The Discriminatory Incentives to Bundle: The Case of Cable Television*

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Abstract

A considerable theoretical literature supports a *discriminatory* explanation for product bundling: it sorts consumers in a manner similar to 2nd-degree price discrimination. The purpose of this paper is to test this theory and quantify its empirical importance in the cable television industry. Specifically, demand for network bundles (cable services) should be greater and more elastic the more networks in the bundle. The results provide broad support for the theory: carriage of almost all of the top-15 cable networks both increase and flatten the cable demand curve. In a simple approximation to cable television markets, the results suggest bundling the average number of top-15 cable networks offered on Basic service increases profits relative to unbundled (component) sales, but decreases consumers surplus by an amount equal to a 4.2% increase in the price of cable. On balance, total surplus *increases*. This suggests seriously considering the welfare consequences of product choice when designing competition and/or regulation policy. (JEL L12, M31, L96, L40, L50, C31).

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1 Introduction

Economists have long been interested in the widespread practice of commodity bundling, the sale of multiple goods in a single package. A common marketing strategy, examples of bundling may be found in health care, telecommunications, financial services, and computing. Despite its prevalence, however, economic analysis of bundling has been limited. Recent research has focused on the antitrust implications of a monopolist bundling its product with another sold in a more competitive market (Whinston (1990), Carlton and Waldman (2000)).[1] When both (or all) products are produced by a single firm, however, the problem is one of optimal product choice and multidimensional nonlinear pricing in monopoly markets (Wilson (1993), Rochet and Chone (1998)).

A considerable theoretical literature suggests bundling may arise in this context to sort consumers in a manner similar to 2nd-degree price discrimination (Stigler (1968), Adams and Yellen (1976), McAfee, McMillan, and Whinston (1989)). When consumers have heterogeneous tastes for products, a monopolist has difficulty extracting consumers' surplus with component (unbundled) prices. Bundling reduces consumer heterogeneity. If marginal costs are low, the monopolist can extract more consumers' surplus than would be possible with component prices (Schmalensee (1984)). Like price discrimination, bundling implicitly charges a higher price to those consumers that most value some components of the bundle.

The implications of bundling for consumer and social welfare are generally unknown, however, and depend on the incentives to bundle. If the purpose is to extend monopoly power, bundling likely reduces welfare by reducing current and future competition in related markets (Carlton and Waldman (2000), Whinston (2001)). If bundling is driven by discriminatory incentives, however, no strong predictions may be made. Like price discrimination more generally, while firms clearly benefit, consumer welfare may increase or decrease depending on the structure of tastes within a particular market (Varian (1989)). Establishing empirical regularities is therefore an important area of research.

The purpose of this paper is to test the discriminatory incentives to bundle in the cable television industry and provide evidence of its empirical importance. The canonical example in many bundling papers, the cable industry provides a natural environment to conduct such a test for several reasons. First, the vast majority of cable systems are multiproduct monopolists and therefore relevant to the discriminatory theory. Second, cable systems are experts at bundling: cable services are fundamentally bundles of various types of television programming. Finally, there is considerable heterogeneity in the contenst of these bundles across cable markets. Along with associated heterogeneity in demand and cost conditions, this permits an explicit test of the theory.

[1] The antitrust lawsuit against Microsoft's bundling of Internet Explorer with the Windows operating system is a recent example. See the Spring 2001 *Journal of Economic Perspectives* for an interesting overview of the case.

The analysis proceeds in 3 stages. I begin by reviewing the literature describing the discriminatory incentives to bundle and discuss the testable implications of the theory. I then describe patterns of bundling in the cable television industry. Data limitations prevent testing the theory across cable services; instead, I exploit variation in the composition of Basic and Expanded Basic Services across markets to test an implication of the theory: cable demand should (i) increase and (ii) flatten as networks are added to the bundle. The flattening of demand especially is idiosyncratic to the discriminatory theory and cannot be generated by alternative incentives to bundle. Building on previous work in Crawford (2000), I then briefly describe the model of cable demand used to test the theory, introduce the data and empirical specification, and present the results.

The results yield broad support for the discriminatory theory: adding almost all of the top-15 cable television networks to program bundles increases the elasticity of cable demand. To assess the empirical importance of these results, I approximate the structure of household preferences for network bundles with a simplified model, calibrate it to my estimates of cable demand, and measure the welfare consequences of bundling. The results are suggestive of the disciminatory power of bundling. Bundling the average number of top-15 cable networks offered on Basic service (7) increases profits relative to unbundled (component) sales, but decreases consumers surplus by an amount equal to a 4.2% increase in the price of cable. On balance, however, total surplus increases. This suggests firms' product choices can be as important as prices in impacting consumer and social welfare. Assessing the benefits of extending competition and regulation policy in this dimension is therefore an important area of further research.

2 The Discriminatory Incentives to Bundle

2.1 The Case of Two Goods

Most of the discriminatory bundling literature has focused on the incentives to bundle two goods. Adams and Yellen (1976) formalize the seminal work of Stigler (1963) and present several examples where bundling is more or less profitable than component sales. Their canonical example, duplicated below, demonstrates the intuition.

Insert Figure 1 Here

There are two goods, 1 and 2, produced at constant marginal cost, \$20 and \$30, and 4 consumers, A - D, whose willingness-to-pay (WTP) for each good is represented by a point in the figure. Goods are assumed to be independent in demand, i.e. reservation values for a good do not depend on the price of the other good.[2] With component sales, optimal prices are $p_1^* = 60$ and $p_2^* = 90$. C and D purchase good 1 and A alone purchases good 2. Profits are \$140. With bundled sales, the optimal price is $p_B^* = 100$ and all consumers purchase the bundle. Profits are \$200.

In a more general setting, when bundled sales are preferred to component sales depends on the nature of preferences and costs for the components of the bundle. As for many price discrimination problems, these conditions defy general characterization. For the case of independent normally distributed tastes (WTP), Schmalensee (1984) in a computational analysis demonstrates that bundling is superior to component sales when demand is high relative to cost. In this case, "*a reduction in heterogeneity [from bundling]* always increases profits by permitting more efficient extraction of consumer surplus" [my emphasis] (p. S220). Salinger (1995) obtains similar results for linear demand.

The following example provides some intuition for these results. Consider the Willingness-To-Pay (WTP) for two goods, 1 and 2, distributed independently in a population of consumers. From elementary statistics, $\sigma_{1+2}^2 = \sigma_1^2 + \sigma_2^2 + 2\rho\sigma_1\sigma_2$, where σ_{1+2}^2 is the variance of a bundle of 1 and 2, σ_1^2 and σ_2^2 are the variances of each component, and ρ is their correlation. Since $(\sigma_1 + \sigma_2)^2 = \sigma_1^2 + \sigma_2^2 + 2\sigma_1\sigma_2$, the standard deviation of the bundle is less than the sum of the standard deviations of the components, $\sigma_{1+2} \leq \sigma_1 + \sigma_2$. Bundling therefore (weakly) reduces heterogeneity in tastes. When costs are low relative to demand, heterogeneity reduction increases profits by permitting greater consumer surplus extraction with the bundle price.

2.2 More than Two Goods

Do these results extend to more than two goods? Bakos and Brynjolfsson (1999) and Armstrong (1999) address this question in recent papers analyzing pricing and bundling with multiple goods. To understand their results, consider the distribution of the *average* WTP of a bundle of n independent goods. Large-sample theory implies this distribution becomes more concentrated as n increases (e.g., White (1984)). As a result, individual outliers in WTP for bundles decrease in frequency as bundle size increases. The implication of this result is demonstrated in Figure 2, taken from Bakos and Brynjolfsson (1999). For the case of uniformly distributed tastes (i.e. linear demand), the figure presents the demand per good for a bundle of size 1, 2, and 20. As bundle size increases, there are fewer extreme tastes, corresponding to an increasingly flat demand curve.[3]

[2] This is not to be confused with statistical independence: reservation prices can be correlated and still be independent in this sense.

[3] Extending these large-sample results to samples of finite size is neccesary for testing the theory on observational data but requires further assumptions. Bakos and Brynjolfsson (1999) assume a single-crossing condition requiring the support of X_n to decrease monotonically with n. This is both analytically convenient and useful for testing the theory as it permits the results of Schmalensee (1984) and Salinger (1995) to be extended to arbitrary n. Fortunately, this property holds for most distributions (e.g. Normal, Logistic, etc.) commonly used in empirical work.

Insert Figure 2 Here

Does the monopolist benefit from this reduction in heterogeneity? It does when costs are low. As average tastes collapse, consumers have fewer extreme tastes, and consumers surplus falls. Importantly, bundling operates on both ends of the taste distribution. There are therefore also few consumers who value the good at more than its cost that do not purchase it, and total surplus increases.

