to more accurately define markets for intermediate goods, expressly taking into account downstream substitution and in certain instances compensating for the lack of exact estimates of the key parameters. This method for defining intermediate goods markets can be applied to merger analyses, attempted monopolization, and other antitrust cases. Although market definition is often critical in intermediate goods antitrust cases, it is only one element of determining the competitive effects.
of a merger or other antitrust case. Considering the Hicks-Marshall conditions can also provide guidance on the likely competitive effects of a merger or other antitrust case. In particular, the Hicks-Marshall conditions can provide insights into the unilateral competitive effects of a merger involving producers of intermediate goods.\textsuperscript{21}

For example, according to the Merger Guidelines, harm from unilateral effects involving differentiated products can arise if a merger “diminish[es] competition by enabling the merged firm to profit by unilaterally raising the price of one or both products above the pre-merger level.”\textsuperscript{22} The Merger Guidelines explain that the two primary economic variables that determine whether unilateral effects are a serious concern are: (1) the diversion ratio between the merging parties’ products (the percentage of the sales leaving one party’s product in response to a price increase that flow to the other merging party’s products) and (2) the gross profit margin (price less incremental cost) of the products. More specifically, the Merger Guidelines describe the determination of the extent of UPP as a function of diversion ratios and margins as follows:\textsuperscript{23}

Adverse unilateral price effects can arise when the merger gives the merged entity an incentive to raise the price of a product previously sold by one merging firm and thereby divert sales to products previously sold by the other merging firm, boosting the profits on the latter products. Taking as given other prices and product offerings, that boost to profits is equal to the value to the merged firm of the sales diverted to those products. The value of sales diverted to a product is equal to the number of units diverted to that product multiplied by the margin between price and incremental cost on that product. In some cases, where sufficient information is available, the Agencies assess the value of diverted sales, which can serve as an indicator of the upward pricing pressure on the first product resulting from the merger ... If the value of diverted sales is proportionately small, significant unilateral price effects are unlikely.

One measure of UPP is the gross upward pricing pressure index (GUPPI):\textsuperscript{24} GUPPI = \( \frac{D_{AB} P_B - C_B}{P_A} \), where \( D_{AB} \) is the diversion ratio from product A to product B upon a price increase of product A, \( P_A \) and \( P_B \) are the prices for products A and B, and \( C_B \) is the marginal cost for product B.\textsuperscript{25} A similar measure is the net UPP, which incorporates marginal cost efficiencies from the merger, and has been defined by Farrell and Shapiro (2010) thusly: UPP = \( D_{AB} \times (P_B - C_B) - E_A C_A \), where \( E_A \) is the marginal cost efficiencies for product A. Importantly, in both measures, \( D_{AB} \) (the diversion ratio from product A to product B) is a key element of the pricing pressure created by the merger. The intuition is simple – if the term \( D_{AB} \times (P_B - C_B) \), which measures the value of diverted sales pre-merger, exceeds a certain threshold (e.g., exceeding the marginal cost efficiencies for
product A), the merged entity may have an incentive to raise price for product A because the lost sales will be internalized.

The diversion ratio is formally defined as the ratio of the cross-price derivative and the own price derivative: $D_{AB} = -\frac{\frac{\partial Q_B}{\partial P_A}}{\frac{\partial Q_A}{\partial P_A}}$. Because of limited data and time constraints, diversion ratios are often approximated using the parties' market shares under the simplifying assumption that sales will be diverted to the other parties' products in proportion to market shares. More specifically, the diversion ratio $D_{AB}$ is approximated as: $1 - \frac{S_B}{S_A}$, where $S_B$ is the market share of product B and $S_A$ is the market share for product A.26

Using share-based diversion ratios provides a rough simplification to competitive effects analysis using the UPP approach. However, in intermediate goods markets with sufficiently high elasticity of demand for the downstream product, relying on market shares calculated at the input product level may not be sufficiently precise, and share-based diversion ratios may be overstated if the relevant antitrust market is defined too narrowly. Thus, if consideration of the Hicks-Marshall conditions suggests that the relevant market is broader than indicated by solely examining demand substitution possibilities for direct customers of an input, then the relevant should be broadened. In turn, the share-based diversions among the parties will be lower, and everything else remaining unchanged, UPP will be reduced. It can be shown that in some circumstances, the adjusted diversion ratio employing the Hicks-Marshall conditions would alter the UPP calculation enough to reverse a presumption that a proposed merger would lead to anticompetitive effects.

