Assessing the accuracy of merger guidelines' screening tools

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Abstract

Since merger assessment is known to be costly for both competition authority and the parties involved, countries adopt merger guidelines to improve the efficiency of the merger control process. Among the screening instruments, one counts the most traditional Herfindahl-Hirschman Index (HHI) and the more recent Upward Price Pressure (UPP).

Our purpose is to test the accuracy of the screening tools by using Monte-Carlo simulations. We create economies that are used as workbenches to measure the effects of mergers and to evaluate how the different screening tools perform.

Our results confirm that HHI can be misleading. We find that in order to avoid type-I errors it is crucial to properly define market borders. In turn, type-II error appears when this condition is satisfied. In this case substitutability between merging products rather than market shares defines whether merger is detrimental or not. More innovative, our computations show that the UPP measure can also be misleading, even if one has perfect information on the main ingredients needed to compute it.

1. Motivation

Merger assessment is known to be costly both for the competition authority and the parties involved. In this perspective, countries adopt merger guidelines with proposed rules and procedures simple enough to improve the efficiency of the merger control process.

Given the diversity and different levels of development of the merger guidelines among countries, we base our discussion on the most recent merger guidelines enacted in 2004 for the E.U. and in 2010 for the U.S. Among instruments proposed in the guidelines, the most traditional Herfindahl-Hirschman Index (HHI) still plays a role, at least as an initial trigger for a merger investigation. The European guidelines, however, has mainly introduced the so called SIEC ("significant impediment to effective competition") test. Though the description of SIEC test is quite extensive, no particular procedures and tools are recommended. To date, the most advanced tool that can be used for implementation of the test involves simulations of an economic model of competition whose parameters are either calibrated from different incomplete sources or estimated based on datasets that permit to apply statistical estimation methods. However, often facing a lack of time, expertise or sufficient data, competition authorities seek for simpler methods, which along with its simplicity would provide a sufficiently low level of wrong predictions. Recently proposed by Farell and Shapiro (2008), the Upward Pricing Pressure (UPP) test, which is intended to fit these requirements while being economically grounded, is now under a heavy discussion if it could be a good alternative to merger simulations.

Based on different economic models and under different assumptions, HHI and UPP have different predictive power. Our purpose is to test the accuracy of these tools. Precisely, we want to characterize economic situations that lead to wrong predictions of HHI and UPP tests given that we control for the pre- and post-merger economic environment. In other words, we intend to predict when type-I and -II errors are likely to occur.[1]

To reach this goal, one can proceed in several possible ways. A set of realized mergers could be analyzed, where its effects could be revealed by comparing pre-and post-merger data. Type-II error level can be further estimated by comparing these results with decisions based on merger-assessing tools. This type of approach has been used by comparing financial data. (See for instance Okpanachi Joshua (2011).)However, evaluating merger decisions by comparing pre- and

[1] Making quantitative predictions about the frequency of type-I and -II errors in the real world is beyond the scope of this paper. Indeed, to achieve this goal we would need ideally an extensive dataset on proposed mergers with pre- and post-merger data for accepted mergers (for evaluating type-II error).

post-merger data can be misleading because new elements may blur the environment that was prevailing when the merger happened. In addition, this method does not allow one to estimate type-I error level.

Buccirossi et al. (2006) review all the different methods for evaluating merger control decisions, in particular event studies, surveys and model-based simulations. In the latter case, they propose to compare outcomes of merger simulations based on pre-merger data to post-merger observed data. Again there is a risk that the potential differences between pre and post merger situations are due to extraneous variables.

Our approach is aimed at avoiding this drawback. We create, by implementing Monte Carlo simulations, a sample of economies that is further used as a workbench to measure the effects of mergers and to evaluate how the different tools perform. The main advantage of this approach is that we possess full information about the economy and its agents. However, those economies are still created under some assumptions, which might not hold in reality. Thus, limitations of this approach – although controlled- should be clearly understood and simulated economies should be verified to be reasonably “realistic.”

The tool that we are building is very flexible and can generate very heterogeneous economic situations. Note that it can be also be used for evaluating real mergers if one uses “true data” to calibrate the distributions of parameters.

In the next chapter we provide more details on the methodology employed and describe the sample of created economies that we use to test the accuracy of merger evaluation tools.

2. Methodology

Assumptions

To pursue our goal, we start by describing the basic setup under which we create a sample of economies. We consider *J* single-product firms that sell differentiated goods and compete in prices. It is a static game in which firms replay after the merger of the first two of them. The quality of each product is drawn exogenously and remains the same after the merger (i.e., there is no repositioning). These assumptions are not be modified throughout the paper (except the number of firms) but our framework could easily be modified in terms of conduct or number of products per firm. A dynamic model with product choice could also be envisioned but at the expense of a greater complexity.

Each economy comprises consumers whose preferences are generated by a random utility model and an oligopoly where firms compete a la Bertrand-Nash. We build mostly on specification as in Berry, Levinsohn and Pakes (1995) (further BLP) with some deviations. This setup is very general and entails mild assumptions.

On the demand side we consider a set of *N* customers buying at most one unit of one product. Preferences are represented by a random utility model where the product *j* provides the following level of utility to consumer *n*

$$U_{nj} = (\beta + \tilde{\beta}_n)x_j - (\alpha + \tilde{\alpha}_n)p_j + \varepsilon_{nj} \tag{1}$$

The consumer has also the outside option of not buying any product. In this case she receives the following level of utility

$$U_{n0} = x_0 + \tilde{x}_{n0} + \varepsilon_{n0} \tag{2}$$

Quality of each product is described by the variable x_j, $j = \overline{1, J}$. Values of this attribute are specific to each product, but drawn from the same distribution $x_j \sim F_x \forall j = \overline{1, J}$. The common quality characteristic of the outside option is constant and denoted as x_0. Besides, every consumer extract idiosyncratic utility equal to $\tilde{x}_{n0}$.

In the utility function, β and α are drawn once for all in a given economy according to F_β and F_α respectively, and are common to all products and to all consumers. Idiosyncratic tastes $\tilde{\beta}_n$, $\tilde{\alpha}_n$ and $\tilde{x}_{n0}$ are distributed according to $\tilde{\beta}_n \sim F_{\tilde{\beta}}$, $\tilde{x}_{n0} \sim F_{\tilde{x}}$ and $\tilde{\alpha}_n \sim F_{\tilde{\alpha}}, \forall n = \overline{1, N}$. Coefficient $(\beta + \tilde{\beta}_n)$ thus reflects consumers' preferences towards the quality of products, while $(\alpha + \tilde{\alpha}_n)$ corresponds to sensitivity to price p_j. Finally, ε_{nj} is an idiosyncratic term related to both product and individual, and drawn from an extreme value distribution denoted by F_ε.

For a given vector of prices, the true demand for good *j* is simply the number of customers that choose this product, i.e. whose utility function is such that $U_{nj} > U_{nj'}$ all *j'*.

On the supply side, we assume that the marginal cost of product *j* is constant and equal to

$$c_j = \exp(\gamma x_j + \omega_j), \tag{3}$$

where γ is common to all firms and ω_j is a firm-specific cost component. These parameters are drawn once for all in a given economy according to F_γ and F_ω respectively.