2.3 When Should Firms Bundle?

The analysis above permits a convenient synthesis of the incentives to bundle. At its core, bundling reduces heterogeneity in consumer tastes. The primary benefit of this reduced heterogeneity is more efficient extraction of consumers surplus with linear prices. There are two costs, however. The first is that bundling requires all consumers purchase all components in the bundle. When the cost of components is high, this reduces the profitability of bundling relative to component sales by sometimes selling goods to consumers who value them less than their cost. The second is that bundling requires firms charge a single price. When consumer tastes for components differ considerably, this reduces the profitability of bundling relative to component sales as it permits fewer instruments (prices) to capture consumers' surplus.[4]

3 Bundling in the Cable Television Industry

Despite any supporting empirical evidence, the cable television market is considered the canonical example of discriminatory bundling in the theory literature (Wildman and Owen (1985); Salinger (1995); Bakos and Brynjolfsson (1999)). In this section, I describe patterns of bundling observed in the industry, characterize the institutional and regulatory constraints placed on system's bundling decisions, and present the specific implications of the theory tested in the paper. I conclude by presenting the econometric model which forms the foundation of these tests.

3.1 Cable Services: Bundles of Program Networks

Cable television systems select a portfolio of television networks, bundle them into one or more services and offer these services to consumers in local, geographically separate, monopoly cable

[4] McAfee, McMillan, and Whinston (1989) extend the analysis of Adams and Yellen (1976) to consider mixed bundling, the offering of *both* component and bundled sales, and show it always yields (weakly) greater profits than pure bundling. The reason for this is clear: it maintains the benefits of bundling (if any) and strictly increases the number of prices available to capture surplus. Despite this fact, mixed bundling is relatively uncommon, perhaps due to the added administrative costs associated with offering both bundled and component goods.

markets. This section briefly defines the types of programming and services common to all cable systems and describes the typical bundling of programming into services.

All cable systems offer four main types of program networks. *Broadcast networks* are television signals broadcast in the local cable market by television stations and then collected and retransmitted by cable systems. Examples include the major, national broadcast networks – ABC, CBS, NBC, and FOX – as well as public and independent television stations. *Cable programming networks* are advertising-supported general and special-interest networks distributed nationally to systems via satellite. Examples include some of the most recognizable networks associated with cable, including MTV, CNN, and ESPN. *Premium programming networks* are advertising-free entertainment networks, typically offering full-length feature films. Examples include equally familiar networks like HBO and Showtime. *Pay-Per-View Networks* are specialty channels devoted to on-demand viewing of high-value programming, typically offering the most recent theatrical releases and specialty sporting events.

With few exceptions, systems do not differ in how they bundle each type of network into services. Broadcast and cable programming networks are typically bundled and offered as *Basic Service* while premium programming networks are typically unbundled and sold as *Premium Services*. In the last decade, systems have begun to further divide Basic service, offering some portion of their cable programming networks on multiple services, called *Expanded Basic Services*. For either Basic or Expanded Basic Services, consumers are not permitted to buy access to the individual networks offered in bundles; they must instead purchase the entire bundle.

3.2 Institutional and Regulatory Constraints on Bundling in Cable

What drives these patterns of bundling in the industry? While the focus of this paper are the discriminatory incentives to bundle, I begin by first describing several institutional and regulatory constraints that impact firms' bundling decisions. This then motivates the cable services studied in the paper.

First, note the least cost method of providing cable service is to bundle *all* offered programming. This is due to the technology of video program distribution in the industry: all signals are transmitted to the customer's home. It is *unbundling* networks that is costly, requiring methods to prevent consumption by non-subscribers. The technology to do this has changed significantly over time, implying the production technology of a given cable system can significantly impact the cost (or even the feasibility) of providing alternative bundles of programming.[5] This suggests observed patterns

[5] Early methods to block consumption relied on electromechanical "traps" placed at the link between the household and the cable distribution system. Most (but not all) systems now offer "addressable" converters which control access via electronic communication with the cable headend.

of bundling in cable may not be driven by discriminatory motives at all, but rather simply be a consequence of cost-minimization by cable systems. Even so, the feasibility of low-cost unbundling accompanying the advent of addressable technology implies that, subject to the regulatory constraints described below, some systems *could* offer networks on a stand-alone basis, recovering their fixed costs from a per-subscriber connection fee as in a two-part tariff. Indeed, this approximates the preferred method of sale for Premium Services. The widespread reliance on program bundles for Basic and Expanded Basic services therefore suggests a role for demand-side effects. I address this point further when discussing the testable implications of the discriminatory theory in Section 3.3 below.

Second, several aspects of cable television service are subject to regulation. While the specific content of any service may not be regulated on First Amendment grounds, the 1992 Cable Act requires the creation of a Basic tier of service containing all offered broadcast and public-interest programming carried by the system. Systems therefore have discretion only over the bundling of cable and premium programming networks. In addition, systems are subject to Must Carry/Retransmission Consent (MCRC) rules.[6] While the focus of these rules are broadcast networks (necessarily offered on Basic Service), Retransmission Consent impacted system's network carriage decisions by inducing systems to carry broadcaster-affiliated cable networks. While an important, ongoing aspect of network carriage decisions, the networks affected in the period under study are relatively small and do not materially affect the analysis in the paper.

Finally, because price regulations introduced by the 1992 Act set different rules for different services, systems had an incentive to change their mix of offered services and the programming provided on them (Hazlett and Spitzer (1997), Crawford (2000)) While this did significantly affect the number of services provided by some systems, changes in the networks provided were relatively minor (Crawford (2000)). This is perhaps not surprising, as *tiering* decisions (i.e. how many, if any, Expanded Basic Services are offered) are often made by a cable system's corporate parent, or Multiple System Operator (MSO), while *carriage* decisions (i.e. what networks to offer on those services) are typically made by the local system.

While institutional and regulatory constraints significantly restrict systems flexibility of bundling some (esp. broadcast) programming, systems maintain control over the selection and bundling of the remaining, cable and premium programming networks, onto Basic, Expanded Basic, and Premium Services. These, then, are the focus of the empirical tests in the paper.

[6] MCRC gives local television stations the option of either (i) requiring carriage on all local cable systems (Must Carry) or (ii) demanding compensation for carriage from all local systems (Retransmission Consent). The majority of stations carrying the four major networks (ABC, CBS, NBC, Fox) opt for Retransmission Consent. Small independent and public television stations typically opt for Must Carry.

3.3 Bundling in Cable: Testing the Discriminatory Theory

What are the implications of the discriminatory theory for these services? There are two. First, the incentives to bundle decrease with increases in the marginal cost of the component goods. A second implication follows from the benefit of heterogeneity reduction caused by bundling. Since this heterogeneity reduction is greater the less is the covariability of components, the incentives to bundle decrease in the covariability of preferences.[7]

To test the discriminatory theory, I would ideally related systems bundling decision to aspects of tastes and costs for the components of those bundles. Unfortunately, this is quite challenging. Testing the first implication requires cost data. The primary marginal cost of providing cable service comes from the fees a system must pay to the programming networks offered on that service. Data on programming costs at the system level are not readily available, however. In many cases, networks are owned by systems, making an accurate estimate of marginal cost difficult to obtain. Even if not, this data is sensitive competitive information to networks that practice widespread price discrimination across systems. Moreover, testing the second implication, relating bundling and covariation in tastes for components, requires very rich data on the level and variability of quantity demanded for cable services as a function of the networks offered there. A difficult estimation problem, this is the subject of ongoing research (Coppejans and Crawford (1999)).

While the data necessary to test the discriminatory theory *across* cable services is not readily available, there is considerable information on heterogeneity *within* cable services. I therefore test a simple but important implication of the discriminatory theory described in Figure 2: bundling implies the demand for cable services should increase and flatten with increases in bundle size. Specifically, I test whether the addition of each of the top-15 cable networks flattens the demand for cable services. I also compare the estimates of these effects across networks with factors related to covariation of household tastes.

It is important to note that the flattening of cable demand is an idiosyncratic prediction of the discriminatory theory and cannot be generated by alternative incentives to bundle. The leading alternative motivation to bundle in cable is complementarity in cost, or economies of scope. As described in the previous subsection, cable distribution technology implies the presence of cost complementarity. So too may administrative and marketing costs exhibit complementarities. Such complementarities should not, however, impact cable demand. The purpose of this paper is to test the discriminatory theory and assess its empirical importance, regardless of any additional benefits from bundling. That said, separating the relative importance of alternative incentives to bundle is

[7] This is most easily seen from the example provided in section 2.1. If $\sigma_1^2 = \sigma_2^2$, the variation of the bundle as a share of the variation of the components can be written as $\frac{\sigma_{1+2}^2}{(\sigma_1+\sigma_2)^2} = \frac{1+\rho}{2}$ Heterogeneity reduction is therefore decreasing in covariability (ρ). In the extreme, if 1 and 2 are perfectly negatively correlated, then there is no heterogeneity at all in WTP for the bundle and *all* surplus can be extracted at the bundle price.

an important area of future research.

In the next subsection, I briefly present the econometric model used to test this implication of the discriminatory theory. As the model builds on previous work in Crawford (2000), the reader is referred there for further details.

