

Evaluating wholesale and retail mergers in pharmaceuticals[†]

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1. Introduction. The price and quality of service of a drug is the result of the transactions and efforts of various agents. Manufacturers, importers/traders, wholesalers/distributors, retailers (whether pharmacies or dispensers), and the regulator, all participate in a supply chain aimed at making the drugs available to the patients, and this is without adding research and development units to the long list. The links between manufacturers, importers and wholesalers can be complex as we can have manufacturers that sell directly to retailers (vertically integrated), manufacturers that have dedicated wholesalers, manufacturers that sell to multiple wholesalers, wholesalers that carry only certain drugs (short-line wholesalers), and wholesalers that provide the full range of medicines (full-line wholesalers). Examples of vertical relations and integrations in the pharmaceutical market are provided in [Cockburn \(2004\)](#); [Guedj \(2005\)](#); [Stuart et al. \(2007\)](#); [Kubo \(2011\)](#); [Jetly et al. \(2012\)](#). Furthermore, the industry is dynamic where entry/exit and horizontal and vertical mergers often occur, either as a response to market shocks or as the result of strategic behavior.

A leading example of a recent vertical merger is Alliance Boots, which is both a pharmacy chain in the UK and eight other countries, as well as a pharmaceutical wholesale business operating in 20 countries and is increasingly developing its own product brands. In a recent move (June, 2012) Alliance Boots announced that it is also entering into a strategic partnership with Wallgreen Co., already the largest US pharmacy chain. Since the early works by [Spengler \(1950\)](#), [Stigler \(1951\)](#) and [Mussa and Rosen \(1978\)](#) much has been learnt on the principle of vertical integration in supply chains, and with the subsequent economic literature on contractual relations (see [Katz \(1989\)](#) for an overview) many facets of possible strategies have been explained. Nevertheless, the literature is still progressing and the current focus is on nonlinear pricing within vertical contracts and the strategic role of discounts ([Calzolari and Denicoló, 2013](#)) - a variable of interest in [Bokhari and Mariuzzo \(2014\)](#) as well. Discounts between manufacturers and wholesalers, or wholesalers and retailers are legal within the EU, and are matched with the claw-back system in the UK, (see [Kanavos \(2003\)](#); [Vogler et al. \(2009\)](#)).

In most European countries there is some form of regulation on mark-ups in the supply chain (see [Ball \(2011\)](#) for a review of regulation in low, medium and high income countries). Mark-up regulation in the pharmaceutical industry has received attention in specialized field literature.

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Enemark et al. (2004) discusses alternative tools to regulate mark-ups for the whole supply chain while a finer separate research for wholesalers and retailers is offered by Rietveld and Haaijer-Ruskamp (2002).

The complexity of the vertical relations maps into significant diversity in the market structure of wholesalers and retailers across different countries. For example, for a selected sample of six major European countries (France, Germany, Italy, Spain, Sweden and the UK) the number of full-line retailers ranges from 2 to 84, the number of pharmacies is between 1,247 and 20,934, and the sales per capita (in EUR) vary from 175 to more than double that figure. Even if we account for country size and GDP, country level variation in number and type of wholesalers persists – full-line, specialized or mid-line, number of warehouses, as well as the average number of deliveries per day – indicating that wholesaling, like most other products and services, is a differentiated service (see Table 1). In turn, this implies that looking at simple market shares of individual firms pre proposed merger, and adding them up to predict shares of the newly merged firm will not be a good indicator of change in market power and/or price cost margins (as one could do for a homogenous service/good).¹

TABLE 1. Sample European country supply chain.