Note that, for the purpose of the exercise, model does not contain any elements unobserved to the analyst.

Sampling

We generate 200,000 economies using a sampling process involving distributions for the products' characteristics, the consumers' preferences and the firms' cost structure.[2] All distributions $F_\bullet$ introduced above are functions of meta parameters that are fixed to values that allows us generate highly heterogeneous economic situations.

An economy is generated along the following steps:

- The nature draws values for $\beta, \alpha,\ x_0$ and γ;
- The nature draws independently *J* product qualities from F_x and *J* associated costs from F_ω. Firms observe the whole set of qualities and costs;
- Firms know preferences but they do not observe idiosyncratic tastes $\tilde{\beta}_n$, $\tilde{\alpha}_n$, $\tilde{x}_{n0}$ and ε_{nj} for all *j*. Thus, conditionally to prices they can only compute expected market shares, given that they know distributions of idiosyncratic tastes; Following BLP the firm's expected market share of product *j* writes

$$s_j(p) = \int \frac{\exp\left[(\beta+\tilde{\beta}_n)x_j - (\alpha+\tilde{\alpha}_n)p_j\right]}{\exp\left[x_0+\tilde{x}_{n0}\right] + \sum_{k=1}^{J}\exp\left[(\beta+\tilde{\beta}_n)x_k - (\alpha+\tilde{\alpha}_n)p_k\right]} dF_{\tilde{\alpha}}dF_{\tilde{\beta}}dF_{\tilde{x}} \tag{4}$$

- The Nash equilibrium is solved for prices (See Appendix A for derivation of the pre- and post-merger equilibrium);
- The nature draws independently the idiosyncratic tastes for *N* individuals. Then consumers observe qualities and prices and eventually make their choice.

Basic setting includes functional form of utility and marginal costs, as presented above, as well as number of firms and consumers, and distributions of the model primitives. Table 1 in Appendix B provides the lists of parameters for the sampling process. The number of firms is set

[2] We use SAS routines and functions.

to 7 to obtain post-merger HHI levels both below and above current US guidelines' thresholds.[3] The number of consumers is large enough (N=10,000) in order that expected market shares computed by firms converge to the true ones. Non-fixed parameters have normal distributions, except for those which have positive restrictions on sign, i.e. marginal utility for numeraire and quality. To assess the robustness of our results, we envision testing different kinds of distributions or functional forms for the utility function. In particular, we consider specifications with and without direct income effects. As the fixed-point algorithm to solve for the equilibrium does not always converge, we cannot consider the corresponding cases which amount to 21% of the initial sample. In addition, the cases where at least one pre-merger market share is equal to zero are also removed which reduces the size of the sample by another 6 percent.[4] Moreover, we delete economies displaying outliers, i.e. economies corresponding to unrealistic or extreme values for the elasticities. Precisely, we only qualify economies for which the own price elasticities and the aggregate elasticity do not fall below the 5th percentile and above the 95th percentile of the original distributions of these variables.

Descriptive statistics

In Table 2-1 and 2-2 of Appendix B we provide descriptive statistics of the main economic variables of an economy at equilibrium, respectively for the cleaned sample after removing non converging economies and zero market shares (sample 1) and for the clean sample after removing extreme value of elasticities (sample 2). Our economies are sufficiently differentiated in terms of share of the outside option (from 0.04% to 99.9%), aggregate demand elasticity (from -5.83 to -0.31) and market shares of merging firms (from 0.0001 to 0.66 for the first merging firm, and similar for the second one). Extreme values of all variables are found to lie in reasonable ranges while mean values are not unrealistic.

After we simulate a merger in each of those economies, we also remove cases with non convergence of post-merger equilibrium (less than 0.31% of the cases).

[3] In a future version of this work this parameter will vary.

[4] Note that zero market share is not a problem *per se*. However it amounts to change the number of active firms on the market, whereas we want to keep this parameter fixed for a given sample of economies.

In the final sample, the average changes in prices vary from -3.03% to 120.45%. We observe negative changes in prices both for merging and non-merging firms[5]. For the latter group, however, these values are very small and statistically non-significant. All those cases are kept in the sample and make a part of the analysis.

We now proceed with critical appraisal of HHI and UPP tests, based on the set of simulated economies. Our task consists in identifying the set of values of the economic variables available to an analyst in practice that affects the accuracy of merger evaluation tools we mention above.

3. HHI test

For a fixed elasticity of demand, the mark-up over the weighted average of marginal costs of all firms in a Cournot model with a homogenous product is proportional to the HHI. This property legitimates the HHI as a measure of market power and a test to flag potentially harmful mergers. However, it is then inaccurate for differentiated product markets with Bertrand conduct, where unilateral effects are found to be a principal cause of potential competition harm.

Let us discuss some properties of the HHI. Consider without loss of generality that the first two firms are merging and denote by $C = \bar{s}_1 + \bar{s}_2$ the *ex ante* market share of the merged entity, where $\bar{s}_1$ and $\bar{s}_2$ are the market shares that are used to calculate the HHI index[6].

Assuming that all the M non-merging firms are symmetric, the post-merger HHI and the change in HHI denote by ΔHHI can be expressed as:

$$HHI_{postmerger} = C^2 + (100 - C)^2 / M \quad HHI_{postmerger} = C^2 + (100 - C)^2 / M \tag{8}$$

and

$$\Delta HHI = HHI_{postmerger} - HHI_{premerger} = 2\bar{s}_1\bar{s}_2 = 2\bar{s}_1(C - \bar{s}_1) \tag{9}$$

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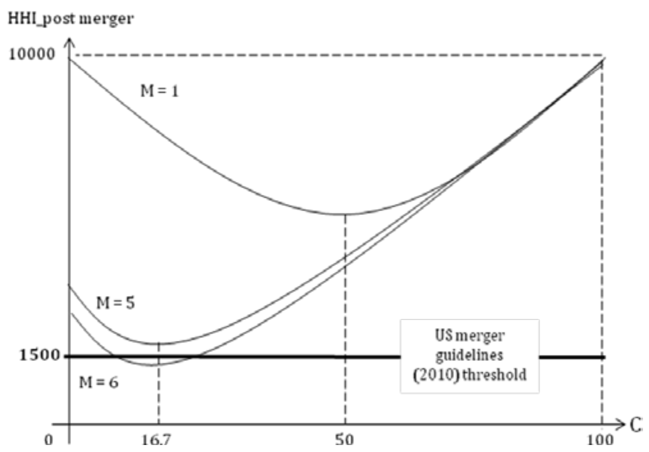
[5] Merger can indeed cause price decreases in some economic settings. See, for instance, Higgins, Johnson and Sullivan (2005). Post-merger price decrease can be also related to strategic substitutability, as explained by Bulow, Geanakoplos, and Klemperer (1985). They show that when marginal costs are constant, as in our case, Bertrand conduct allows products to be both strategic substitutes and strategic complements, thus price increase and price decrease are both possible.