CONCLUSIONS

The question of the appropriate definition of the relevant market for an input has often been important in antitrust inquiries. As established by examining the tools of relevant market definition in light of the long established Hicks-Marshall conditions of derived demand for an input, downstream conditions can be very important in properly delineating the relevant market for inputs. Past analyses of market definition of intermediate goods have often not taken downstream substitution into consideration. Moreover, even where downstream competition has been given consideration, it has not been rigorously or systematically analyzed.

In this paper, we adapt the often used tool of critical loss analysis to take into account the Hicks-Marshall conditions of derived demand for inputs. Several important insights emerge. First, solely examining the
demand substitution possibilities for direct consumers of an input can lead to the wrong relevant market definition. Second, critical loss analysis in conjunction with the Hicks-Marshall conditions can provide an additional avenue for delineating the relevant market when it is difficult to directly estimate the elasticity of demand for an input. They can also provide a "reality check" on the results obtained from typical critical loss analysis. Third, reasonable ranges on parameters related to the ability of users of the input to substitute to other inputs and downstream market conditions instead of precise estimation will often be sufficient to define relevant markets for inputs using critical loss analysis in practice, and these analyses should be more economically reliable than qualitative analyses that have been done in past cases. Finally, we show how the Hicks-Marshall conditions may be relevant when analyzing the competitive effects of a merger.

NOTES

1. In this paper, references to products should be read to include both products and services.

2. Some authors have focused on aspects of the upstream/downstream relationship that we do not explicitly address here. For example, we do not explore the role of vertical integration or the role of varying market shares downstream. See, for example, Inderst and Valletti (2007), for a detailed exploration of these and related issues.

3. Even advocates of reducing the importance of market definition in antitrust matters have stated that market definition is still an important part of antitrust cases. See, e.g., Carl Shapiro, Deputy Assistant Attorney General for Economics, Antitrust Division, U.S. Department of Justice, Update from the Antitrust Division, at 15 (November 18, 2010), http://www.justice.gov/atr/public/speeches/264295.pdf (recognizing need to define relevant market in any antitrust challenge). At a minimum, market definition analyses can be used to check the robustness of any analysis that attempts to measure the direct effects of an alleged anticompetitive act.

4. For a set of products to constitute a relevant market under the Merger Guidelines' hypothetical monopolist test, "a hypothetical profit-maximizing firm not subject to price regulation, that was the only present and future seller of those products (hypothetical monopolist') likely would impose at least a small but significant and non-transitory increase in price ..." (Merger Guidelines, Section 4.1.1). The European Commission (1997) applies a very similar test for market definition. "The question to be answered is whether the parties' customers would switch to readily available substitutes or to suppliers located elsewhere in response to a hypothetical small (in the range 5% to 10%) but permanent relative price increase in the products and areas being considered. If substitution were enough to make the price increase unprofitable because of the resulting loss of sales, additional substitutes
and areas are included in the relevant market. This would be done until the set of products and geographical areas is such that small, permanent increases in relative prices would be profitable. Commission Notice on the definition of relevant market for the purpose of the Community Competition Law, Official Journal C 372, 09/12/1997 P. 0065–0013. The Canadian Competition Bureau also applies a highly similar test: "The market definition analysis begins by postulating a candidate market for each product of the merging parties. For each candidate market, the analysis proceeds by determining whether a hypothetical monopolist controlling the group of products in that candidate market would profitably impose a SSNIP, assuming the terms of sale of all other products remained constant. If the price increase would likely cause buyers to switch their purchases to other products in sufficient quantity to render the price increase unprofitable, the postulated candidate market is not the relevant market, and the next-best substitute is added to the candidate market. The analysis then repeats by determining whether a hypothetical monopolist controlling the set of products in the expanded candidate market would profitably impose a SSNIP. This process continues until the point at which the hypothetical monopolist would impose and sustain the price increase for at least one product of the merging parties in the candidate market. In general, the smallest set of products in which the price increase can be sustained is defined as the relevant product market." Merger Enforcement Guidelines released by the Canadian Competition Bureau on October 17, 2011.

