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# Introduction

Competition Policy is a one of the few domains where theoretical developments are constantly enjoying application in practice. A great variety of topics that it offers and the possibility of an immediate application of the results in practice keep attracting the attention of researchers from around the world. Present thesis contributes to the existing knowledge on some of the Competition Policy issues - it covers two of its' branches: assessment of cartel damages and merger evaluations.

The detection and sanction of cartels traditionally remains of a high importance for developed anti-trust authorities because of a clear understanding of their potential harm, and therefore of the potential benefits of their deterrence. In the majority of jurisdiction collusive practices that aim at fixing either prices or market shares are considered as damaging *per se* as firms get an opportunity to block the entry of new rivals or to overcharge for their products or services without adapting the quality. Nevertheless, developing countries still often struggle to create or reinforce their competition authority - running an antitrust division is costly and the supportive evidence concerning the potential benefits is still missing. Research on the cartels' damages for developing countries appears not to be not only limited, but also mainly of a qualitative nature. To provide the missing quantitative evidence, **Chapter 1** offers an assessment of the aggregate economic harm caused by cartels in developing countries. This harm is measured in terms of sales affected by collusive practices as well as in terms of cartel excess profits arising from overcharging consumers, both related to GDP. For this purpose, a substantive dataset containing the information on more than 200 major 'hard-core' cartels prosecuted in more than 20 developing countries was collected. In addition, an original and relatively simple methodology was developed to estimate the price overcharges when they were missing. Our analysis confirms that cartels` impact can indeed be substantial. For example, in terms of sales affected by collusive practices the maximal rate reaches up to 6.38%. The estimated damage in terms of cartels' excess profits divided by GDP can be also significant, with the maximal rate reaching almost 1%. Furthermore, as the maximal annual probability of uncovering an already existing cartel is estimated to be around 24%, it is suggested that the actual economic harm caused by 'hard-core' cartels in developing countries exceeds our estimations at least fourfold.

These results can serve to advocate the introduction or reinforcement of the antitrust control in developing countries. More than that, competition authorities may wish to take advantage of the proposed methodology for their own cartel investigations as it will reduce the data required to estimate the economic damages. The last, but not the least, the created cartels database may be seen as a reference list containing industries that are potentially vulnerable to collusive behavior. Cartel members often enter into collusive agreements in multiple, often neighboring, economies. Therefore, evidence from other countries can (and should) be employed by the competition authorities in local investigations.

Merger evaluation, in turn, is aimed at preventing the potential damage from increasing market concentration beforehand. Since this procedure is known to be costly for both competition authority and the parties involved, countries adopt merger guidelines to improve the efficiency and facilitate the merger control process. Among the proposed instruments that gauge the firms' incentives to unilaterally increase their prices post-merger, the most advanced guidelines offer the traditional Herfindahl-Hirschman Index (HHI) and a more recent Upward Price Pressure (UPP) test. **Chapter 2** offers a comprehensive assessment of the accuracy of these tools and, most importantly, defines economic conditions that favor misleading predictions. Monte-Carlo simulations are used to create economies that are further employed as workbenches to measure the effects of mergers and to evaluate the performance of the chosen evaluation instruments. Results suggest that the HHI test, being originally developed for homogenous good markets, when applied to a market with differentiated products has a very weak performance in identifying the potential for the price increase by merging parties. In its' turn, the UPP test can also be quite misleading, even if one has perfect information on the main ingredients needed to compute it. The UPP value represents an approximation of the alternative costs that the merged firms would face if they would leave their prices on the pre-merger level. Therefore, whenever the UPP is positive, firm is said to experience a positive pricing pressure, i.e. it has incentives to increase its' price. It appears that type-I and type-II errors may occur because the UPP significantly underestimates or overestimates the respective alternative costs. Second reason is that the UPP-like tests by construction ignore the pricing pressure experienced by the merging partner. The present paper demonstrates how this can be fixed by taking into account the corresponding cross pass-through rate that represents the firm's price reaction on the cost shock of the other firm.

**Chapter 3** demonstrates that the ignorance of the cross pass-through effect, and particularly of its sign, can lead to misleading conclusions as well in other stages of merger investigations, including the market definition procedure and the assessment of coordinated effects. Studies that attempted to derive the main drivers of the cross pass-through sign and magnitude were often tailored to particular industrial settings and have, therefore, only limited relevance for the horizontal merger analysis. Chapter 3 of the present thesis offers an examination of the properties of the pass-through matrix in a more convenient and at the same time sufficiently general framework. It particularly focuses on the cross pass-through rate and defines conditions affecting its sign and magnitude. It demonstrates, among other things, that the cross pass-through rate cannot dominate the own pass-through one and its relative significance decreases with higher number of firms. Nevertheless, as illustrated by some examples, this does not mean that the cross pass-through effect can be neglected in merger evaluations, especially when it is negative. Second, it provides derivation of the exact characteristics of *both* the demand and supply systems that affect the sign of the cross pass-through. Therefore it is suggested that the usually adopted in merger simulation assumption of constant marginal costs may *a priori* limit the cross pass-through pattern and hence the simulation outcomes.