3.4 An Econometric Model of Demand for Cable Television Services

The goal of the demand model is to estimate preferences for cable services (i.e. bundles of networks) from preferences for the components of those bundles (i.e. the networks themselves). As the implications of the discriminatory theory tested in this paper exploit variation in the composition of Basic and Expanded Basic service bundles, I only model the demand for these services. Let the demand for each of the Basic and Expanded Basic services, s, offered by a cable system in market n be given by

$$\log(\frac{\tilde{w}_{sn}}{w_{0n}}) = X'_{sn}\beta + D'_n\gamma_s + (\alpha_s + X'_{sn}\eta + D'_n\iota)p_{sn} + \xi_{sn} \tag{1}$$

where s indexes {Basic Service, Expanded Basic Service 1 (if offered), Expanded Basic Service 2 (if offered) }, 0 indexes the purchase of no cable service, $\frac{\tilde{w}_{sn}}{w_{0n}}$ is a nonlinear transformation of the market share for that service,[8] X_{sn} indexes the programming provided on service s in market n, D_n measures demographic attributes of the population in market n, p_{sn} measures the price of service s in market n, and ξ_{sn} measures unobserved attributes (i.e. quality) of service s in market n.[9] α_s, β, and η measure, respectively baseline aggregate price sensitivity for cable service s, the impact to demand from the carriage of the program networks in X_{sn}, and the impact to aggregate price sensitivity from the carriage of the networks in X_{sn}, while γ_s and ι measure differences in the tastes for cable services arising from differences in demographic characteristics of cable markets.

Econometric Tests of the Discriminatory Theory The key independent variables in equation (1) are the vector of programming networks, X_{sn}, bundled on service s. If systems are bundling

[8] The particular nonlinear transformations chosen are such that under the assumptions described in Crawford (2000), observed market shares may be derived from an underlying model of household utility maximization, yielding household demand for combinations of cable services, and a procedure aggregating these demands across households. The specific functional forms for the dependent variable vary slightly between Basic and Expanded Services to incorporate the requirement that Basic Service be purchased in order to purchase any Expanded Services. See Crawford (2000) for details.

[9] These estimating equations are built under the assumption that household preferences for the combinations of cable services available to them are distributed as a Type I Extreme Value, implying logit market shares. The estimating equations therefore have the familiar logit log-ratio form. The validity of this assumption for cable markets was tested and could not be rejected in Crawford (2000).

to price discriminate, adding a network in X_s to a service bundle should shift out and flatten the service demand curve.

The primary hypothesis test of the discriminatory theory tests the converse of this: adding a network decreases aggregate price sensitivity and makes demand less elastic, $H_0^1 : \eta \leq 0$ v. $H_A^1 : \eta > 0$. Rejecting this hypothesis at reasonable confidence levels provides evidence of the discriminatory incentives to bundle.[10] Further evidence of the discriminatory theory comes from comparing the values of η_k across networks, $k = 1, \ldots, 15$. Specifically, networks that contribute more to a reduction in household tastes should flatten the demand curve more than those that contribute less, or $H_0^2 : \eta_{k''} \leq \eta_{k'}$ v. H_A^2: Not H_0^2, where k' indexes the first group of networks and k'' indexes the second. Rejecting this hypothesis provides further evidence of the discriminatory incentives to bundle.

4 Empirical Model and Results

4.1 Data

I've compiled a market-level dataset on a cross-section of United States cable systems to test the discriminatory theory. The primary source of data is Warren Publishing's Television and Cable Factbook Directory of Cable Systems. The data for this paper consists of the population of cable systems recorded in the 1996 edition of the Factbook for which complete information was available. From the population, a sample of 1,169 systems remained.[11]

Tables 1 and 2 present summary statistics for these systems. When modeling the demand for cable services, it is important to distinguish between the specific networks offered to households. I do so according to the size of their potential audience: the top 15 cable programming networks available in the United States in 1998 are listed in Table 3. While all systems offer a Basic Service, Table 1 shows that slightly more than a third of systems offer Expanded Basic Services. Of these, most offer just one Expanded Service. Aggregating over all Basic and Expanded Basic Services, systems typically offer almost 6 broadcast networks and more than 17 cable networks.

As heterogeneity in the bundling decisions across services is critical to the testing procedure, Table 2 considers cable network carriage in more detail. The 1st column reports the proportion of systems

[10] I also test the hypothesis that adding a network fails to increase the demand for the bundle, $H_0^3 : \beta \leq 0$ v. $H_A^3 : \beta > 0$. This is fairly uninformative since all theories of bundling imply that the bundle demand curve should shift out with additions to the bundle. As such, it has little power to discriminate among them.

[11] While there are over 11,000 systems in the sample, persistence in non-response over time as well as incomplete reporting of critical variables required imposing a large number of conditions in order for a system to be included in each sample. Missing information on prices, quantities, and reporting dates were responsible for the majority of the exclusions.

in the sample that carry each of the top-15 cable programming networks on any Basic Service. The remaining columns of the table examine the proportion of systems that carry each of the top-15 cable networks on each Basic or Expanded Basic Services. Several interesting patterns emerge. First, note the majority of the networks are offered on *some* service by the majority of systems. Some of the most popular networks, WTBS, CNN, and ESPN are available on over 95% of all systems. Systems differ, however, in how they allocate these networks among Basic and Expanded Basic services. While some, like CSPAN and QVC, are almost exclusively offered on Basic, others, like TNT and TNN, are often found on Expanded Services. Importantly, there is significant heterogeneity both in the carriage of networks across systems, as well as in their allocation to Basic and Expanded Basic Services.

4.2 Empirical Specification

The estimating equations for the demand system were given in equation (1). The dependent variables are functions of the market shares for each service, defined as the number of subscribers to that service divided by the number of homes passed by the cable system, where homes passed are the number of households accessible by a cable system's distribution network.

The programming provided on each services is denoted by X_s. Ideally, I would like to measure the impact to the demand for cable of adding *each* network offered on any cable system. There are far too many networks, however, for this to be practical. Instead, I measure the impact to demand of adding each of the top 15 cable networks, aggregating the remaining cable networks into a single category, "other cable networks." This implies 15 separate tests of the discriminatory incentives to bundle, one corresponding to each parameterized network.

Demand shifters are denoted by D_n and include the Designated Market Area (DMA) rank and its square, measuring the strength of the local television market, median income and its square, the percentage of the population aged 5 to 18, and the percentage of the population with any college experience. Also included are region dummies to control for taste differences across regions and Expanded Service dummies in the Basic equation.

4.2.1 Instrumental Variables

Price Instruments Recent developments in the industrial organization literature have emphasized the importance of allowing for endogenous prices when estimating the demand for differentiated products (Berry (1994), Berry, Levinsohn, and Pakes (1995)). Results from estimation with two sets of price instruments are therefore reported.

Recall the primary marginal costs to a system are the per-subscriber fees paid to programming networks. The first set of instruments proxies for differences across systems in these costs. The first three costs shifters, homes passed and the number and square of subscribers served by the systems corporate parent (MSO), proxy for system size at the local and national level. They capture differences in the marginal programming cost arising from heterogeneity in bargaining power in the programming market (Noam (1985); Chipty (1995)). I also include a dummy variable if a system's MSO has vertical ties to programming networks. Both Chipty (1993) and Waterman and Weiss (1996) find that systems tend to favor affiliated networks, at least in part because they can purchase programming from their affiliates at its true, very low, marginal cost. A final cost shifter, channel capacity, proxies for the ability for systems to earn reduced rates on bundles of programming networks provided by the same supplier.[12]

I also report specifications based on a second set of instruments that rely more heavily on institutional features of cable program supply. In cable, MSOs negotiate programming fees on behalf of all their member systems. Individual systems then select the networks to offer given these input prices. As a result, marginal costs across systems within an MSO share common components, a fact that may be exploited in constructing instrumental variables. Because of these common components, differences in prices across systems within an MSO reflect either differences in demand for cable service across markets or idiosyncratic components of cost. If demand shocks for systems owned by a given MSO aren't correlated, prices for systems within an MSO outside of market n will be good instruments for prices within market n.[13] I call these instruments 'MSO Prices'.

The use of prices in other geographic markets as instrumental variables has recently been successfully implemented in the market for ready-to-eat cereals by both Hausman, Leonard, and Zona (1994) and Nevo (2001). The primary concern in its use is that the assumption of independent demand shocks across markets may not hold, introducing inconsistency into the econometric estimation. For example, regional (national) advertising campaigns could introduce a regional (national) demand shock to cable prices. While common in retail packaged goods like cereal, however, these are quite rare in cable. More problematic in cable is geographic concentration of ownership by MSOs. The sorting of people with similar preferences into communities (or regions) introduces the possibility of regional correlation in tastes. I include region dummies in the demand estimation as

[12]In principle, channel capacity may also measure unobserved elements of the demand for cable not captured in X. This concern is moderated by the inclusion in X of the empirically relevant types of programming offered on cable systems. In practice, excluding channel capacity from the instrument set yields virtually identical results.