Variables	France	Germany	Italy	Spain	Sweden	UK
Population	65,327,724	81,843,743	60,820,696	46,196,276	9,417,570	62,989,551
GDP per capita (EUR)	31,986	32,299	25,700	23,100	41,108	30,000
Full-line Wholesalers	17	13	84	51	2	9
Pharmacies	22,198	20,934	18,021	21,500	1,247	14,179
Dispensing Doctors	88	0	0	na	na	2,239
Warehouses	180	111	na	150	5	57
Sales per capita (EUR)	na	309	181	254	363	175
Average delivery frequency per day	2	3	3	3	1	2

Source: Authors' compilation from 'Wholesalers' Directory, Country Profiles' GRIP - European Association of Pharmaceutical Full-line Wholesalers, <http://girp.eu/members/wholesalers>

As highlighted by Kanavos et al. (2011), in the recent years nearly all European countries had to cope with horizontal mergers in the wholesaler and retailer sectors, and most of the mergers occurred at the retailer level with the establishment of large pharmacy chains. Horizontal mergers can impact price cost margins and eventually consumer welfare. Jacobzone (2000) documents that the percentage mark-up for wholesalers ranges between 2 and 21 and for retailers between 4 and 50 (importers also contribute to the mark-up, but their figures are not available).

Our purpose is to develop an understanding of how horizontal mergers at the wholesale and retail level affect the market outcomes in the pharmaceutical regulated market. For instance, when two or more wholesalers merge, how does it effect the wholesale mark-up, especially if the regulators have already set a maximum limit for wholesale mark-up over the ex-manufacturer price? Is this simply a change in rent from retail pharmacy to wholesaler due to a change in level of discounts offered to retailers, or are there significant implications for consumers? Particularly, how much of the

¹One contemporaneous issue which is possibly related to the average delivery of the supply chain is the occurrence of medicine shortages. As pointed out in, "Medicine shortages in European community pharmacies" (PGEU - Pharmaceutical Group of European Union, 2012) in the EU such phenomenon is increasing and affects various classes of medicines, from complex chemotherapy drugs, to diabetes, hypertension, and asthma medication. This is considered a major issue of concern for the pharmacists community and a problem to be tackled jointly by health and competition authorities in developed countries.

increased mark-up by wholesalers is absorbed by retail pharmacies, and what percentage is passed through to the final payers (third party payers such as private or national insurance, national health care system or individual patients)? Equally important, since consumers care for both, the price of medicine but also the quality of pharmacies that dispense otherwise same products (availability and advice from a trained pharmacist, location of store, hours of operation, computerized records, and automated reminders to patients for refills), how do the changing mark-ups effect the quality of services at these pharmacies?

Using a simple model with two differentiated retailers and two homogenous wholesalers, [Bokhari and Mariuzzo \(2014\)](#) describe how changes in structure or conduct at one level can effect performance at another. In particular, they show that a decrease in equilibrium level of discounts by the wholesalers (say because they have merged) unambiguously increases the prices that the retailers charge. However, the increase in retail price is not dollar-for-dollar, i.e., if the discount decreases by a dollar, the retail level price will (typically) increase by less than a dollar and the quality of services at the two pharmacies will also decrease. In this situation there would a decrease in consumer welfare. However, if the cross-price effect is larger than own-price effect for one of the pharmacies, then the price in that pharmacy can increase by more than a dollar, but the equilibrium quality of services will also increase in that store.² In equilibrium its pass-through rate will be greater than one, and its quality will be higher.³ In such cases the change in consumer welfare effect is ambiguous, and primarily an empirical issue.

From the perspective of evaluating a proposed horizontal merger – either at the wholesale level, or at the retail level to form a national or regional pharmacy chain – it is vital that the regulating authorities estimate predicted changes in firm level profits and consumer welfare in order to balance these against any cost saving or synergies associated with the merger. With that in mind, we describe in this paper the type of data that a researcher must acquire, as well as econometric methods they can employ to evaluate the changes in the prices, price-cost margins and consumer welfare. We adapt techniques that are standard in the horizontal merger literature, to pharmacy data and explain the effect on market outcomes of horizontal mergers at various levels of the distribution. The analysis is carried out with a generalization of the intuition provided in economic models of differentiated products by multiple firms, but because of difficulties in acquiring (or aggregating) data at the wholesaler level, we center the estimation problem around retailers' data.