[6] Further in the paper we call $\bar{s}_i$ an *internal* market share of the firm *i*, which highlights the fact that it does not take into account the presence of the outside option, i.e. is calculated on the basis of the quantity sold only. In turn, variable s_i , which does take into account outside option, is called a *true* market share.,

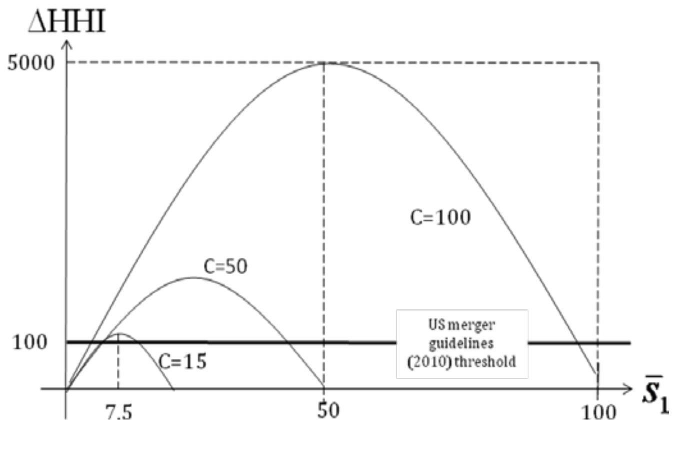
Equation (8) is the formula of a convex parabola with respect to C, with the following coordinates of minimal point: $C_{\min HHI\_post} = 100/(1+M)$ and $HHI\_post_{\min} = 5000/(M*(1+M))$. Examples are provided on Graph 1.

Note that Equation (9) is always correct and does not depend on the initial industry structure. The function for ΔHHI is a reverse parabola with respect to s_1 and reaches a maximum when the market shares of the merging firms are equal. Examples are provided on Graph 2.

Graph 1. Relation of the change in HHI to the merged entity's market share.



Graph 2. Dependence of ΔHHI on merging firms' market shares.



Graph 1 suggests as well that any merger on a market with 5 non-merging firms will exceed the US guidelines HHI threshold of 1500. If, in this case, both merging firms would have relatively low equal market shares of 7.5%, ΔHHI threshold of 100 would be as well over passed and merger would be put under further scrutiny as shown in Graph 2. However, there is no economic evidence that this situation really creates a serious concern to competition.

Proposition 1: The post-merger HHI test does not reveal any explicit relation of the industry structure with possible price increase

Indeed, our simulations results confirm that this relation is quite complex. See, for instance, Graphs 3-5 reported in Appendix C, where we plot post-merger HHI, ΔHHI and sum of market shares of the merging firms against the simulated price increase (average for merging firms). Reference lines reflect 2010 US merger guidelines thresholds. One can easily observe that the high post merger HHI and ΔHHI values can correspond to either high or relatively low price increases, and even price decreases, whether the guidelines' thresholds are exceeded or not.

The ΔHHI largely depends by construction on the proportion of merging firms' market shares. The economic intuition suggests that higher market shares of the merging firms might reflect a higher market power, thus a stronger ability of firms to raise prices, and in our experiment, we should track some positive relationship between the two variables. However, on Graphs 4 and 5 (in Appendix C), one can easily find cases where this intuition is not supported.

Simulation results confirm the existence of some effects that the HHI test does not catch. The main criticism of HHI as a merger evaluation tool is that it is relevant for homogeneous good markets and so does not take into account any product differentiation effect nor heterogeneity in preferences. Instead, in the unilateral effect theory based on differentiated product market, a merger causes more concerns if merging products are closer substitutes, with similar quality levels, and thus having higher diversion ratios. (See, for instance, Farrell and Shapiro (2010).)

Inability to catch these effects may lead to type-I error and type-II error. To characterize type-I and type-II errors we need to apply an *ad hoc* criterion indicating when a merger is detrimental. There are several possibilities whether we use price increase or welfare decrease as a criterion. Ideally our results should be robust to any specification. We decide to fix a threshold for price increase on 2% level under which the merger is considered as not detrimental and thus should not be challenged. Following 2010 U.S. guidelines' thresholds, we assume that mergers involving an increase in the ΔHHI of less than 100 points or a post-merger HHI of less than 1500 are unlikely to have adverse competition effects and require no further analysis. On the other hand, all other cases potentially raise significant competition concerns.

We define a type-I error generated by the HHI test as a situation where price increase is below 2% together with HHI greater than 1500 and ΔHHI greater than 100. Type-II errors of the HHI test occur when price increase is greater than 2% together with a post-merger HHI less than 1500 or ΔHHI less than 100. We also name as "predicted anticompetitive" the case when the HHI test well predicts detrimental merger and as "predicted pro-competitive" the case when the HHI test well predicts non detrimental merger. Below we display descriptive statistics for the main variables in the economy and compare them among the different regimes.

Table A: Predicted pro-competitive cases

Variables	N	Mean	Variance	Min	Max
Markup of the 1st merging firm	24317	0.1127	0.0511	0.0014	0.4488
Markup of the 2nd merging firm	24317	0.1124	0.0505	0.0046	0.4518
Own price demand elasticity, 1st firm	24317	-10.4071	4.0578	-21.5670	-2.5752
Cross price demand elasticity , 1st firm	24317	0.3040	0.5168	0.0000	15.9261
Own price demand elasticity, 2nd firm	24317	-10.4266	4.0550	-21.4746	-2.5821
Cross price demand elasticity, 2nd firm	24317	0.3062	0.5007	0.0000	11.6597
Aggregate demand elasticity	24317	-1.7261	1.0144	-5.8207	-0.3085
Share of the outside alternative	24317	0.7446	0.1479	0.0783	0.9983
Market share of the first firm (true)	24317	0.0155	0.0318	0.0001	0.6466
Market share of the second firm (true)	24317	0.0152	0.0306	0.0001	0.5743
Sum of the market shares of merging firms, %	24317	11.9022	15.1338	0.0512	99.4177
Average price increase for merging firms, %	24317	0.2530	0.3298	-0.0012	1.9943
Post-merger HHI	24317	4982.80	1753.72	1668.15	9895.27
ΔHHI	24317	32.66	29.66	0.0010	99.99

Table B: Type-II error cases

Variables	N	Mean	Variance	Min	Max
Markup of the 1st merging firm	255	0.2354	0.0642	0.0668	0.3889
Markup of the 2nd merging firm	255	0.2371	0.0627	0.0561	0.3922
Own price demand elasticity, 1st firm	255	-4.7813	1.8708	-16.9930	-2.6005
Cross price demand elasticity , 1st firm	255	0.5807	0.6496	0.1243	5.5479
Own price demand elasticity, 2nd firm	255	-4.7087	1.7814	-16.3084	-2.6193
Cross price demand elasticity, 2nd firm	255	0.5756	0.7018	0.1084	7.9199
Aggregate demand elasticity	255	-0.5202	0.1987	-2.1063	-0.3089
Share of the outside alternative	255	0.4159	0.1300	0.1392	0.9139
Market share of the first firm (true)	255	0.0325	0.0122	0.0062	0.0771
Market share of the second firm (true)	255	0.0347	0.0166	0.0035	0.1688
Sum of the market shares of merging firms, %	255	11.3598	2.6353	3.8148	24.1787
Average price increase for merging firms, %	255	2.7896	0.9470	2.0050	8.2895
Post-merger HHI	255	2843.1100	591.9888	1680.0700	4678.6300
ΔHHI	255	64.5372	24.4640	7.2760	99.8639