# CHAPTER 1

# Cartels Damages to the Economy:

# An Assessment for Developing Countries

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# 1. Introduction

The detection and sanction of cartels traditionally remains of a high importance for developed anti-trust authorities because of a clear understanding of their potential harm, and therefore of the potential benefits of their deterrence. In the majority of jurisdiction collusive practices that aim at fixing either prices or market shares are considered as damaging *per se* as firms get an opportunity to block the entry of new rivals or to overcharge for their products or services without adapting the quality. For example, on a sample of international cartels operating in primary product markets Connor (2011a) demonstrated that in last twenty years cartels' prices were at least 25% higher than their competitive benchmark.

As implementation of the antitrust enforcement requires substantial investments, it can be questioned to which extent those expenditures are compensated in terms of prevented consumers' damages. Especially this is relevant for developing competition authorities that often experience tough budget constraints. Nevertheless, they often struggle to find the supportive evidence that could advocate their efforts - the research that focuses on the effects of cartels in developing economies appears to be very scarce and has mainly taken a qualitative approach. Among the few relevant studies, e.g. those of Jenny (2006), Connor (2011a) and Levenstein, Suslow and Oswald (2003), only the latter offers a relatively comprehensive quantitative assessment of the aggregate impact of cartels' agreements. Based on the international trade flows data and a list of forty-two detected international cartels prosecuted in the U.S. and the EU in 1990s and operating on developing markets, authors estimated that imports affected by cartel agreements constitute 3.4-8.4% of total imports in developing economies, or 0.6-1.7% when divided by the corresponding GDPs. Due to hidden and sometimes tacit nature of cartels and various methodological problems that did not allow authors to take all the observations into account, it is suggested that the actual impact could be much more significant.

Taking into account both international and local cartels and having measured the aggregated cartel excess profits resulting from price overcharges could provide a clearer picture of the actual damage suffered by consumers in developing countries. These estimations can in turn be employed to advocate the introduction or reinforcement of the antitrust control in the concerned economies. Present study aims at providing the required evidence.

The paper will stick to the following outline. **Section 2** comprises a description of the data mining process and a discussion over the descriptive statistics of the collected sample of cartels. We also present our original methodology that was developed to recover the missing price overcharges. While being quite simple and intuitive, its' main advantage is that it requires a very limited data to be implemented. In Appendix C we illustrate the application of this methodology on one of the cases from our database. Overall, collected data do not bring any strong evidence to the widespread idea that cartel overcharges in developing countries are more significant than those in developed countries. We show, however, that the anticompetitive impact in terms of price overcharges is at least of a similar scale, which calls for adequate antitrust measures. We believe that stronger results are achieved by looking at the aggregate measures of cartelization harm that we present in **Section 3.** We focus on several aggregate indicators. To estimate the cartels' impact on the country level, as in Levenstein, Suslow and Oswald (2003) we find it appropriate to consider aggregated sales affected by collusive practices and, more innovatively, aggregated cartels' excess profits that result from price overcharges. Both measures related to GDP. We find that in terms of affected sales related to the GDP the maximal rate reaches up to 6.38%. The actual harm to consumers in terms of cartels' excess profits can be also significant, with the maximal rate reaching almost 1% of the GDP. We supplement the discussion with a simplified cost-benefit-like analysis of the antitrust enforcement by relating aggregated cartels' excess profits to the budget of the corresponding competition authority. Our results demonstrate that in majority of considered countries price overcharges significantly exceed budget expenses aimed at preventing them. Overall, obtained estimates reflect the very minimal bound for the economic harm caused by collusive behaviour because data on detected cartels in developing countries are very limited, but mostly because some of them remain uncovered. To assess how far (or how close) our aggregated estimates are from the reality, in **Section 4** we adopt the methodology proposed in Combe et al (2008) to estimate the deterrence rate, i.e., the annual probability of a cartel to be uncovered. We find that at least three out of four existing cartels remain undetected. To our knowledge this is the first attempt to apply this methodology on a sample of cartels detected in developing countries. **Section 5** concludes the paper.