[13]The identification assumption may be described by assumptions on the following generic reduced form for cable prices:

$$p_{sn} = c_{sn} + \epsilon_{sn}$$

where p_{sn} measures the price of good s in market n, c_{sn} is its marginal cost, and ϵ_{sn} measures unmodeled cost and demand shocks to cable prices. Then if $E(c_{sn}c_{sn'}) \neq 0$ and $E(\epsilon_{sn}\epsilon_{sn'}) = 0$, prices in other markets will be valid instruments for prices in market n. The nature of MSO bargaining for programming networks justifies the correlation in marginal costs across markets within an MSO. The validity of the assumption on ϵ is discussed in what follows.

a first line of defense against such concerns. In addition, I also construct variations of this class of instrument based on prices for systems within an MSO which are located in another state of the country. This necessarily reduces sample size for these specifications, but mitigates concerns that regional demand shocks might bias the results.

Network Instruments In addition to setting prices, systems also plausibly select (i) the networks to offer on Basic and Expanded Basic Services and (ii) their allocation across services on the basis of unobserved tastes in each market. If so, then the elements of X_{sn} may be correlated with ξ_{sn} for service s in market n.[14] I therefore report results from estimation with instruments for networks as well as prices.

The number of networks offered by systems, however, implies instrumenting for both prices and networks is significantly more difficult than instrumenting for prices alone. What is needed are variables that shift the probability that a system carries a given network which is uncorrelated with demand for a cable service including that network. As for prices, cost shifters are best, but finding variables that shift marginal costs for individual networks is a difficult challenge.

The solution implemented here constructs instruments for network carriage based on carriage decisions for other systems owned by the same MSO. Specifically, for each network offered on each service for each system in the sample, I estimate the average likelihood of offering that network on the same service at all other systems owned by the same MSO. This is the same instrumenting strategy described above for the second set of price instruments.

Summary I present results from reduced form regressions of both price and network carriage (RHS endogenous variables) on all included exogenous variables and instruments in the Appendix. For each instrument set, I can almost always reject the null hypothesis of joint insignificance for the instruments in each reduced form regression. The lack of variability of the cost shifters across services, however, suggests instruments for prices based on prices within MSOs, may outperform those based on cost shifters. MSO networks also look to be powerful instruments. I explore these issues further when discussing the results.

[14] This may not be as severe a problem as would appear at first glance. In cable, while local systems typically select what networks to offer, the decision to offer one or more Expanded Basic Services and the decision of where to place networks, *if offered*, among these services is typically made by the MSO. In addition, as most systems offer most networks (cf. Table 2), the econometric identification of tastes for networks is driven as much by the service on which a network is offered as whether it is carried at all. As such, it is the allocation of networks across services that is the important source of possible correlation with the econometric error, at least for the most popular networks. Since this decision is made by the MSO, it is unlikely to be correlated with tastes for cable in any particular market. This is less true for less popular networks, where endogeneity may therefore be a greater issue.

4.3 Results

Table 4 presents the the results of the demand model under alternative instrument sets. In all specifications, the estimating equations are those given in equation (1) for Basic Service and up to two Expanded Basic Services (if offered). As suggested by these equations, in all specifications I impose the cross-equation restriction that the impact to the level or slope of demand of the inclusion of a network in X_{sn} is the same across services.[15] The remaining parameters, however, are free to vary across equations.

The results are organized in pairs of columns. For each pair, the first column presents estimates of β, the impact to the level of demand from adding the reported cable network to a cable service bundle. The second column presents estimates of η, the impact to aggregate price sensitivity from adding the reported network to a cable service bundle. For all specifications, results are reported for each of the top-15 cable networks, other satellite networks (in levels), bundle size (in slope), and, to summarize the findings, an average effect for the top-15 networks. Not reported are parameter estimates for the constant, broadcast programming, and demographic variables. Also reported is the average aggregate price sensitivity, $\alpha_s + X'_{sn}\eta + D'_n\iota$, for each of Basic Service, Expanded Basic I and Expanded Basic II.

The results in this second column provide the primary test for the discriminatory theory presented in this paper: if systems are bundling to reduce household heterogeneity, then one would expect $\eta_k < 0$, $k = 1, \ldots, 15$. Regardless of the incentives to bundle, because of free disposal one might expect $\beta_k \geq 0$, $k = 1, \ldots, 15$. For all specifications, estimates in bold represent statistically significant support for these hypotheses at size 0.10. I also report at the bottom of each column the number of networks with the expected sign and that are statistically significant for both the slope and the level.

In practice, these are stronger tests of the discriminatory theory than that implied by Figure 2. The data sometimes have difficulty distinguishing the slope and level effects, leading to a simultaneous inability to reject *both* hypotheses above. I therefore also report at the bottom of each column the cumulative effect of adding each network to a cable service bundle. Specifically, I report the number of networks among the top-15 that are estimated to increase (in absolute value) the average own-price elasticity of Basic Service, ϵ_{bb}. As is evident across specifications, this value is consistently

[15]This is mostly done of necessity. There is insufficient variation in the data to identify separate effects for most networks on a second Expanded Basic service, where offered. Were this not the case, there is still a strong case for imposing the restrictions. Unlike many differentiated products markets where branding is important, households in cable markets are plausibly indifferent about the name attached to the service purchased. They rather care about the programming provided on those services, implying a common effect to demand. In Crawford (1998), I test this assumption for Basic and the first Expanded Basic Service offered on a similar datset and cannot reject the hypothesis that the parameters are the same for most cable networks.

higher than might be expected examining the point estimates alone.[16]

The first pair of columns, labeled (1), presents SUR estimates of the demand system, while the second and third pairs, (2) and (3), present 3SLS estimates using cost shifters and MSO prices, respectively, as price instruments. As expected, instrumenting for prices significantly increases estimated price sensitivity for cable: average estimated own-price elasticities for Basic Service implied by these results are -0.26 for the OLS results and -0.51 for either 3SLS results.[17] Across specifications, the estimates for the level effects are broadly consistent with those obtained in Crawford (2000) on a slightly different dataset. Point estimates are usually positive and often significant. Furthermore, the estimated magnitudes are intuitively appealing.[18]

The second set of columns of for each of the 3SLS specifications presents the tests of the discriminatory theory. Point estimates differ little across choice of price instruments and broadly support the discriminatory theory. Using measures of bargaining power as cost instruments, 10 of 15 of the estimated effects is negative, half of these significantly so. Furthermore, *all* networks are estimated to increase the Basic own-price elasticity. Using prices of other systems within the same MSO as cost instruments yield comparable results: 12 of the 15 networks are estimated to flatten the cable demand curve, 7 significantly so. In addition, 14 of the 15 networks are estimated to increase the Basic elasticity. Somewhat surprisingly, bundle size appears to reduce price sensitivity. This, however, could be measuring the reduction in decision costs associated with bundling or the impact of unobservable characteristics of household preferences correlated with the amount of programming systems offer.[19] Given the possibility that MSO prices may not be appropriate instruments, the similarity of the results using different instrument sets for prices is encouraging.[20] As MSO prices

[16] Even absent this identification concern, there are other reasons one might obtain a negative estimate for β_k. The true distribution of willingness-to-pay for networks is likely asymmetric, bounded below at zero and with a possibly substantial right tail. This underlying structure cannot be easily accommodated in a simple demand specification. The logit errors underlying the tastes for services in this model may well approximate the tail, with the cost of possibly estimating a negative mean for individual networks, particularly those that are less popular or appeal to relatively narrow tastes.

[17] The latter estimate is slightly lower in absolute value that that found in Crawford (2000) (-1.64), but comparable to estimates found in Mayo and Otsuka (1991) (-0.96), Crandall and Furchtgott-Roth (1996) (-0.63), and Goolsbee and Petrin (2001) (-0.43). Note as Basic Service is required to purchase all other services, it need not be priced on the elastic portion of the demand curve.

[18] To facilitate the interpretation of the level effects, under the assumptions described in Crawford (2000), one may approximate the mean willingness-to-pay for each network by dividing the estimated level effect by (minus) the estimated average aggregate price sensitivity. For the specification in (3), this implies the average top-15 cable network increases mean WTP for cable by between (0.23/0.31) = \$0.74 and (0.23/0.23) = \$1.00. As institutional reasons may constrain Basic Service prices (e.g., the tying of Basic Service to other services and the threat of regulation), the estimates of price sensitivity for Expanded Services are more likely to accurately reflect the underlying preferences for networks.

[19] For example, investments in cable facilities (e.g. channel capacity) have long been targeted at high-income (i.e. low price sensitivity) areas. Unfortunately, allowing for this requires good instruments for bundle size and these are hard to find.

[20] Reported in a table in the appendix are comparable results using as instruments prices of other systems within the same MSO but outside the state or region of the given system. While quite consistent with the results presented here, the estimates are slightly less precisely estimated and appear to adversely affect the estimated baseline price

vary considerably more than the cost shifters (cf. Appendix A.1), specification (3) is chosen as the baseline specification for further analysis.[21]

The final pair of columns, labeled (4), examines the sensitivity of these conclusions to the possible endogeneity of bundles themselves. To do so, I augment the instruments for prices with instruments for network carriage itself. As described earlier, these instruments are the average propensity to carry a given network on a given service for all other systems owned by the same MSO. The final pair of columns presents the results of this specification when using MSO prices as instruments. The results weaken but do not refute the findings of the discriminatory theory. Relative to specification (3), 10 (v. 12) of the top-15 networks are estimated to increase price sensivitive. Due to the significant increase in the instrument set, however, now only 4 (v. 7) are statistically significant. Furthermore, 12 (v. 14) of 15 networks are estimated to increase the Basic own-price elasticity.[22] As they do not provide strong evidence against the baseline specification, I maintain a preference for those results.