Table C: Type-I error cases

Variables	N	Mean	Variance	Min	Max
Markup of the 1st merging firm	35431	0,1368	0,0656	0,0155	0,4602
Markup of the 2nd merging firm	35431	0,1371	0,0656	0,0043	0,5337
Own price demand elasticity, 1st firm	35431	-8,8002	3,7387	-21,5662	-2,5765
Cross price demand elasticity , 1st firm	35431	0,6613	0,9574	0,0000	17,0261
Own price demand elasticity, 2nd firm	35431	-8,7877	3,7221	-21,4663	-2,5785
Cross price demand elasticity, 2nd firm	35431	0,6583	0,9536	0,0000	20,4102
Aggregate demand elasticity	35431	-2,0661	1,3011	-5,8229	-0,3086
Share of the outside alternative	35431	0,6900	0,2097	0,0419	0,9989
Market share of the first firm (true)	35431	0,0537	0,0615	0,0001	0,6604
Market share of the second firm (true)	35431	0,0536	0,0612	0,0001	0,6425
Sum of the market shares of merging firms, %	35431	36,6445	18,8498	14,1506	99,4300
Average price increase for merging firms, %	35431	0,6011	0,5176	-3,0361	1,9991
Post-merger HHI	35431	3100,9900	1454,4200	1670,0000	9886,4000
ΔHHI	35431	363,9972	223,4300	100,0038	3192,7400

Table D: Predicted anticompetitive cases

Variables	N	Mean	Variance	Min	Max
Markup of the 1st merging firm	7207	0,1909	0,0785	0,0383	0,6718
Markup of the 2nd merging firm	7207	0,1912	0,0775	0,0260	0,5396
Own price demand elasticity, 1st firm	7207	-6,4310	3,3244	-21,4805	-2,5762
Cross price demand elasticity , 1st firm	7207	2,1197	2,7257	0,0338	20,4733
Own price demand elasticity, 2nd firm	7207	-6,3800	3,2587	-21,4887	-2,5789
Cross price demand elasticity, 2nd firm	7207	2,0755	2,6175	0,0075	19,1031
Aggregate demand elasticity	7207	-0,9853	0,6352	-5,7105	-0,3085
Share of the outside alternative	7207	0,5033	0,2137	0,0656	0,9789
Market share of the first firm (true)	7207	0,0934	0,0609	0,0032	0,6031
Market share of the second firm (true)	7207	0,0941	0,0622	0,0036	0,6304
Sum of the market shares of merging firms, %	7207	43,7532	22,4984	14,1887	99,5940
Average price increase for merging firms, %	7207	5,8566	7,4847	2,0000	120,4555
Post-merger HHI	7207	3369,5500	1978,3100	1670,1900	9919,0100
ΔHHI	7207	910,5384	866,6120	100,2506	4750,3800

First note that the number of cases in each of the four regimes is not informative *per se*. It depends on the structure of the economy (as well as the price increase threshold and the HHI test definition- different in the U.S. and the EU) and can vary significantly depending on the model primitives that we use for simulations. What we need is to have a sufficient number of observations in each regime in order to identify some striking features. We acknowledge that there are not so many observations in type-2 error regime, especially because with 7 firms HHI does not go below 1500. Indeed as market is getting more concentrated the probability of type-2 error decreases. We intend to increase the number of firms in the next version of this paper.

Not surprisingly Type-I error cases (see Table C) arise when the merging firms enjoy a relatively low markups, high share of the outside option and elastic demands: own-price and aggregate elasticities are quite high compared to other regimes (see Table A, B and D).

The logic behind these results is quite intuitive. Since the share of the outside option is very big, internal market shares that are employed for the HHI test are overestimated, which in turn increases the probability of exceeding HHI thresholds. The outside good market share is also high which is consistent with high aggregate elasticity and competitive pressure exerted by the outside world. Last argument explains low markups and, in couple with relatively high cross-price elasticities, justifies the fact that merging firms were unable to significantly increase prices. Note that the share of the outside option is not directly observable by competition authorities, however one can instead refer to the aggregate elasticity, since they are strongly linked. General conclusion that could be done is that correct market definition is crucial to avoid type-I error.

Type-II error (see Table B) is basically associated with quite inelastic demand - this regime displays the lowest aggregate elasticity. This is both due to insensitive customers to prices and low market share for the outside good. It is noticeable that this regime exhibits on average a strong products differentiation. Merging products are rather of low quality whereas competing products belong to a high quality segment. Because of this reason, internal market shares and own-price elasticities of merging products are quite low as well. In addition, because of the low market share of the outside option, internal market shares of merging products are rarely overestimated, which explains why these cases were not flagged by the HHI thresholds. In comparison with the group of anticompetitive cases, type-II error cases exhibit relatively low cross-price elasticities, which reflect high level of substitutability among merging products. This observation explains the ability of merging firms to significantly increase prices. The above analysis allows concluding that when markets are properly defined, substitutability of merging products rather than market shares level defines whether merger is detrimental or not.

UPP test

In part because of the drawbacks of the HHI test and also because simulation methods are often deemed too sophisticated or too demanding in terms of data and time availability, the Upward Pricing Pressure (UPP) test is proposed by Farell and Shapiro (2008) as a tool to flag mergers which could potentially create serious concerns for competition, simple enough to be easily implemented while well economically founded.

A question that the UPP test is aimed to answer is whether a merger gives to the merging firm an incentive to increase price or not. For this one needs to compare two controversial effects that a merger creates: the loss in competition between merging firms that pushes price upwards, and cost efficiencies, which offset the first effect. Farell and Shapiro (2008) propose a way of measuring these two effects such that they can be compared in a simple manner. Precisely, they argue that net effect for the firm *i* when merging with the firm *j* can be calculated as

$$UPP_i^1 = D_{ij}(p_j^* - c_j^*) - E_i c_i^* \tag{15}$$

where D_{ij} is the diversion ratio from product *j* to product *i*, p_j^* and c_j^* are the pre-merger price and marginal costs of product j. First element of the formula $D_{ij}(p_j^* - c_j^*)$ is responsible for the positive pricing pressure while $E_i c_i^*$ reflects the offsetting effect of cost efficiencies for the firms *i*, where E_i is a constant fraction of marginal costs.