Competition authorities in developing countries could have a practical interest in the respective results for the advocacy of their efforts. Furthermore, they may wish to take advantage of the proposed methodology for their own cartel investigations as it will reduce the data required to estimate the damages caused by cartelization, in terms of, for instance, price overcharges and output losses.

## 2. Collected data: cartels' profile in developing countries

### *Data collection process*

Our analysis is based on the original dataset containing information on 249 major 'hard-core' cartels that were prosecuted in more than 20 developing countries from 1995 to 2013.[1] In Appendix A we provide a reduced version of this dataset that contains the list of countries, identified cartel cases and their respective periods of existence. We restrict our attention to the chosen period because many of developing countries have established their competition authorities just recently, if at all; hence no or very poor data could be collected for earlier years. Nevertheless, we find it sufficiently long to obtain a representative sample.

The list of countries chosen to participate in the study was created according to the active state of their competition authorities and sufficiency of their experience. For this reason many of the developing economies were excluded from consideration. Nevertheless, they could still profit of the current study results to advocate the introduction of the competition law or its enforcement.

Given the complexity of possible reasons for collusive behavior and consequent welfare effects, we only focus on so-called 'hard core' cartels, i.e. when cartel participants aim at increasing their profits by the means of collective price or market share fixing. These agreements between firms are assumed to be harmful for consumers *per se* and, therefore, are illegal in the majority of antitrust jurisdictions. Hence, we do not include in the database buyers' cartels, collective predatory pricing cases or collusive agreements that were given an exemption by competition authorities.[2]

For every defined 'hard core' cartel, we aimed at collecting quite substantial descriptive data, including relevant market(s), number of colluding firms, cartel duration, cartel's sales, applied penalties and estimated price overcharges. Given the absolute lack of data on losses in

[1] The chosen countries are considered as developing economies according to the International Monetary Fund's World Economic Outlook Report, April 2010.
[2] Collusive behavior could be given an exemption by competition authority if it is proven to be beneficial for consumers or necessary in given economic conditions. This was, for instance, the case of the cartel in the mixed concrete industry in South Korea in 2009.

output or welfare, we have chosen price overcharges as a measure of the economic damage. When a cartel operated on several relevant markets we considered those episodes separately, if available data allowed doing so. When no exact date or month but only year of cartel's creation or breakdown was known, we assumed that cartel's duration comprises the complete year from January to December, similar for months. Cartel's sales were calculated as revenues of all colluding firms during the considered period on the relevant market only. Data on penalties include all applied fines (both for companies and executives) as well as finalized settlements. In some cases inputs were provided in different currencies. Therefore, when needed, cartel's sales were converted by using average exchange rates corresponding to the period of cartel's existence, while for penalties we used the exchange rate that corresponded to the period when the final decision on the case was made. To be able to perform the cost-benefit analysis we also looked for budgets of competition authorities.

The data were obtained from numerous sources such as competition authorities' websites, companies' annual reports, reports of international organizations such as OECD, UNCTAD, etc. A significant piece of information came from the existing database on international cartels.[3] However, our sample would not be so rich without cooperation with local competition authorities.[4] For this purpose, they were asked to fill out a special questionnaire. (See Appendix B.) In addition to the mentioned above target data this questionnaire requests for some additional inputs required for our original methodology that we developed to estimate the price overcharges. The minimal data that are necessary to for this purpose are quite limited and include only prices, market shares and sales of colluding companies at least for one period of cartel existence. All the other cartel-specific information requested in the questionnaire is not mandatory to implement the methodology, but helps to better calibrate market parameters and, eventually, improve the estimation results. We explain the methodology in more detail and report obtained estimates later in the section.

Our database makes a substantial contribution in summarizing and, most importantly, enriching the existing knowledge on price overcharges caused by cartels. It comprises not only international cartels (as, for instance in Levenstein et al. (2003)), but also cartels formed by domestic firms only. Cartels' industrial profile in our sample is similar to the one described

[3] Private International Cartels spreadsheet by John M. Connor, Purdue University, Indiana, USA (March 2009).

[4] We wish to thank for a fruitful cooperation competition authorities from Brazil, Chile, Colombia, Indonesia, Peru, South Africa, Russia, Mexico, Ukraine, Pakistan, Zambia and South Korea and Mauritius, as well as UNCTAD RPP initiative coordinators.

extensively by Jenny (2006), therefore we do not go deeper in this aspect but instead focus on the quantitative assessment.

***Descriptive statistics of the sample***

We provide some descriptive statistics of the collected data in Table 1.