5. The hypothesized price increase is most often 5% but dependent upon the merger under consideration.

6. **Merger Guidelines**, Section 4.3.1.

7. The elasticity of substitution is approximately equal to the percent change of the ratio of the two inputs used by a downstream firm divided by the corresponding percent change in their relative prices.

8. The **Merger Guidelines** generally assume that alternatives to a product are available in unlimited quantities at constant prices, an assumption that, if not true, tends to overstate the demand elasticity of an input.

9. It may not be necessary to consider each of the Hicks-Marshall conditions if it is clear that the input at issue faces strong competition from other substitute inputs.

10. **Merger Guidelines**, Section 4.1.3.

11. Of course, estimating $A$ can often be more challenging than estimating $c$ directly from market data and other available information.

12. **Merger Guidelines**, Section 4.1.3.


14. The proof for Eq. (6) is as follows: $E_2' = \frac{S(MX + \theta - M - \theta + 1)}{\theta(M + 1)} - \frac{S(MX + \theta - M - \theta + 1)}{\theta(M + 1)}$. Given that $v_i (M + \theta)$ is positive and $(v_i - 1)$ is negative, $E_2'$ is decreasing in $S$. Further rearranging yields $E_2' = \frac{S(Y - 1)}{\theta} + \frac{1}{\theta(M + 1)}$. Examination of the second term in this equation shows that $E_2'$ is decreasing in $M$ as both $v_i$ and $\theta$ are positive. The last equation further reduces to:

$$E_2' = \frac{S(Y - 1)}{\theta} + \frac{1}{\theta(M + 1)} = S_i - v_i + \frac{1}{\theta(M + 1)} = S_i + \frac{1 - S_i M - S_i}{\theta(M + 1)}.$$  

This equation demonstrates that $E_2'$ is decreasing in $v_i$ only if the term $[1 - S_i M - S_i]$ is positive.
15. The critical elasticity of demand will exceed 10 unless the input constitutes at least 14% of the cost of the downstream product.

16. This result holds assuming a break-even critical elasticity. Similar examples can be shown for the profit-maximizing elasticity as well.

17. From Eqs. (6) and (8), it can also be seen that the Hicks-Marshall conditions can yield a negative value of \( E^*_i \), meaning that input \( i \) does not constitute a relevant market regardless of the value of the final elasticity of demand. This can occur when the elasticity of substitution is high enough to establish that enough switching will occur among direct customers of the input to make a price increase unprofitable regardless of the elasticity of final demand.

18. We consider 0—1 to be a plausible range for the elasticity of substitution, and 2 is likely at the high end for many industries (see, e.g., Young, 2013).

19. The input’s share of total cost of the final good, \( \nu \), can be a negligible in some industries (e.g., auto parts), hence we consider \( \nu = 0.001 \). It is also likely that \( \nu \) falls below 70% of total variable costs for many industries.

20. The choice of \( s = 0.5 \) is guided by the fact that the elasticity of substitution is often estimated to be below 1, see, e.g., Young (2013). This value is also the midpoint between the Leontief production function \( (S = 0) \) and the Cobb-Douglas production function \( (S = 1) \).

21. For a general discussion of unilateral effects from a merger, see Merger Guidelines, Section 6.


25. If prices are assumed to be symmetric (which is the assumption in a paper proposing the GUPPI measure — see Salop & Moresi, 2009) so that \( P_A = P_B \), then \( \text{GUPPI} = D_{AB}M_B \), where \( M_B \) is the percentage margin for product B.


REFERENCES


RSR Corp. v. FTC, 602 F.2d 1317, 1320-22 (9th Cir. 1979).