In the more accurate version of the test (UPP^2), Farell and Shapiro (2010) propose to take into account the fact, that cost efficiencies of the second merging firm will increase its margin, thus increasing further net pricing pressure of the first firm:

$$UPP_i^2 = D_{ij}(p_j^* - c_j^*) - E_i c_i^* + D_{ij} D_{ji}[p_i^* - c_i^*(1 - E_i)]\; i, j = 1,2 \tag{16}$$

or

$$UPP_i^2 = UPP_i^1 + D_{ij} D_{ji}[p_i^* - c_i^*(1 - E_i)]\; i, j = 1,2 \tag{17}$$

Farell and Shapiro (2010) suggest that the merging firm has an incentive to increase price whenever UPP value, measured either as UPP^1 of UPP^2, is positive. Because UPP^2 is always larger than UPP^1, it will potentially flag more mergers for further scrutiny. In current paper we will test the accuracy of both versions.

Basically just requiring knowledge of diversion ratios and pre-merger markups, the UPP test calls for a huge interest from competition authorities that face lack of relevant expertise or other resources. However, even being recognized as a simple tool that catches the essence of the unilateral effects of mergers, it is still subject to extensive critics.

Indeed, its original version is restricted to a single product version and does not provide a link to the magnitude of the price increase, just to its sign. When the required ingredients such as diversion ratios or marginal costs are not available to a competition authority, they need to be estimated or approximated, which could significantly reduce the test's accuracy. Besides, as we show later in the paper, approximations of the test's elements can raise an issue of market definition as well, even if the original UPP test is meant to avoid this problem.

Literature review

To address some of those critics, several extensions and simplifications to the original UPP formula were proposed and discussed in the literature. For instance, Shapiro (2010) and Hausman, Moresi, and Rainey (2010) discuss some practical implications and propose several approximations of the UPP test inputs by making assumption on the demand structure. Jaffe and Weyl (2011) extend original formula of UPP^1 to the multiproduct case and propose its analog for non-Bertrand conducts. However, one must remember that extensions and simplifications often come at a cost of either higher data requirements or losses in predictive power of the test.

Even though our approach allow testing all the modifications proposed in the literature, in current paper we will only focus on the formulas proposed by Farell ans Shapiro (2010), namely UPP^1 and UPP^2.

The UPP test allows getting along without any structural demand estimation and was aimed to replace merger simulations when a competition faces lack of time or sufficient expertise. However, in its original version, it misses one important qualification that a merger simulation has: the ability to predict *magnitude* of the price change.

To make a link with the possible price increase Farell and Shapiro (2010), Jeffe and Weyl (2011), Simons and Coate (2010), Pakes (2010) propose applying pass-through rate to the UPP value[7]. To explain this approach, we should come back to the theoretical basis of the UPP test and refer to the Proposition 2 of Farell and Shapiro (2010), where they show that the change in the price incentives caused by a merger is equivalent to a situation where the merging partners are simultaneously imposed a tax. The value of this tax for the firm *i* when merging with firm *j* is computed in the following way:

$$t_i = D_{ij}^m (p_j^m - c_j^m) \tag{18}$$

where D_{ij}^m is a post-merger diversion ratio of product *j* to product *i*, p_j^m and c_j^m are post-merger price and marginal costs of the firm j (subscript *m* is referred to the post-merger equilibrium). Here we call this variable a "merger tax."

In other words, Farell and Shapiro (2010) state that in terms of price effects a horizontal merger with no cost efficiencies is equivalent to a positive cost shock (merger tax) for both partners. The formula for the merger tax can be easily extended to count for cost efficiencies, in the same manner as in UPP.

In addition to own cost shock, firm's price will react on the cost shocks of the other firms on the market. This reaction can be very different, price can both increase (positive pass through) and decrease (negative pass through), depending on the demand system[8]. Since both merging firms are involved, the final impact on the price is defined by a bundle of own and cross pass through rates.

Information on the pass-through rates should help an analyst to link the merger tax with the price increase. However, one would face at least two practical limitations with this approach. First, one can notice that the computation of the merger tax already includes the variable of interest to be (post merger price). Farell and Shapiro (2008) address this issue by proposing the UPP formula as an approximation of the merger tax, precisely, its first-round level. Thus, to assess the magnitude of the possible price increase, instead of the merger tax one can indeed apply pass-through rate to the UPP level.

[7] Pass - through rate measures the extent to which the firm passes its cost shock on consumers (in terms of price increase). For instance, if price increases on 5 units due to a 10 units cost increase (positive cost shock), then pass through rate is equal to 5/10=0.5.

[8] Precisely, demand's curvature was found to play a crucial role in defining the sign and magnitude of the price change due to a cost shock (See for instance Weyl and Fabinger (2009) or Jaffe and Weyl (2011).

Second, when two firms experience a cost shock *simultaneously*, one can't simply apply own and cross pass-through rates to the corresponding values as relationships within economic system become more complex. True price increase can be obtained only after full re-equilibration. Jeffe and Weyl (2011) propose to use only own-cost pass through to approximate price increase. We further assess empirically whether the cross pass-through can indeed be ignored.

While theoretical discussions are quite extensive, still few researchers focused on empirical performance of the UPP test, especially on its implementation when data are scarce. Similarly to the approach employed in our paper, Varma (2009) simulates mergers in hypothetical economies where he compares performance of the UPP and the HHI tests. He shows that the former, in general, flags a merger for further scrutiny more often than the concentration based test. However, we argue that these results heavily depend on the characteristics of economies that one considers.

Cheung (2011) attempts to estimate the ability of UPP test as a substitute to merger simulations, e.g. as a good predictor of the price increase. On a sample of 256 overlapping routes in the America West - US Airways merger (2005), she demonstrates that, when a structural demand estimation is used to calculate the UPP, it generally provides accurate predictions in sign of a price change for a large range of cost efficiencies. Precisely, in only 10% of all cases UPP test predicted a wrong sing of the price change, while the correlation of its magnitude with the structurally simulated price changes was on average 0.92. The test was found to perform better for small price increases.

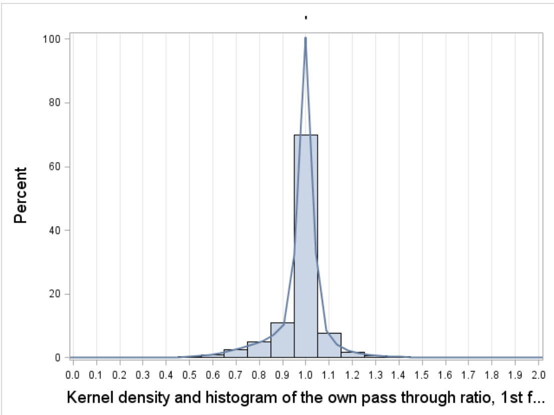
More interestingly for antitrust practitioners, she estimates the impact of approximations of the test's ingredients on its accuracy. First, assuming that demand is drawn from a simple LOGIT model, she easily approximates the diversion ratios only using the observed market shares. This assumption result in wrong sign predictions over a much larger range of cost synergies than when true diversion ratio is used. An obvious advantage of this approach is its computational ease. However, the Independence of Irrelevant Alternatives assumption on which the logit model is built, is not in general true, and, as a result of this simplification, the accuracy of the test might decrease significantly. Second, following the proposition of Pakes (2010), she uses UPP level (with approximated diversion ratio) itself to approximate the magnitude of the price change, which is equivalent assuming the pass-through rate equal to one. She concludes that on her sample of markets this assumption leads to higher number of wrong predictions; however it is less detrimental for test's accuracy than the approximation of diversion ratio. Due to the features of the markets she considers, Cheung (2011) restricts the share of the outside option to zero. Clearly this is a strong assumption which can strongly distort test performance and lead to misleading conclusions.