2. Preliminary Considerations. In this section we describe some practical aspects of evaluating the impact of a horizontal merger either at the pharmacy level or at the wholesale level. The methods we describe below allow for multiple wholesalers and pharmacy chains, and for each chain to have multiple outlets within a geographic market (for example a city). Our objective is to outline an estimation strategy that relies primarily on pharmacy level sales data – which is usually available from third party commercial companies specialized in collection of sales data.

While there are alternative approaches to evaluating horizontal mergers, as highlighted in [Jacquemin and Slade \(1989\)](#) and in [Davies and Bruce \(2008\)](#), one that has gained considerable popularity is where researchers predict post-merger prices based on demand estimation from pre-merger data (see [Nevo \(2001\)](#); [Mariuzzo et al. \(2007\)](#); [Bokhari \(2013\)](#)). The attraction of this method comes from

²The cross-price effects cannot be larger than own price effects for both the pharmacies without violating usual restrictions on diversion ratios of demand parameters, see [Shapiro \(1996\)](#).

³The intuition for the result is that when cross-price effect is larger than own-price effect for one of the pharmacies, say pharmacy 2, then a decrease in quantity demanded at that pharmacy due an increase in its own price is more than compensated by an increase in its demanded for an equivalent increase in the price of the competitor. Since the competitor (pharmacy 1) increases its price by less than the proportionate amount, pharmacy 2 can take advantage of this, and increase its price by more than the increase in its own cost.

the fact that cost data, which is typically not available at individual firm level, is not necessarily needed. For instance, a fundamental issue in merger analysis is to measure market power, which is measured by the price-cost margin (or the Lerner index), as

$$\frac{p - c}{p}$$

where p is the price and c is the marginal cost of the product under consideration. The problem is that data on marginal costs is not always available. Industrial economists address this problem by first estimating demand functions, and from these, mark-ups are then backed out. The intuition of this approach is most easily seen in the monopoly case, where for an arbitrary demand function $q = D(p, z; \theta)$ (q is quantity demanded, p is the price, z are the exogenous variables such as income, that shift demand curve and θ are the parameters of the demand function) the monopolist's profit maximizing price is found by solving the first order condition

$$p = c - [\partial D(\cdot)/\partial p]^{-1} D(\cdot) \quad (1)$$

which gives the inverse elasticity rule,

$$\frac{p^* - c(q(p^*))}{p^*} = -\frac{1}{\eta(p^*)} \quad (2)$$

where $\eta(p^*) = \frac{p}{q(p)} \frac{\partial D(\cdot)}{\partial p} \Big|_{p=p^*}$ is the price elasticity of demand at the profit maximizing price. Thus, if we can get a good estimate of elasticity of demand (by estimating the parameters θ of the demand function), we can infer this mark-up due to the inverse relationship given above. This reasoning extends to oligopoly case as well, where with several differentiated products, we can estimate a joint system of demand equations and infer the mark-ups for each firm using the full cross-price elasticity matrix.

We can adopt this general methodology to the pharmaceutical case with some small modifications. Consider the case where there are K pharmacies in a market, competing with each other on prices and quality of services to fill an order for a specified prescription. Let demand at pharmacy k be a function of its own price and price of competitors (R_k, R_{-k}), quality of services at own and other pharmacies (N_k, N_{-k}), exogenous market level demand shifters Z , and other unobserved random factors ϵ_k (for instance store level quality which is observed by patients but not by the econometrician), such that demand at pharmacy k is given by a general demand function