Further Evidence of the Discriminatory Theory A closer look at the relation between the programming provided on each network and its impact on price sensitivity provides further support for the discriminatory theory. Recall the list of top-15 networks presented in Table 3. These are categorized into formats characterizing the types of programming provided on the network. The broadest distinction is between "general-interest" programming appealing to a wide range of tastes and "special-interest" programming appealing to a narrow range of tastes.

How might one use programming formats to further test the discriminatory theory? Recall from Section 2 that the heterogeneity reduction achieved by bundling decreases with covariation in tastes for networks. In cable, programming formats are plausibly related to taste variation. Specifically, if (i) different special-interest networks are targeted to different segments of the viewing population (as for example MTV targets teenagers and Lifetime targets adult women) and (ii) tastes of these population segments negatively covary (as for example preferences of teenagers and their mothers), one would expect tastes for special-interest networks to covary less with other networks than do general-interest networks.

In fact, this is exactly what the results suggest. For the baseline results, the average impact to

sensitivity. For these reasons, I maintain a preference for the results presented above.

[21] Using cost shifters as instruments for price in all subsequent specifications and applications does not change the qualitative conclusions presented in the paper.

[22] These results provide an interesting case study about the use of instrumental variables. Instruments have power to the extent they induce sufficient variation in the endogenous variable to identify the parameters of interest (cf. Angrist and Krueger (1998) for a useful summary and Levitt (1997) for a recent application). The considerable differences in the estimates between specifications (3) and (4) suggest network carriage by other systems within an MSO either proxy poorly for the costs of network carriage or do not cause sufficient variation in observed network carriage to identify the parameters.

aggregate price sensitivity of the 9 special-interest networks listed in Table 3 is -0.027 (0.005) while that of the 6 general-interest networks is -0.006 (0.005), implying the hypothesis that the effects are equal across these two types of networks can be rejected (Test Statistic = 11.3, χ^2 Critical Value (0.05) = 3.84). Moreover, it is interesting that one cannot reject the hypothesis that bundling general interest networks does not reduce price sensitivity at all. This suggests covariability in tastes may be a particularly important determinant of the incentives to bundle.

4.4 Implications of the Results

I now briefly consider the implications of these results for aggregate tastes and consumer welfare in cable markets. To quantify the magnitude of the reported effects, I would ideally calculate the effect on consumers and producers surplus of alternative bundling strategies pursued by systems. Specifically, I would like to compare the welfare benefits of the observed set of cable services with a counterfactual set of cable services with more or fewer program bundles. To do so, however, requires introducing a supply side that reflects the institutional characteristics of cable television services that is able to simulate the prices associated with the counterfactual product bundles. That is quite challenging, however, and is beyond the scope of this paper.

Instead, I implement a considerably simpler exercise. Specifically, I approximate the demand for cable program bundles with a highly simplified model which is easy to solve. Features of this model are calibrated to the baseline estimates obtained in the last section and counterfactual exercises are conducted in this simplified setting. While such an exercise necessarily breaks the link between the results and any specific conclusions that can be made about the cable industry, they provide important evidence of the (potential) empirical importance of bundling to consumer and producer welfare. I describe this simple model in what follows.

Suppose for simplicity cable systems offered only a single service offering two types of networks, "popular" networks and "less popular" networks. Suppose that tastes for each type of network were normally distributed in the population of households with a common mean and variance within each type. Suppose further that less popular networks have a lower mean but common variance with more popular networks. This implies we may describe household tastes by the two distributions, $N(\mu, \sigma^2)$ and $N(\lambda\mu, \sigma^2)$, where λ measures the perceived quality difference between popular and less popular networks. An appealing feature of the normality assumption is that if demand for networks is independent, household tastes for bundles of networks will also be normally distributed. The optimality of bundling under these conditions was studied in depth by Schmalensee (1984), the results of which I will rely on here.

Before analyzing the consequences of bundling in this simplified setting, I must obtain a suitable estimate for μ and σ. I do so as follows. Let the top-15 cable networks correspond to the "popular" networks mentioned earlier and all other networks offered on Basic Service correspond to the less popular networks. For the baseline estimates presented earlier, I calculate the change in elasticity of Basic Service from the addition of each of the top-15 networks and average this effect across networks. Under the simplified model, the change in elasticity from such an addition to a bundle is a function of μ, σ, λ, and the number of networks of each type, n_1 and n_2.[23] Solving this relationship yields an estimate of the ratio of μ to σ of 1.39, suggesting that tastes for individual networks are quite disperse in the population of households. Separating the effects of μ and σ requires introducing a supply-side. Schmalensee (1984) solves for and characterizes optimal pricing in this setting. Importantly, I assume that there are no incremental costs associated with unbundling and that networks are available at zero marginal cost.[24] Implementing his procedure and exploiting the mean observed price in the sample yields point estimates for μ of \$1.88 and σ of \$1.35.[25]

Given this structure, I can now quantify the consequences to consumer and producer welfare of bundling. To do so, I take as given that systems will offer all 24 “less popular” networks as a bundle and consider the decision of whether or not to bundle each of the 7 additional, “popular”, networks. The results are suggestive of the discriminatory power of bundling. In each case, the system profits by bundling, and at an increasing rate. Bundling the first (seventh) additional top-15 network implies profits 1.3% (3.0%) higher than that available from component sales, for a total increase of 14.4%. Consumers are worse off from bundling, with losses to consumers surplus from the first (seventh) bundled network of 3.0% (2.6%), for a total loss of 13.3%. The gains to firms outweigh the losses to consumers, and total surplus from bundling the seven networks increases by 3.4%. In dollar terms, the profit gain to systems from bundling in this simplified setting is approximately \$1.37 per household per month, while the loss to households is \$0.72 per household per month. The latter is equivalent to a 4.2% increase in the price of Basic cable service.

5 Conclusion

This paper presents an initial exploration of firms' incentives to bundle. The discriminatory theory of bundling suggests bundled sales increases profits relative to component (unbundled) sales by reducing consumer taste heterogeneity. While commonly advanced in the study of industrial orga-

[23] Explicitly, it is $\Delta\epsilon_{bb} = \Delta\frac{\Delta\% w_{bb}}{\Delta\% p_b}$. I evaluate the right hand side for a standard deviation change in p_b, or $\frac{\sigma^{\text{bun}}}{\mu^{\text{bun}}}$. For a mix of n_1 networks of type 1 and n_2 networks of type 2, $\mu^{\text{bun}} = (n_1 + \lambda n_2)\mu$ and $\sigma^{\text{bun}} = (\sqrt{n_1 + n_2})\sigma$, implying $\frac{\Delta\epsilon_{bb}}{\Delta\% w_{bb}} = \frac{\mu}{\sigma} * (\frac{n_1+\lambda n_2+1}{\sqrt{n_1+n_2+1}} - \frac{n_1+\lambda n_2}{\sqrt{n_1+n_2}})$. n_1 and n_2 were evaluated at their sample means, 7 and 24. As tastes for other networks are plausibly much lower than tastes for the top-15 satellite networks, λ was set to 0.20.

[24] The first assumption is the more important one. Any cost savings from bundling will increase the benefits of bundling relative to the ones reported here.

[25] Note the mean is a fair bit higher than that obtained by direct calculation (cf. footnote 18). As a consequence, the simplified model over-predicts market shares by approximately six percentage points. This is unlikely to affect the calculated profitability of bundling relative to component sales, but may cause a slight upward bias in the calculated dollar magnitude of estimated costs and benefits.

nization, marketing, and business strategy, this is the first paper to explicitly test the implications of this theory and quantify its empirical relevance.

I do so by analyzing bundling in the cable television industry. The industry provides an ideal environment in many ways, not least of which is the fundamental role bundling plays in systems' strategic decision-making. While there is little heterogeneity in patterns of bundling across systems, there is considerable heterogeneity in the contents of bundles themselves. This permits testing the discriminatory theory by examining the impact to the level and (especially) the slope of the bundle demand curve from changes in bundle size. Specifically, the discriminatory theory predicts that demand should flatten with increases in bundle size as a consequence of the reduction in taste heterogeneity from bundling.

The results provide strong support for the discriminatory theory. For the preferred specification, carriage of 14 of the top-15 cable television networks is found to increase the elasticity of the (Basic) cable demand curve. Furthermore, as predicted by the theory, the effect of bundling on heterogeneity reduction is greater for special-interest networks than for general-interest networks. Analysis of the welfare consequences of bundling in a simple approximation to cable television markets are suggestive of the empirical importance of these effects: bundling the average number of top-15 cable networks offered on Basic cable service (7) increases profits relative to unbundled (component) sales, but decreases consumers surplus by an amount equal to a 4.2% increase in the price of cable. On balance, however, total surplus *increases*.