The role of pass-through rate

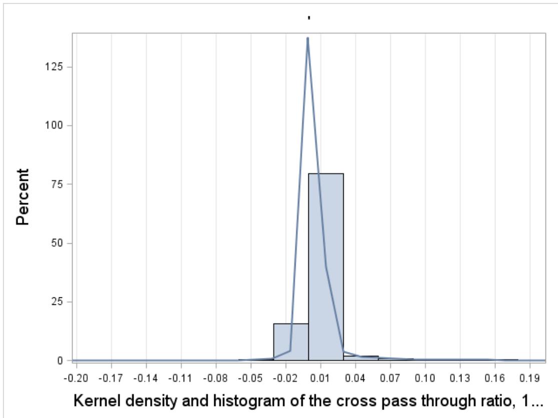
As was discussed before, pass through rate is as a useful tool that could be used in couple with UPP level to approximate the magnitude of the price increase. Thus, it is important to have an idea about its magnitude and especially its sign.

In our simulations we assume that mergers do not lead to cost efficiencies, thus UPP values are always positive. As we already mentioned above, in our sample we obtain both price increase and price decreases, which indicates that both positive and negative pass-through rates are present. On the Graphs 6 and 7 we present corresponding histograms and kernel distributions which confirm the presence of pass-through rates of both signs. Without loss of generality we consider pass-through rates of the first merging firm only.

Graph 6. Kernel density and histogram of the own pass through ratio, 1st firm



Graph 7. Kernel density and histogram of the cross pass through ratio, 1st firm



Analysis of Graph 7 may suggest that in our sample of economies pass-through rate on partner's cost shock (cross pass-through) is not significant[9]. This justifies proposition of Simons and Coate (2010) and Jaffe and Weyl (2011)) to use only own cost pass through rate for price increase approximation. This principle will be used in the rest of the paper.

[9] This result is somehow supported by some theoretical literature. Weyl and Fabinger (2009) show that cross pass-through effects can not dominate own ones. Aleksandrov and Bedre-Defoliee (2011) end up with the same conclusion for logit demand systems.

The UPP test performance

How precise are the price increase predictions when we use UPP level instead of the merger tax itself? How harmful is ignoring cross pass-through rate for test's accuracy? Given that own pass- through rate can vary significantly (see Graph 6), which effect would have its restriction to one? How trustful are tests' conclusions when it uses approximated diversion ratio? The rest of the paper is aimed to answer these questions.

Proposition 2:

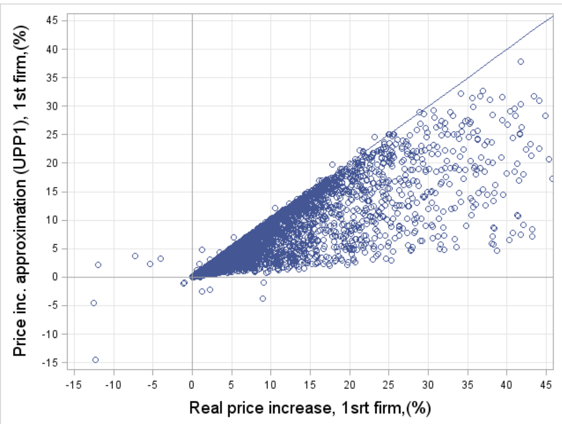
1. When only true data is used, test based on UPP^1 performs better than the one based on UPP^2 in terms of both type-I and type-II errors;

2. When at least one test ingredient need to be approximated, test based on UPP^1 leads to higher type-II and lower type-I error than the test based on UPP^2;

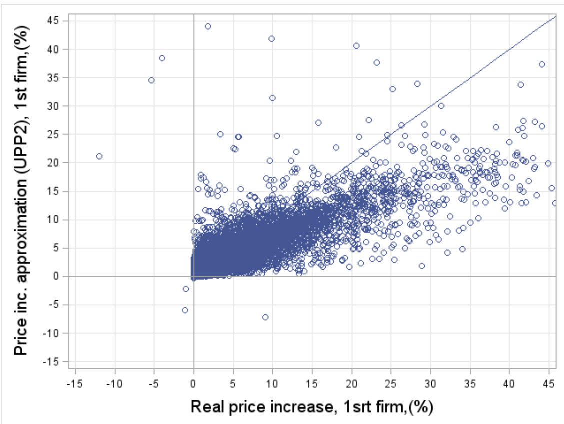
3. For accurate test results it is more important to have correct estimations of diversion ratios rather than pass through rates.

We assume, to begin, that true values of UPP test ingredients are known. Price increase for each firm is then approximated with the product of UPP value and own pass through rate. Note, that since true own pass-through rates are employed, approximated price change can take negative values. On the Graphs 8 and 9 we plot real and approximated price increase for the first firm calculated on the basis of UPP^1 and UPP^2 (45^0 reference line is used to facilitate the comparison of confronted variables).

Graph 8. Approximated vs real price increase (based on UPP^1)



Graph 9. Approximated vs real price increase (based on UPP^2)



One can observe that even though employed approach uses only "true" data, it can still lead to wrong predictions, both over- and underestimating price increase. Price approximation based on UPP^1 generally underestimates real price increase, while the one based on UPP^2 have both significant positive and negative deviations.

Table 3 (Appendix B) provides estimations of type-I and type-II errors for the UPP test under different assumptions. Assuming a price increase of 3% as non-significant (and significant otherwise), we count cases when UPP test predicts a price increase of more than 3% while in reality it is lower (type-I errors) and cases where predicted price increase is less than 3% while in reality it is higher (type-II error) . Without loss of generality we consider test application for the 1st merging firm only.

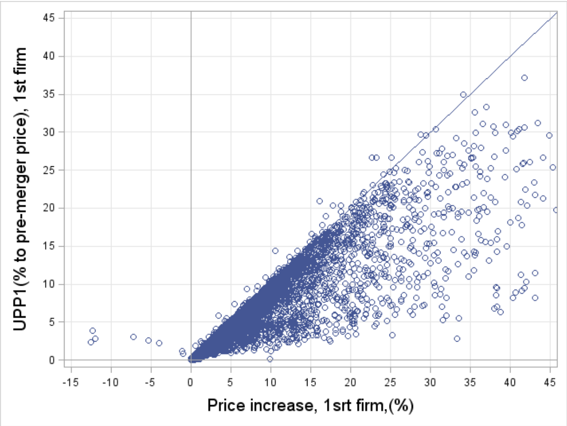
Results in the Table 3 show that price increase approximation that is based on the true data leads to higher level of type-II errors rather than type-I errors. Surprisingly, test based on UPP^2, which is supposed to be more accurate, performs worse than the one based on UPP^1. Unfortunately, our analysis does not allow disentangling negative effects of two simplifications used so far: the use of UPP instead of a merger tax and ignoring partner's cost shock.