$$q_k = D_k(R_k, R_{-k}, N_k, N_{-k}, Z, \epsilon_k; \theta_k) \quad (3)$$

where θ_k are the parameters of the k th demand function (intercept and slope coefficients) and the subscript $-k$ indicates prices and qualities of all other $K - 1$ firms except the k th firm. Define the effective marginal cost \tilde{c}_k at pharmacy k as $\tilde{c}_k \equiv p_m(1 + \mu) - d_k + c_k$ where p_m is the ex-manufacturer price for the drug, μ is the maximum allowed mark-up by the wholesaler (set exogenously by a regulator), d_k is the discount the pharmacy obtains from the wholesaler and c_k it's own or internal marginal cost of actually filling the script (thus $p_m(1 + \mu) - d_k$ is the net ingredient cost of the drug for the pharmacy, and c_k is its own cost of filling the script). If we assume that pharmacy costs are linearly increasing in output and convex and increasing in quality (for instance, variable cost at pharmacy k is given by $TC(q_k, N_k) = \tilde{c}_k q_k + (1/2)N_k^2$), then it can be shown that each pharmacy would choose its price and quality at the levels that satisfy the relationships

$$\begin{aligned} R_k &= \tilde{c}_k - [\partial D_k(\cdot)/\partial R_k]^{-1} D_k(\cdot) \\ N_k &= (R_k - \tilde{c}_k)[\partial D_k(\cdot)/\partial N_k]. \end{aligned} \quad (4)$$

Note that but for the small change in notation, the first equation above is precisely the same as that specified earlier for the monopolist (equation (1)), and yields a similar relationship between

mark-ups and own and cross price elasticities as that given above, while the second condition is for setting the profit maximizing quality.

The exercise of estimating pre-merger mark-ups and/or predicting post-merger prices takes a three step procedure:

- (1) empirically estimate demand parameters and elasticities
- (2) infer mark-ups, and using current prices, back out marginal costs for each firm
- (3) using demand and cost estimates, allow proposed merging firms to engage in joint profit maximization to predict post-merger prices for all firms.

In general we can use this three step procedure to estimate mark-ups and/or predict post merger prices (or evaluate other policy interventions) at the *manufacturer level*. In that case there are clear cut J number of products produced and sold in the market by L multiproduct manufacturing firms that are maximizing profits by strategically setting the prices of these J products. However, at the retail or wholesale level, where the profit maximizing conditions need to be over potentially thousands of products being sold at the pharmacy, it is clear that some appropriate aggregation of data is needed.

3. Defining Quantity And Price At Pharmacy Level. Sales data is often available by individual products (brand name, manufacturer, strength, ATC4 and NFC3 level) and can be aggregated up to the pharmacy level. Thus we assume that such a data set is available to the investigator, and that it is possible to aggregate sales of individual drugs to pharmacy level within geographic markets. However, we do not assume that there is enough identifying information in the data to allow sales aggregation at the wholesale level (which could allow for direct methods to evaluate wholesale mergers, and hence we must be content with sales at pharmacy level). To be clear, we assume that it is possible to aggregate sales of a specific drug, e.g. methylphenidate HCL by manufacturer M , up to the level of pharmacy or pharmacy chain within geographic markets (defined either as national, regional or city) and time periods (monthly, quarterly or annual). Nonetheless, similar aggregation is not possible by wholesalers A, B, C , etc., i.e., sales of methylphenidate HCL by manufacturer M cannot be separately identified by wholesale routes A, B, C , etc., used to reach market T .

For the thousands of different drugs sold at a given pharmacy, each of these can be converted to a standard unit (SU) using ‘defined daily dosage’. For instance, 90 pills of 30mg tablets of immediate release methylphenidate HCL would be roughly one month supply or 30 SUs, while 30 pills of the same strength would be 10 SUs (assuming 30mg tabs have to be administered 3 times a day). Similarly, drugs in alternative forms (extended or sustained release tablets or capsules, oral liquids, ointments etc.) can be converted to SUs via defined daily dosages and hence aggregation over J different medicines in standard units (within a pharmacy) would then provide a measure of total quantity sold at the pharmacy per time period. Price of a standard unit would then be total revenue of the pharmacy (from all pharmaceutical products) over the same time period divided by the total number of SUs sold. Note that this is precisely the same as share weighted sum of price of individual SUs, where the share is defined as SUs of product j relative to all SUs.⁴ Next, the data can be aggregated from individual outlets to the pharmacy chain level (within each market) using sum of SUs across outlets as the total quantity for a given chain, and price for an SU at the chain could be derived as earlier. The main difficulty can arise in handling data for independent pharmacies, as