One must be careful extrapolating the findings from this simple setting to conclusions about the profitability of bundling in cable: depending on the technology available to systems, unbundling networks may be quite costly, something not captured in the model in this paper. The results above are meant to quantify how much bundling *could* impact welfare in cable markets, not necessarily how much they do. This is unfortunate, of course, as quantifying the welfare consequences of bundling might well serve regulators concerned about the market power of cable systems and the inability of price regulation or competition to limit this power (Crawford (2000), Goolsbee and Petrin (2001)). Extending the research here by explicitly modeling preference heterogeneity for the components of cable bundles and documenting the consequences to consumer and producer surplus of bundling is a topic of ongoing research (Coppejans and Crawford (1999)).

While precise conclusions are impossible, the results do suggest that bundling can significantly impact consumer and producer welfare in cable markets. An important implication of this finding is that the product choices of firms can be as important as prices in impacting consumer and social welfare. This nicely complements similar findings in the industrial organization literature of the welfare consequences of new goods (Griliches and Cockburn (1994), Bresnahan and Gordon (1996), Petrin (1999)). It also highlights the importance of extending models of price competition widely used in merger and regulatory analysis to consider product choice as well (Nevo (2001), Pakes, Berry, and Levinsohn (1993)). Indeed, given the recent unbundling of elements of the local telephone, electric power, and software markets, assessing the benefits of extending competition and regulatory policymaking in this dimension is an important area of further research. The results presented here suggest there may be short-run social *losses* from unbundling which must be balanced against the gains from increased competition in components markets. Establishing empirical regularities of the competitive consequences of bundling is therefore of considerable interest.

A Appendix

In this appendix, I present an analysis of the instruments used for prices and network carriage in the econometric analysis and present additional results based on MSO-based instruments outside a system's state.

A.1 Power of the Instruments

Price Instruments To assess the power of the price instruments, Table 5 presents results from reduced form regressions of prices on the instruments and exogenous variables.[26] The results are organized in sets of three columns. For each set of three, the first column reports the point estimates from the regression of the price of Basic service, p_b, on the instruments and included exogenous variables. Similarly in the second and third columns for the price of Expanded Basic services I and II, p_I and p_{II}, if offered.

The first set of three columns report estimates using cost shifters as instruments for cable prices. As these shifters do not vary across services, I interact them with cable service dummy variables to allow their effects to differ by service. Reported are the estimated parameters for these interactions.[27] Evidence in support of the cost instruments is mixed. While homes passed does not appear to be an important cost shifter in any equation, the remaining variables enter intermittently. Most influential are affiliation (negative and significant in the first and third columns) and MSO subscribers and its square (negative for large values and occasionally significant in the first and third columns). Channel capacity enters as expected only in the second column. That said, p-values associated with the hypothesis test of joint insignificance for all parameters are trivially small in all but the Expanded I equation.[28] On balance, while supporting their use as instruments, lack of variation across services and an indirect connection to marginal costs suggests the cost shifters may be weak instruments.

The second set of three columns report estimates using prices of cable services of other systems within an MSO as instruments.[29] The results are quite promising. Other-system prices within an

[26] Only results for the instruments are reported here.

[27] Note since all systems that offer an Expanded Service also offer a Basic Service, separate parameters are not identified for the Expanded I parameters in the second column. For an analogous reason, separate parameters aren't identified for either Expanded Service in the third column.

[28] Note that because of the cross-equation restrictions on β and η, identification obtains as long as the instruments are valid for at least one of the endogenous prices.

[29] Not all systems belong to an MSO. To address this issue, I pool systems with a single owner and treat them as other MSOs: including as a value for the instrument in market n the average price for all single-owner systems other than that in n. While the argument advocating marginal costs are correlated is weaker in this case than in the case of a common owner, single-owner systems tend to be smaller than average and, due to a common disadvantage when bargaining with network providers, have similar marginal costs.

MSO provide strong and significant effects for both Basic and Expanded I equations, particularly for prices of the same service. Results for a second expanded service are poor, possibly due to relatively few observations. As expected, p-values associated with the hypothesis of joint insignificance are soundly rejected for the Basic and Expanded I equations.

Network Instruments To assess the power of the network instruments, Table 6 presents a synopsis of reduced form (probit) regressions of network carriage on the instruments and included exogenous variables. As above, the results are organized in sets of three columns. As I must predict the carriage of each of the top-15 cable networks (as well as the sum of other cable networks) on all the exogenous variables and instruments, the number of estimations performed was considerable.[30] Rather than report the point estimates of the instruments for each specification, I simply report the p-value from the hypothesis test of joint insignificance of the instrument set. As can be seen from the table, the instruments have considerable power, at least for the Basic and first Expanded Basic equation.[31] Coefficient estimates were as expected - particularly powerful predictors of the carriage of network q on service s was the corresponding likelihood it was carried on service s by other systems within its MSO.

A.2 Out-of-state MSO Instruments

As discussed in section 4.2.1, the primary concern with the use of prices in other markets as instruments is that there may be correlation in demand across these markets that would violate the assumption of mean independence between the instruments and errors. To address this concern, I construct variations of the instruments described in the text - the average price or network carriage of all systems sharing the same owner (MSO) as the given system - based on systems outside the state each given system. The results from these specifications are reported in Table 7 for the latter two specifications presented in Table 4. For reference, these are duplicated here, under the same column headings (3) and (4), for comparison to their analogues using the new instruments, labeled (3') and (4').

The results of the new analysis largely replicate those obtained in Table 4. Of particular interest is the impact to the number and significance of the slope effects. These are largely unaffected in sign (falling from 12 to 11 under the assumption of exogenous network carriage and from 10 to 9 when instrumenting for networks), but fall dramatically in precision. This reduction in precision

[30] Specifically 16 networks * 3 services = 48 specifications.

[31] The problem of imprecision seen in the third column of the price regressions was exacerbated in the network carriage specifications. For some networks, only one or two of the 178 systems that offered a second Expanded Basic service carried that network on that service, implying an inability to identify the effects of any instruments. Analogously to that described above, identification of the parameters of interest requires the instruments have power for carriage on at least one service.

also affects the estimated level effects, no doubt as a consequence of the reduction in sample size from excluding systems whose owner only owns systems in a single state and for whom the new instrument set is therefore undefined. As the loss in precision comes without significant impact to my previous conclusions, I maintain a preference for the results presented in the body of the paper.

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Table 1: Summary Statistics

Variable	Mean	SDev	Min	Max
Expanded Basic Services				
Any Exp. Basic Svcs.	0.38	0.48	0.00	1.00
One Exp. Basic Svc.	0.22	0.42	0.00	1.00
Two Exp. Basic Svcs.	0.15	0.36	0.00	1.00
Market Shares				
w_{Basic}	0.68	0.15	0.18	0.99
$w_{\text{Exp. I}}$	0.23	0.31	0.00	0.98
$w_{\text{Exp. II}}$	0.08	0.21	0.00	0.98
Programming				
Broadcast Networks				
Over-the-Air	2.60	1.41	0.00	8.00
On Cable	5.84	2.03	0.00	13.00
Cable Networks				
Individual Networks		See Table 2		
Top-15 on Basic	7.66	4.05	0.00	15.00
Top-15 on Exp. I	2.38	3.94	0.00	15.00
Top-15 on Exp. II	0.42	1.14	0.00	10.00
Top-15 on Any Basic	17.12	7.82	1.00	47.00
Other than Top-15 on Basic	4.84	4.11	0.00	32.00
Other than Top-15 on Exp. I	1.53	3.45	0.00	23.00
Other than Top-15 on Exp. II	0.29	1.01	0.00	12.00
Other than Top-15 on Any Basic	6.66	5.08	0.00	32.00
Other Channels on Basic	13.88	10.44	0.00	56.00
Prices				
p_{Basic}	17.30	4.83	4.42	37.07
$p_{\text{Exp. I}}$	2.88	5.07	0.00	24.08
$p_{\text{Exp. II}}$	0.67	1.73	0.00	14.73
Instruments				
Homes Passed (000s)	5.04	17.37	0.05	275.39
MSO Subscribers (000s)	79.28	194.18	0.00	1200.00
Affiliation	0.09	0.29	0.00	1.00
Channel Capacity	39.21	13.88	6.00	110.00

Notes: Sample is 1,169 U.S. cable systems. Cable data from *The Cable and Television Factbook, vol. 64 (1996)* by Warren Publishing. Over-the-air broadcast programming defined as "Significantly Viewed" broadcast stations by county from *Cable and Station Coverage Atlas, 1987* by Television Digest, Inc. All systems offer Basic Service and up to two Expanded Basic Services, indexed by *I* and *II*. Market shares defined as subscribers divided by homes passed, defined as households able to purchase cable services from each system. Top-15 Networks defined in Table 3. Multiple System Operator (MSO) Subscribers defined as the total subscribers to all systems owned by same firm. Affiliation equals 1 if system owned by MSO with ownership interests in programming networks. Homes Passed and MSO Subscribers measured in thousands. See Crawford (2000) for more detail on data sources.