One should not refer to absolute values of type-I and type-II errors and make a reference to a real world as these results hold for our sample only. However, we can use them as a benchmark to compare tests performance under different assumptions.

When no true data is at hands and no re-equilibration or demand estimation is feasible, UPP ingredients and pass-through rates need to be approximated. Leaving aside estimation of marginal costs, we will further focus on approximation of two key elements of the test: pass through rates and diversion ratios.

On Graphs 10 and 11 we plot obtained values of UPP^1 and UPP^2 (in percentage of the pre-merger price) and real price increase for the first of the merging firms. Considering just UPP level as a price increase approximation is equivalent applying a pass-through rate equal to one.

Graph 10. UPP^1 **(in % to the pre-merger price) versus real price increase, 1st firm**



Graph 11. UPP^2 **(in % to the pre-merger price) versus real price increase, 1st firm**

One can notice that UPP^1 generally underestimates the price increase, while UPP^2 deviates significantly in both directions. Because we consider only mergers with no cost efficiencies, UPP^2 by construction is always higher than UPP^1 and thus one can expect higher Type-I and lower type-II error level for this version of the test. Our results in Table 3 (Appendix B) confirm this intuition.

Even though Pakes (2010) justifies replacing true pass through rate with one, results in Table 3 suggest that one faces a risk of decreasing accuracy of predictions when using UPP^1 as a basis. However, this is not true for the test on the UPP^2 basis, for which performance is improved. One should keep in mind that this test modification will never identify cases with post-merger price decrease, as all ingredients never take negative values.

So far, having all required information about economies, we were able to calculate “true” level of UPP for each of them. When diversion ratio is not known, it can be approximated just with use of market shares if one assumes that demand is drawn from the simple logit model[10]. Note that required market shares are the true ones, i.e. they take into account the existence of the outside option. As a result of the logit approximation of diversion ratios test accuracy is reduced significantly both in terms of type-I and type-II errors (See Table 3 in the Appendix B). Further approximation of the pass through rate as one reduces performance of the UPP test derived under logit assumptions even more, but not significantly. This exercise is not original and was first

[10] In this case diversion ratio can be approximated with $D_{ij}^{appr} = \frac{s_j}{(1-s_i)}$, where s_j and s_i are true market shares of firm *j* and *i* correspondingly.

performed by Cheung (2011), as described in the literature review part. However she assumed that the share of the outside option is equal to zero which is very restrictive and could lead to misleading conclusions. Even though we relaxed this assumption in our research, we obtain similar results.

Finally, when only internal market shares are available for an analyst, test accuracy for both UPP^1 and UPP^2 is reduced in terms of type-I error, but improved in terms of type-II one (see Table 3). This result can be explained by the fact that internal market shares always exceed the true ones. In this case diversion ratio becomes overestimated, which result in higher level of price increase approximation. UPP test was announced to be free of market definition problem. However, as we just showed, information on the market borders can significantly affect the accuracy of its implementation.

In practice, estimation of both pass-through and diversion ratio is a very complex task which is often hardly feasible, if at all. Analysis of all considered approximations of the UPP test ingredients suggests that it is more important to have correct diversion ratio rather than pass through rate.

4. Conclusions

Current paper is aimed to assess the accuracy of the two instruments, proposed in the US merger guidelines (2010), namely Herfindahl-Hirschman Index (HHI) and Upward Pricing Pressure test, recently introduced by Farell and Shapiro (2008). We have created by simulation economies that are used as workbenches to measure the effects of mergers and to evaluate the performance of mentioned above merger evaluation tools. The tool that we have built is very flexible and can generate very heterogeneous economic situations. It can be also be used for evaluating real mergers if one uses “true data” to calibrate the distributions of parameters.

Our results confirm how misleading the use of HHI can be. We find that in order to avoid type-I errors it is crucial to properly define market borders. In turn, type-II error appears when this condition is satisfied. In this case substitutability between merging products rather than market shares defines whether merger is detrimental or not.

More innovative, our computations show that the UPP test can also be misleading, even if one has perfect information on the main ingredients needed to compute it. When no true data is at hands and no re-equilibration or demand estimation is feasible, UPP ingredients and pass-through rates need to be estimated or approximated. Any approximation distorts test performance to some extent in terms of type-I and type-II errors, and losses in accuracy are different for two considered by Farell and Shapiro (2008) test versions, namely UPP^1 and UPP^2. We show that it is more important to have correct diversion ratio rather than pass through rate.

To assess the robustness of our results, we envision testing different kinds of distributions or functional forms for the utility function, as well as different number of firms and multiproduct cases.

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6. Appendix A

Pre- and post-merger equilibrium:

Firms compete "a la Bertrand", maximizing their profits:

$$\Pi_j = (p_j - c_j) N s_j(p),\ j = \overline{1, F} \tag{10}$$

Thus, first order conditions for J firms pre-merger are the following:

$$s_j(p) = (p_j - c_j) \frac{\partial s_j(p)}{\partial p_j},\ \forall j = \overline{1, J} \tag{11}$$

We assume, without loss of generality, that merger occurs between two first firms, then post-merger FOCs are described by the following system of equations:

$$s_1(p) = (p_1 - c_1) \frac{\partial s_1(p)}{\partial p_1} + (p_2 - c_2) \frac{\partial s_2(p)}{\partial p_1} \tag{12}$$

$$s_2(p) = (p_1 - c_1) \frac{\partial s_1(p)}{\partial p_2} + (p_2 - c_2) \frac{\partial s_2(p)}{\partial p_2} \tag{13}$$

$$s_j(p) = (p_j - c_j) \frac{\partial s_j(p)}{\partial p_j}, \quad \forall j = \overline{3, J} \tag{14}$$

Note, that we don't assume any cost efficiencies caused by a merger.

Pre - merger $(p^*, s^*(p^*))$ and post-merger $(p^m, s^m(p^m))$ theoretical equilibrium are then fully described by equations [(4),(11)] and [(4), (12)-(14)] correspondingly.

7. Appendix B

Table 1 : Basic setting for simulations

Parameter	Basic setting
J	Number of products J is fixed to 7 for all economies
F	Number of firms F is fixed to 7 for all economies
N	Number of consumers is set to 10,000, fixed for all economies
α	α is constant in each given economy, but varies across economies with uniform distribution $U_{[0,15]}$
$\tilde{\alpha}_n$	For a given economy $\tilde{\alpha}_n$ varies among consumers with exponential distribution E_{1/σ_α}. Parameter σ_α is distributed uniformly $U_{[0,7]}$ among economies
β	β is fixed in each given economy, but varies across economies with uniform distribution $U_{[0,1.1]}$
$\tilde{\beta}_n$	For a given economy $\tilde{\beta}_n$ varies among consumers with normal distribution $N_{(0,\sigma_\beta)}$. Parameter σ_β varies across economies with uniform distribution $U_{[0,5]}$
ε_{nj}, ε_{n0}	ε_{nj} and ε_{n0} are both drawn from extreme value distribution $F_{(\lambda)}$, where scale parameter λ is equal to 0.5
x_j	For each economy $x_j = \exp(\tau \cdot \xi_j)$, where $\tau = 0.3$ and ξ_j is distributed normally with $N_{(2,5)}$
x_o	For a given economy, x_o is drawn from a $N_{(0,5)}$
$\tilde{x}_{no}$	For a given economy $\tilde{x}_{no}$ varies among consumers with normal distribution $N_{(0,\sigma_x)}$. Values of σ_x for different economies are drawn from uniform $U_{[0,3]}$ distribution
ω_j	For each economy ω_j is distributed normally with $N_{(0,0.05)}$.
γ	γ is fixed for each given economy, but varies across economies with uniform distribution $U_{[0,0.7]}$