⁴For instance, for pharmacy k , $\bar{R}_k = \sum_j r_{jk} q_{jk} / \sum_j q_{jk} = \sum_j (q_{jk}/q_k) r_{jk}$. Alternative price indexes, such as share (of pharmacy revenue) weighted geometric means of individual prices (or equivalently the $\ln(R)_k = \sum_j s_{jk} (\ln r_{jk})$) would be very demanding in terms of data requirements as the researcher would then need to first construct shares of revenues for each of the J products.

observations are not repeated across geographic markets. If the share of independent pharmacies is not large, they can be aggregated into one group, as if they were one chain.

4. Demand Estimation. Standard demand estimation methods based on discrete choice models (e.g. logit, nested logit, or random coefficients logit) or on multi-stage budgeting by a representative consumer allocating their budget across choices (such as ‘almost ideal demand system’ – AIDS), can now be employed to compute demand parameters and to back out the marginal costs at the pharmacy level. The choice of which type of model to use, in part, depends on what the researcher is willing to assume about consumer preferences and substitution patterns between pharmacies, as well as the reality of quality of data (level of variation in prices, quantities, and number and relative shares of independent pharmacies). We briefly describe here one specific method, multi-stage budgeting with AIDS specification, as it is easy to implement and yet allows for a very flexible substitution pattern, in order to highlight how to use demand parameter estimates of pharmacies to draw inferences on changes in prices and quality post wholesale or retail horizontal merger (but other demand estimation methods can be used as well).

In a typical multi-stage budgeting model, a representative consumer faces a two level decision. First, given their income, demographics, pharmacy prices and quality of services at the pharmacies, consumer decides how much of their budget should be allocated to pharmaceutical products. And second, conditional on allocating a budget towards these medical products, how much to allocate across different pharmacies. That (a) the two stage-budgeting should lead to the same overall allocation across choices as they would be done in a single stage choice model, (b) that the ‘representative consumer’s’ choices result from a well defined utility function that aggregates over the distribution of the underlying population and (c), that the choice itself results from a utility maximization problem, imposes several requirements on the utility function. Typically we require that the overall utility is separably additive in the sub-utilities, and that the indirect utility functions for each subgroup are of the generalized Gorman polar form. These in turn lead to AIDS specifications for demand functions (for details see [Deaton and Muellbauer \(1980a,b\)](#)) at the lower level. The two-stage model can then be estimated as follows.

Let there be T markets (say cities and quarters) and K pharmacies per market, where $K - 1$ are the chains and the K th ‘pharmacy’ is a group of independent pharmacies within the market (henceforth we refer to them as just pharmacies rather than pharmacy chains). Let also S_{kt} be the revenue share of the k th pharmacy in market t . Then at the second stage (i.e., bottom-level) we specify S_{kt} as

$$S_{kt} = \alpha_k + \gamma_k \ln\left(\frac{E_t}{R_t}\right) + \sum_l \beta_{kl} \ln R_{lt} + \sum_l \theta_{kl} N_{lt} + \kappa_k Z_t + \phi_{kt} \quad (5)$$

where $\ln R_{kt}$ and N_{kt} are the log price and observable quality of the k th pharmacy and E_t is the total pharmaceutical expenditures on all pharmacies.⁵ The variable $\ln(R_t)$ is a pharmaceutical price index and can be constructed using the Stone price index as

$$\ln(R_t) = \sum_l \bar{S}_l \ln(R_{lt}) \quad (6)$$

where \bar{S}_k is the average share of pharmacy k either over time periods or geographic areas. Similarly, Z_t are market level characteristics that may effect demand/shares of specific chains (for instance demographic characteristics). Finally, the error term ϕ_{kt} captures unobserved characteristics of