Table 2: Summary Statistics, Top-15 Cable Networks

Services	Any Basic	Basic	Expanded Basic I	Expanded Basic II
TBS	0.98	0.77	0.10	0.11
Discovery	0.83	0.54	0.24	0.05
ESPN	0.98	0.79	0.19	0.01
USA Network	0.87	0.60	0.26	0.02
C-SPAN	0.42	0.36	0.06	0.00
Top-5	4.09	3.05	0.85	0.18
TNT	0.81	0.55	0.20	0.06
Family	0.92	0.69	0.19	0.04
TNN	0.93	0.63	0.25	0.06
Lifetime	0.51	0.36	0.15	0.00
CNN	0.96	0.67	0.25	0.04
Top-10	8.22	5.94	1.89	0.39
A&E	0.52	0.39	0.13	0.00
Weather	0.47	0.30	0.15	0.02
QVC	0.51	0.47	0.04	0.00
TLC	0.24	0.19	0.05	0.00
MTV	0.51	0.38	0.13	0.00
Top-15	10.46	7.66	2.38	0.42
Other Cable Nets.	6.66	4.84	1.53	0.29
Total Cable Nets.	17.12	12.50	3.91	0.71

Notes: Reported are the proportion of sample systems carrying each top-15 network on Basic Service, Expanded Basic Service I, or Expanded Basic Service II and corresponding average number of networks offered. 1st column reports carriage on *any* offered service (Any Basic). Remaining columns disaggregate carriage by service.

Table 3: Top-15 Cable Programming Networks

Rank	Network	Subscribers (millions)	Proramming Format
1	TBS Superstation	77.0	General Interest
2	Discovery Channel	76.4	Nature
3	ESPN	76.2	Sports
4	USA Network	75.8	General Interest
5	C-SPAN	75.7	Public Affairs
6	TNT	75.6	General Interest
7	FOX Family Channel	74.0	General Interest/Kids
8	TNN (The Nashville Network)	74.0	General Interest/Country
9	Lifetime Television	73.4	Women's
10	CNN (Cable News Network)	73.0	News
11	A&E	73.0	General Interest
12	The Weather Channel	72.0	Weather
13	QVC	70.1	Home Shopping
14	The Learning Channel (TLC)	70.0	Science
15	MTV: Music Television	69.4	Music

Notes: Data on network subscribers from NCTA (1998). Data on programming formats from individual network promotional material (available from http://www.ncta.com), NCTA (1998), or industry sources.

Table 4: Estimates of the Impact of the Addition of Cable Networks on Cable Demand

Specification	(1)		(2)		(3)		(4)	
	Level Effects	**Slope Effects**	**Level Effects**	**Slope Effects**	**Level Effects**	**Slope Effects**	**Level Effects**	**Slope Effects**
WTBS	**1.03**	**-0.03**	**1.11**	**-0.04**	**1.04**	**-0.03**	**1.79**	**-0.13**
	(0.18)	(0.01)	(0.21)	(0.01)	(0.19)	(0.01)	(0.62)	(0.05)
Discovery	0.10	0.00	0.11	0.00	0.14	-0.01	**0.91**	-0.05
	(0.11)	(0.01)	(0.12)	(0.01)	(0.12)	(0.01)	(0.62)	(0.05)
ESPN	0.29	**-0.02**	**0.35**	-0.01	**0.45**	**-0.02**	**0.96**	-0.06
	(0.23)	(0.01)	(0.26)	(0.01)	(0.26)	(0.01)	(0.75)	(0.06)
USA	**0.18**	-0.01	0.18	0.00	**0.21**	-0.01	**1.35**	-0.06
	(0.13)	(0.01)	(0.14)	(0.01)	(0.14)	(0.01)	(0.76)	(0.05)
CSPAN	0.16	-0.01	0.40	-0.03	0.41	-0.03	0.82	-0.08
	(0.49)	(0.03)	(0.47)	(0.03)	(0.45)	(0.03)	(1.15)	(0.07)
TNT	0.02	-0.01	-0.05	0.00	-0.02	0.00	0.94	**-0.07**
	(0.13)	(0.01)	(0.13)	(0.01)	(0.13)	(0.01)	(0.84)	(0.05)
Family	-0.31	0.01	-0.34	0.01	-0.29	0.01	-0.88	0.08
	(0.15)	(0.01)	(0.15)	(0.01)	(0.15)	(0.01)	(1.30)	(0.09)
Nashville	0.03	**-0.02**	0.00	**-0.01**	0.02	**-0.01**	-1.62	0.04
	(0.13)	(0.01)	(0.13)	(0.01)	(0.13)	(0.01)	(0.88)	(0.06)
Lifetime	**0.33**	**-0.03**	**0.31**	**-0.03**	**0.30**	**-0.03**	0.04	-0.03
	(0.17)	(0.01)	(0.17)	(0.01)	(0.17)	(0.01)	(1.27)	(0.08)
CNN	0.04	**-0.02**	0.10	**-0.02**	0.12	**-0.02**	-0.43	0.01
	(0.13)	(0.01)	(0.13)	(0.01)	(0.13)	(0.01)	(0.57)	(0.05)
A&E	-0.24	0.00	-0.41	0.01	-0.39	0.01	-1.21	0.06
	(0.25)	(0.01)	(0.26)	(0.01)	(0.26)	(0.01)	(1.23)	(0.07)
Weather	0.07	-0.01	0.09	-0.01	0.08	-0.01	-1.03	0.10
	(0.14)	(0.01)	(0.14)	(0.01)	(0.14)	(0.01)	(0.88)	(0.06)
QVC	**0.56**	**-0.04**	**0.65**	**-0.05**	**0.50**	**-0.04**	0.82	**-0.07**
	(0.36)	(0.02)	(0.36)	(0.02)	(0.34)	(0.02)	(0.81)	(0.05)
Learning	**0.83**	**-0.06**	**0.92**	**-0.07**	**0.90**	**-0.06**	**3.43**	**-0.17**
	(0.42)	(0.02)	(0.44)	(0.03)	(0.44)	(0.02)	(1.71)	(0.10)
MTV	0.12	-0.02	0.01	-0.01	-0.04	-0.01	0.12	-0.03
	(0.30)	(0.02)	(0.29)	(0.02)	(0.30)	(0.02)	(1.02)	(0.06)
Other Nets.	-0.21	—	-0.22	—	-0.21	—	-0.28	—
	(0.03)		(0.03)		(0.03)		(0.06)	
Bundle Size	—	0.01	—	0.01	—	0.01	—	0.01
		(0.00)		(0.00)		(0.00)		(0.00)
Average Top-15 Effect	**0.21**	**-0.02**	**0.23**	**-0.02**	**0.23**	**-0.02**	**0.40**	**-0.03**
	(0.04)	(0.00)	(0.05)	(0.00)	(0.04)	(0.00)	(0.11)	(0.01)
Average Price Sensitivity (b/I/II)	(-0.05/-0.10/-0.12)		(-0.09/-0.27/-0.31)		(-0.09/-0.23/-0.31)		(-0.09/-0.14/0.00)	
(Expected Sign/Significant)	(13/5)	(12/7)	(12/5)	(10/6)	(11/6)	(12/7)	(10/5)	(10/4)
Number that increase ϵ_{bb}	15		15		14		12	
Price Instruments	None		Cost		MSO Prices		MSO Prices	
Network Instruments	None		None		None		MSO Networks	

Notes: Reported in each pair of columns are results from joint estimation of aggregate demand for Basic Service (b) and up to two Expanded Basic Services, (I, II). Number of observations is 1,169 for Basic, 439 for Expanded I, and 178 for Expanded II. Reported parameter estimates are constrained to be the same across services. Broadcast programming, demographic variables, and region dummies also included in all specifications. Specifications differ in their choice of instruments; see table bottom for instruments and Section 4.2.1 for instrument definitions. Columns report β and η, the impact of adding the reported cable network to the level and slope of demand. Also reported is average price sensitivity for each service, $alpha_s + X_{sn}'\eta + D_n'\iota$, the number of level and slope effects of the expected sign and statistically significant, and the number of networks estimated to increase the average own-price elasticity of Basic service, ϵ_{bb}.