Table 2-1: Descriptive statistics of main economic parameters: (pre-merger cleaned sample 1)

Variable	Mean	Variance	Min	Max	Q1	Q2	Q3
Markup of the 1st merging firm	0.1506	0.1122	0.0000	0.9749	0.0768	0.1130	0.1847
Markup of the 2nd merging firm	0.1509	0.1122	0.0000	0.9818	0.0770	0.1136	0.1849
Own price demand elasticity, 1st firm	-10.0723	8.3813	-610.9017	0.0000	-12.8270	-8.5713	-5.3100
Cross price demand elasticity , 1st firm	0.6874	1.7097	0.0000	162.5623	0.0670	0.2543	0.6465
Own price demand elasticity, 2nd firm	-10.0465	8.3006	-671.5751	0.0000	-12.8120	-8.5631	-5.3030
Cross price demand elasticity, 2nd firm	0.6794	1.5833	0.0000	110.2017	0.0670	0.2527	0.6429
Aggregate demand elasticity	-1.9747	1.7392	-15.5230	-0.0003	-2.5697	-1.3945	-0.7748
Share of the outside alternative	0.6848	0.2329	0.0000	0.9992	0.5455	0.7289	0.8715
Market share of the first firm	0.0446	0.0670	0.0001	0.7185	0.0034	0.0171	0.0572
Market share of the second firm,	0.0447	0.0667	0.0001	0.7317	0.0034	0.0171	0.0575
Sum of the market shares of the merging firms, %	28.4050	24.1171	0.0457	99.8328	9.7850	22.5507	38.9393
Average price increase for merging firms	1.2265	4.0038	-11.4159	198.4930	0.0592	0.2884	1.0446
Post-merger HHI	4188.35	2113.74	1668.15	9966.60	2388.71	3647.11	5404.66
ΔHHI	281.42	418.74	0.0009	4925.13	28.69	151.16	385.05

Table 2-2: Descriptive statistics of main economic parameters (pre-merger cleaned sample 2)

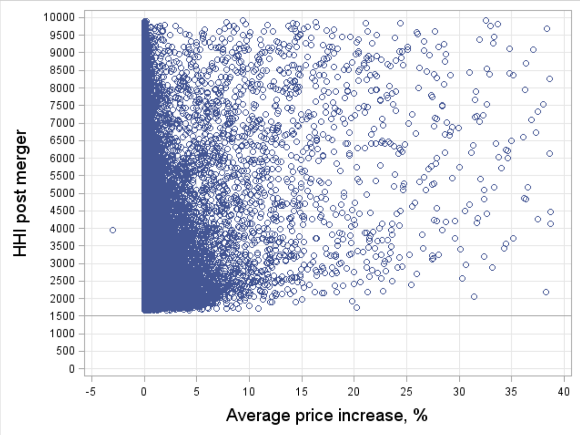
Variable	Mean	Variance	Min	Max	Q1	Q2	Q3
Markup of the 1st merging firm	0.1343	0.0666	0.0014	0.6718	0.0855	0.1148	0.1645
Markup of the 2nd merging firm	0.1343	0.0665	0.0043	0.5396	0.0856	0.1150	0.1646
Own price demand elasticity, 1st firm	-9.1123	4.0030	-21.5670	-2.5752	-11.6742	-8.5611	-5.9643
Cross price demand elasticity , 1st firm	0.6881	1.2852	0.0000	20.4733	0.0989	0.3144	0.7140
Own price demand elasticity, 2nd firm	-9.1070	3.9947	-21.4887	-2.5785	-11.6814	-8.5532	-5.9603
Cross price demand elasticity, 2nd firm	0.6826	1.2515	0.0000	20.4102	0.0994	0.3163	0.7144
Aggregate demand elasticity	-1.8213	1.1935	-5.8229	-0.3085	-2.3848	-1.4914	-0.9233
Share of the outside alternative	0.6887	0.2029	0.0419	0.9989	0.5633	0.7231	0.8485
Market share of the first firm	0.0441	0.0580	0.0001	0.6604	0.0058	0.0211	0.0592
Market share of the second firm,	0.0440	0.0578	0.0001	0.6425	0.0058	0.0209	0.0593
Sum of the market shares of merging firms, %	28.3590	22.0263	0.0512	99.5940	11.6392	23.9504	37.9589
Average price increase for merging firms	1.0470	3.0026	-3.0361	120.4555	0.1042	0.3473	0.9751
Post-merger HHI	3809.66	1853.59	1668.15	9919.01	2258.28	3310.89	4841.62
ΔHHI	301.58	418.75	0.0010	4750.38	46.19	187.90	407.43

Table 3. Type-I and Type-II errors level for UPP test under different assumptions

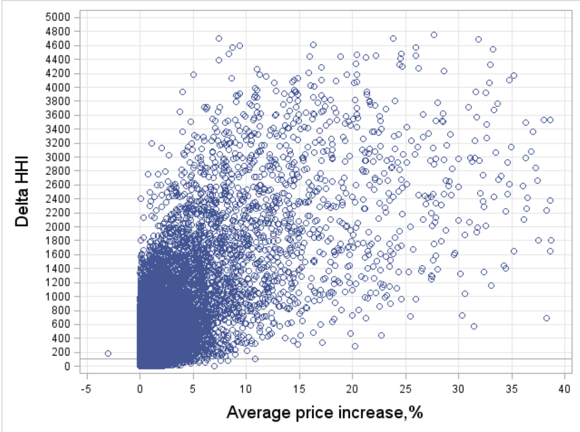
Assumptions	Error type	3% price increase threshold	
		UPP1	UPP2
True UPP and true own pass through rate	Type-I	0.01%	1.38%
	Type-II	1.37%	2.63%
True UPP and own pass through rate =1	Type-I	0.03%	0.79%
	Type-II	1.61%	0.53%
Diversion ration approximated with true market stares and true own pass through	Type-I	4.31%	4.48%
	Type-II	5.11%	4.83%
Diversion ratio approximated with true market shares and own pass through=1	Type-I	4.25%	4.40%
	Type-II	5.29%	4.98%
Diversion ratio approximated with internal market shares and own pass through=1	Type-I	13.19%	18.05%
	Type-II	1.66%	0.85%

8. Appendix C

Graph 3. Post merger HHI vs average price increase



Graph 4. ΔHHI vs average price increase



Graph 5. Average price increase vs sum of the market shares of merging firms (C)