⁵In general, quality will be multidimensional with measures such as number of stores/outlets in a market, average open hours per day, number of trained pharmacists, etc. for the k th pharmaceutical firm and can be included in the equation as a series of such variables.

individual pharmacy outlets within a market and may be correlated with shares, prices and observed chain-level quality, making both the price variables and the quality variables potentially endogenous. Considerations from consumer theory (regarding adding-up, homogeneity and symmetry of the Slutsky matrix) imply imposing

$$\sum_l^K \alpha_l = 1 \quad \sum_l^K \gamma_l = 0 \quad \sum_l^K \beta_{kl} = 0 \quad \sum_l^K \beta_{lk} = 0 \quad \beta_{lk} = \beta_{kl} \quad (7)$$

as restrictions on the parameters of the model.

At the top level is the overall demand for the pharmaceutical products and for the representative consumer can be written as

$$\ln Q_t = \alpha + \gamma \ln(Y_t) + \beta \ln R_t + \theta N_t + \kappa Z_t + \phi_t \quad (8)$$

where Q_t is the total quantity, Y_t is the real income, Z_t are the exogenous demand shifters, R_t is the overall price index for these products (constructed earlier as the Stone price index), and N_t is a quality index aggregated from chain level to market level (again it can be a share weighted average). Note also that due to the assumption of additive sub-utilities, we do not need to include price indexes of other segments such as housing, food, etc. in the top level equation (8).

Quality and price in equations (5) and (8) are endogenous and the researcher would need to find appropriate instruments for each. While there are no universally accepted set of instruments (as each situation is different), the assumption of common cost side shocks and lack of similar common demand side shocks has allowed researchers to use prices from other markets as instruments for prices in a given city in some cases (see [Hausman and Taylor \(1981\)](#); [Hausman \(1997\)](#); [Hausman et al. \(1994\)](#)). Hausman exploits the panel nature of his data (cities and time periods) and the assumption that prices in different cities are correlated via common cost shocks to use prices from one city as instruments for prices in the other city. The identifying assumption is that after controlling for brand specific intercepts (here chain specific intercepts) and demographics, the city specific valuations of a product are independent across cities, but may be correlated within a city over time. Given this assumption, the prices of the brand (chain pharmacies) in other cities are valid instruments, so that prices of pharmacy k in two cities will be correlated due to the common marginal cost (see first order conditions in equation (4)), but due to the independence assumption will be uncorrelated with the market specific valuation of the pharmacy. For similar reasons, we can use observed chain quality from another city as instrument for quality in the initial city.

5. Merger Simulations. Regression coefficients from equations (5) and (8) can be used to obtain conditional and unconditional elasticities, both for a specific market or all markets, or for the ‘average’ market in the sample (for an example of computing unconditional elasticities see [Bokhari and Fournier \(2013\)](#)). These in combination with actual observed (pre-merger) prices, quantities and qualities provide estimates of the unconditional demand parameters.⁶ Using equation (4), we can then back-out the ‘effective’ marginal cost for the pharmacy chains using

$$\begin{aligned} \mathbf{R} &= \tilde{\mathbf{c}} - \left(\mathbf{O} \cdot \hat{\mathbf{\Omega}} \right)^{-1} \mathbf{q} \\ \mathbf{N} &= \left(\mathbf{O} \cdot \hat{\mathbf{\Psi}} \right) (\mathbf{R} - \tilde{\mathbf{c}}) \end{aligned} \quad (9)$$