Table 5: First-Stage Estimation, Prices

Price Inst: Cost				Price Inst: MSO Prices			
	Dependent Variable				Dependent Variable		
Instrument	p_b	p_I	p_{II}	Instrument	p_b	p_I	p_{II}
Homes Passed, Basic	0.00	0.00	0.00	IPB	0.64	0.03	0.13
	(0.03)	(0.01)	(0.01)		(0.07)	(0.10)	(0.20)
MSO Subs, Basic	0.01	0.00	-0.03	IPE	-0.03	0.34	-0.17
	(0.01)	(0.01)	(0.02)		(0.12)	(0.13)	(0.31)
MSO Subs^2, Basic	0.00	0.00	0.00	IPF	-0.22	0.48	-0.41
	(0.00)	(0.00)	(0.00)		(0.24)	(0.42)	(0.42)
Affiliation, Basic	-3.48	0.96	0.36				
	(1.22)	(2.13)	(1.48)				
Channel Capacity, Basic	0.03	0.02	0.00				
	(0.08)	(0.02)	(0.00)				
Homes Passed, Expanded I	-0.02	—	—				
	(0.03)						
MSO Subs, Expanded I	0.00	—	—				
	(0.01)						
MSO Subs^2, Expanded I	0.00	—	—				
	(0.00)						
Affiliation, Expanded I	6.12	—	—				
	(3.83)						
Channel Capacity, Expanded I	-0.05	—	—				
	(0.02)						
Homes Passed, Expanded II	0.01	-0.01	—				
	(0.01)	(0.01)					
MSO Subs, Expanded II	0.06	-0.04	—				
	(0.03)	(0.04)					
MSO Subs^2, Expanded II	0.00	0.00	—				
	(0.00)	(0.00)					
Affiliation, Expanded II	-8.63	-1.54	—				
	(4.32)	(2.27)					
Channel Capacity, Expanded II	0.00	-0.01	—				
	(0.03)	(0.03)					
Observations	1,169	439	178	Observations	1,169	439	178
R-squared	0.649	0.818	0.888	R-square	0.720	0.818	0.888
p-value	0.000	0.567	0.000	p-value	0.000	0.029	0.350

Notes: Reported are results from reduced form estimation of prices for Basic Service (b) and up to two Expanded Basic Services, (I,II), on the instruments and exogenous variables. Results are organized in sets of three columns. The first set report estimates using Cost shifters as instruments, defined as homes passed, number and square of subscribers served by same firm (MSO), owner affiliation with programming networks, and channel capacity, interacted with cable service dummy variables. Separate effects for each service are not identified for some parameters in the Expanded Service equations. The second set of columns report estimates using MSO Prices as instruments, defined for each service as the average price for that service at other systems owned by the same MSO. Reported p-value in each column is for hypothesis test of joint insignificance of reported parameters.

Table 6: First-Stage Estimation, Network Carriage

	Dependent Variable		
Instrument	NET_b	NET_I	NET_{II}
WTBS	<0.001	<0.001	0.002
Discovery	<0.001	<0.001	0.240
ESPN	<0.001	0.029	0.249
USA	<0.001	0.020	0.082
CSPAN	<0.001	0.229	—–
TNT	<0.001	<0.001	0.065
Family	<0.001	<0.001	0.701
Nashville	<0.001	0.001	0.222
Lifetime	<0.001	<0.001	—–
CNN	<0.001	<0.001	—–
A&E	<0.001	0.016	—–
Weather	<0.001	<0.001	0.067
QVC	<0.001	0.089	—–
Learning	<0.001	0.084	—–
MTV	<0.001	0.011	—–
Other Satellite	<0.001	<0.001	<0.001
Observations	1,169	439	178

Notes: Reported are results of reduced form (probit) estimation of the carriage of each reported network on Basic Service (b) and up to two Expanded Basic Services, (I,II), on the instruments and exogenous variables. All specifications use MSO Networks as network instruments, defined for each network on each service as the proportion of other systems owned by the same MSO carrying that network on that service. Reported are p-values for hypothesis test of joint insignificance of network instruments. Lack of carriage on Expanded Service II prevented identification of the impact of instruments for some networks.

Table 7: Estimates of the Impact of the Addition of Cable Networks on Cable Demand

Using Out-of-State Systems to Define MSO Instruments

Specification	(3)		(3')		(4)		(4')	
	Level Effects	**Slope Effects**	**Level Effects**	**Slope Effects**	**Level Effects**	**Slope Effects**	**Level Effects**	**Slope Effects**
WTBS	**1.04**	**-0.03**	**1.13**	**-0.04**	**1.79**	**-0.13**	**1.90**	**-0.14**
	(0.19)	(0.01)	(0.21)	(0.02)	(0.62)	(0.05)	(0.75)	(0.07)
Discovery	0.14	-0.01	0.09	-0.00	**0.91**	-0.05	0.05	0.01
	(0.12)	(0.01)	(0.12)	(0.01)	(0.62)	(0.05)	(0.26)	(0.03)
ESPN	**0.45**	**-0.02**	**0.45**	**-0.03**	**0.96**	-0.06	1.02	-0.04
	(0.26)	(0.01)	(0.27)	(0.01)	(0.75)	(0.06)	(0.82)	(0.07)
USA	**0.21**	-0.01	**0.18**	-0.01	**1.35**	-0.06	0.45	0.00
	(0.14)	(0.01)	(0.14)	(0.01)	(0.76)	(0.05)	(0.80)	(0.05)
CSPAN	0.41	-0.03	0.29	-0.02	0.82	-0.08	0.17	-0.06
	(0.45)	(0.03)	(0.50)	(0.03)	(1.15)	(0.07)	(1.32)	(0.08)
TNT	-0.02	0.00	-0.19	0.01	0.94	**-0.07**	-2.46	0.15
	(0.13)	(0.01)	(0.14)	(0.01)	(0.84)	(0.05)	(1.33)	(0.09)
Family	-0.29	0.01	-0.33	0.01	-0.88	0.08	0.26	-0.05
	(0.15)	(0.01)	(0.15)	(0.01)	(1.30)	(0.09)	(1.27)	(0.09)
Nashville	0.02	**-0.01**	-0.08	-0.00	-1.62	0.04	-0.92	0.04
	(0.13)	(0.01)	(0.13)	(0.01)	(0.88)	(0.06)	(0.84)	(0.06)
Lifetime	**0.30**	**-0.03**	0.21	**-0.03**	0.04	-0.03	-1.49	0.06
	(0.17)	(0.01)	(0.17)	(0.01)	(1.27)	(0.08)	(1.25)	(0.09)
CNN	0.12	**-0.02**	-0.06	-0.01	-0.43	0.01	0.27	-0.05
	(0.13)	(0.01)	(0.13)	(0.01)	(0.57)	(0.05)	(0.60)	(0.05)
A&E	-0.39	0.01	-0.27	0.01	-1.21	0.06	-0.14	-0.00
	(0.26)	(0.01)	(0.27)	(0.01)	(1.23)	(0.07)	(1.19)	(0.07)
Weather	0.08	-0.01	0.01	-0.00	-1.03	0.10	-0.49	0.03
	(0.141)	(0.009)	(0.139)	(0.009)	(0.879)	(0.063)	(0.781)	(0.060)
QVC	**0.50**	**-0.04**	0.40	**-0.03**	0.82	**-0.07**	0.96	-0.06
	(0.34)	(0.02)	(0.34)	(0.02)	(0.81)	(0.05)	(0.88)	(0.06)
Learning	**0.90**	**-0.06**	**0.95**	**-0.07**	**3.43**	**-0.17**	2.08	-0.08
	(0.44)	(0.02)	(0.49)	(0.03)	(1.71)	(0.10)	(1.67)	(0.10)
MTV	-0.04	-0.01	-0.24	0.01	0.12	-0.03	0.67	-0.05
	(0.30)	(0.02)	(0.29)	(0.02)	(1.02)	(0.06)	(1.37)	(0.09)
Other Nets.	-0.21	—	-0.15	—	-0.28	—	-0.04	—
	(0.03)		(0.04)		(0.06)		(0.10)	
Bundle Size	—	0.01	—	0.01	—	0.01	—	0.01
		(0.00)		(0.00)		(0.00)		(0.01)
Average Top-15 Effect	**0.23**	**-0.02**	**0.17**	**-0.01**	**0.40**	**-0.03**	0.15	**-0.02**
	(0.04)	(0.00)	(0.05)	(0.00)	(0.11)	(0.01)	(0.13)	(0.01)
Average Price Sensitivity (b/I/II)	(-0.09/-0.27/-0.31)		(-0.06/-0.23/-0.13)		(-0.09/-0.14/0.00)		(-0.06/-0.19/-0.08)	
(Expected Sign/Significant)	(11/6)	(12/7)	(9/4)	(11/5)	(10/5)	(10/4)	(10/1)	(9/1)
Number that increase ϵ_{bb}	14		12		12		9	
Observations	1,169		999		1,169		999	
Price Instruments	MSO Prices		MSO Prices Out-State		MSO Prices		MSO Prices Out-State	
Network Instruments	None		None		MSO Networks		MSO Networks Out-State	

Notes: Reported in each pair of columns are results from joint estimation of aggregate demand for Basic Service (b) and up to two Expanded Basic Services, (I,II). See Table 4 for further details. Specifications differ in their choice of instruments. Specifications (3) and (4) are duplicated from Table 4. Specifications (3') and (4') differ in their definition of MSO instruments: here only systems sharing the same owner (MSO) and operating in a different state are used to construct instruments. This reduces the number of observations to 999 for these specifications.

Figure 1: Bundling versus Component Sales: An Example

Source: Adams and Yellen (1976).

Figure 2: Demand Per Good by Bundle Size

Source: Bakos and Brynjolfsson (1999).