⁶For example, if $\hat{\boldsymbol{\eta}}$ is a $K \times K$ estimated matrix of unconditional price elasticities, a $K \times K$ matrix of price related coefficients $\hat{\mathbf{\Omega}}$ (with individual terms of the matrix being $\hat{\Omega}_{kl} = \partial \hat{D}_l(\cdot) / \partial R_k$) for a linear demand system would be estimated as $\hat{\mathbf{\Omega}}^T = \hat{\boldsymbol{\eta}} \# \mathbf{A}$ (where $\#$ stands for element by element multiplication and superscript T is for transpose), and \mathbf{A} is a matrix with entries $A_{kl} = q_k / R_l$. Similarly, one can obtain a matrix $\hat{\mathbf{\Psi}}$ where $\hat{\Psi}_{kl} = \partial \hat{D}_l(\cdot) / \partial N_k$ consists of parameters associated with quality.

where $\widehat{\Omega}$ and $\widehat{\Psi}$ are the estimated price and quality slope coefficients, and where \mathbf{O} is the $K \times K$ joint 1/0 pharmacy ownership matrix with ones in the leading diagonals and the off-diagonal terms are zero or one if two chains are co-owned.⁷ Thus, to back out the marginal costs we initially set the joint chain ownership matrix to an identity matrix, and solve the first equation above for $\widehat{\mathbf{c}}$.

Post-merger prediction of retail prices and quality, $\widehat{\mathbf{R}}$ and $\widehat{\mathbf{N}}$, from a proposed merger of two pharmacy chains follows from solving for these two vectors in (9) by changing the ownership matrix \mathbf{O} to include ones in the locations for these chains. For instance, if pharmacy 3 and 5 are proposing a merger, then entries (3, 5) and (5, 3) of the ownership matrix would be changed to one, and using the estimated value of the marginal cost $\widehat{\mathbf{c}}$ and the demand parameters, $\widehat{\Omega}$ and $\widehat{\Psi}$, the new predicted prices and qualities can be obtained. The predictions can be further refined to include efficiency arguments by replacing $\widehat{\mathbf{c}}$ above with $.9\widehat{\mathbf{c}}$ to reflect 10% reduction in marginal costs due to the merger (or other similar percentages).

Given that the data (and demand parameters) are at the pharmacy level, there is no direct method of estimating the impact of a wholesale horizontal merger. To do so would require first estimating the wholesale mark-ups and then predicting the change in the discount levels post wholesale merger. This could then be used to get the pass-through rate to predict changes in prices and quality and the retail level. Nonetheless, we can still gauge the likely effect of wholesale merger on consumer level prices and quality of pharmacy stores via simulations. Recall that the effective marginal cost for pharmacy k is $\tilde{c}_k \equiv p_m(1 + \mu) - d_k^* + c_k$, and if due to a merger at the wholesale level, the equilibrium discount changes (and nothing else), then $\Delta\tilde{c}_k = -\Delta d_k^*$. Thus, once the initial $\widehat{\mathbf{c}}$ has been estimated using pharmacy level data, the impact of wholesale mergers can be simulated by replacing these marginal costs with $\widehat{\mathbf{c}} + \Delta\tilde{\mathbf{c}}$ (corresponding to 10%, 25% etc. changes in discounts to all pharmacies) in (9) to get the new pharmacy prices and quality.

Finally note that if both pre and post (wholesale) merger sales data is available at the pharmacy level, then changes in discounts at the pharmacy level can be identified: using pre and post merger data, estimate the entire demand system given in the previous section twice, and obtain marginal costs from both the periods. The difference in the two estimates of marginal costs vector is equal the change in the discounts received by the pharmacies.

6. Welfare Effects. We can use the pre and post-merger (predicted) prices and qualities to compute changes in consumer welfare (as *compensating valuations* measure) using estimates from the top level demand curve. Let $(\mathbf{R}^o, \mathbf{N}^o)$ be the vectors of observed pre-merger prices and quality indexes at the K pharmacies and similarly $(\mathbf{R}', \mathbf{N}')$ be the predicted post merger values. Recall that to estimate the top level demand equation (equation (8)) we first need to use the Stone index (see equation (6)) to construct a price (and quality) index at the market level. Thus, using share weighted averages (original shares), we can convert each of these vectors to their index values so that the pre-merger values are (R^o, N^o) and the post-merger values are (R', N') (we are using bold vs normal font convention to distinguish between vectors and scalars).

Consider first the case where *only* the price had changed (i.e., no quality change, or equivalently if $N' = N^o$). In that case we could ask how much to *compensate* a representative consumer so that they are as well off as they were before the price changes, i.e., how much would it cost to put them at the same level of utility as before the price change. In this case we would evaluate the area to the left of the compensated (or Hicksian, i.e., $h(x, N^o, u^o(\cdot))$) demand curve at the original level of

⁷Note that the vector of pharmacy marginal costs $\tilde{\mathbf{c}}$ is over-identified and implies that if the terms of Ω and Ψ are constant (for instance in a linear demand function) then quality and quantity will be proportional.

utility u^o for the given price change as

$$CV = \int_{R'}^{R^o} h(x, N^o, u^o(\cdot)) dx. \quad (10)$$

Since the compensated demand curve is not observed, we can use the standard identities from consumer theory and a first order Taylor series expansion of the compensated demand curve at the point where it equals the original price to convert the integrand above into the parameters of the Marshallian demand curve already estimated in equation (8). Specifically,

$$\begin{aligned} h(x, N^o, u^o(\cdot)) &\approx h(R^o, N^o, u^o(\cdot)) + \frac{\partial h(R^o, N^o, u^o(\cdot))}{\partial R} \cdot (x - R^o) \\ &= Q(R^o, N^o, Y) + \left(\frac{\partial Q(\cdot)}{\partial R} + \frac{\partial Q(\cdot)}{\partial Y} Q(\cdot) \right) (x - R^o) \end{aligned} \quad (11)$$

and hence the integral can be evaluated for a given price change using the parameters of the demand function (8).

Since the predicted quality will also change (i.e., $N' \neq N^o$), we can adjust the amount above by computing how much of the change in quantity demanded is due to the change in quality, and what change in income would have *shifted* the demand by the same amount had the quality not changed. Thus, given the parameters of (8), let $\widehat{Q}'(R', N', Y)$ be the predicted quantity at R', N', Y . Then solve for Y' such that

$$\widehat{Q}'(R', N', Y) = \widehat{Q}'(R', N^o, Y') \quad (12)$$

i.e., after computing $\widehat{Q}'(R', N', Y)$, set N back to the pre-merger level of quality N^o and change the income level to get the same shift in the demand curve. Then the total compensating valuation due to changes in both price and quality is given by

$$CV = (Y' - Y) + \int_{R'}^{R^o} h(x, N^o, u^o(\cdot)) dx. \quad (13)$$

For exposition purposes we have dropped the subscript t from the welfare calculations in this section. However, they can (and should) be done for each market separately, so as to take into account differences in demographics and tastes in local markets. The individual market level welfare effects can then be stratified by combinations of size (population) and income levels in each market.

7. Summary. This short note emphasizes the use of pharmacy level sales data to access the impact of horizontal mergers in pharmaceutical supply chain. Even though wholesalers and pharmacies sell the same physical products, prescription or over the counter medicines, the final bundled good is highly differentiated due to the nature of services attached to these products (e.g., frequency of delivery by wholesalers or advice by pharmacist and physical location of outlets). Thus merger analysis should not rely solely on changes in market shares via predicted changes in the Herfindahl index. Instead, we recommend that effort be placed on collecting sales data, along with observable measures of pharmacy quality, to estimate demand functions that can be used for estimating pre-merger price-cost margins as well as predicting post-merger price and quality. These in turn can be combined to measure changes in consumer welfare. Finally, while the data requirements and econometric methods needed – aggregation of individual sales data to pharmacy chain level, estimation of demand parameters, and conditions for backing out price-cost margins – have been outlined here, this note should be viewed as a general introduction or overview of these methods, rather than a technical ‘how-to’, as we have (for the purpose of brevity) omitted some technical details from this discussion.

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