**Table 1: Descriptive statistics of the collected sample**

| Variable | #obs. | Mean | Median | St. dev. | Min | Max |
|---|---|---|---|---|---|---|
| Duration, months | 185 | 46 | 27 | 50 | 1 | 420 |
| Number of cartel members | 200 | 15 | 5 | 37 | 2 | 300 |
| Price overcharge, % | 83 | 23.1 | 20.0 | 14.6 | 2.4 | 75.0 |
| Penalties/Excess profits ratio, % | 72 | 51.8 | 19.0 | 118.2 | 0.0 | 950.5 |

*Table 1:* We measure the price overcharge as % of the cartel price. Whether minimal and maximal bounds for the price overcharge are both known , we used the average between the two.

The median number of colluding firms and median cartel's duration in months are equal to 5 and 27 correspondingly.[5] Analogous calculations for developed economies (see Connor (2011b)) indicate similar results for the number of cartel participants but, surprisingly, a higher level of median cartel duration - around 50 months in the North America and 70 in the E.U. These results may seem to be in conflict with the popular opinion that in developing countries collusion is sustainable for longer periods because of stronger market imperfections and a weaker antitrust enforcement. However, this observation can be supported by theoretical results that demonstrate that on unstable but growing markets deviation from cartel agreement can indeed be very attractive. (See Motta (2004)).

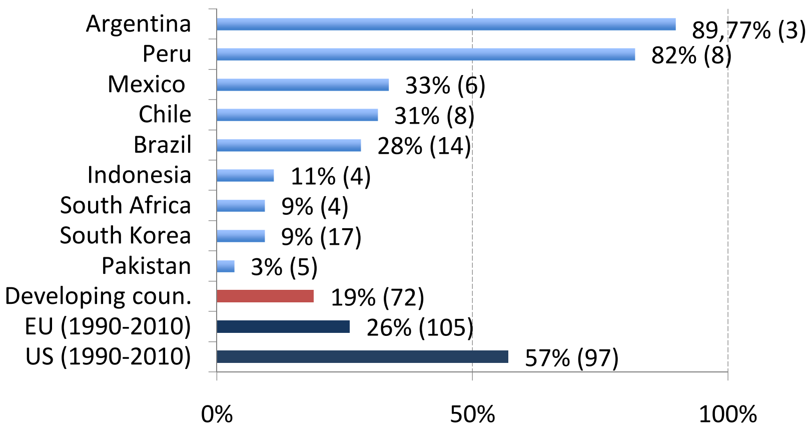
We do not provide descriptive statistics for the absolute values of cartels' sales and penalties because considered countries, their economies and, eventually, cartels are diversified in scale. Instead, we find it important to report descriptive statistics of some relative measures, such as penalties-excess profits ratio and price overcharges that we measure with respect to the cartel price. We define cartel's excess profits as the extra margin resulting from sales at higher prices, taking cartel unit sales as a basis.

We observe that the penalties-excess profits ratio for our sample has quite extreme ends – it varies from 0% to 950%. The former can be explained by the fact that not all of the detected cartels were subject to the fine. The reason for the latter is that penalties were

[5]Median values are more convenient to consider because the data are skewed and contain a few outliers with number of cartel participants more than 200 and duration of more than 150 months thatrenders mean values uninformative.

sometimes calculated as percentage of the total sales of cartel members instead of sales on the relevant market only. Nevertheless, the average for developing countries ratio remains very low compared to the U.S. level (19% against 57%) and is just slightly below the E.U. level of 26% (see Graph 1).

**Graph 1: Comparison of penalty-excess profits ratios, %**




*Graph 1:*In brackets we provide the number of observations used. Country-level data is given only when number of observations is more than 2. Data on the E.U. and the U.S. is obtained from Connor (2011b).

Remarkably, even in developed countries competition authorities on average do not recuperate excess profits gained by cartel members. Moreover, if one would appropriately discount overcharges and penalties to account for money depreciation, those rates would be even lower. According to Hammond (2005) and Connor (2011a) such a situation should be characterized as 'under-punishment' because optimal deterrence of cartels formation requires penalties to be higher than extra profits resulted from collusive arrangements. At the same time, Allain et al. (2011) argue that the E.U. penalty rules can be considered as 'optimal', even if eventual penalty–excess profits ratio is relatively low. They demonstrate that the dynamic effects together with an appropriate estimation of price overcharges (i.e. corrected for model and estimation error and publication bias) have a significant impact on the determination of the optimal dissuasive penalties, i.e. penalties that wipe out all the expected profits resulting from the anticompetitive infringement. The optimality of a penalty rule that does not require a 100% recuperation of the excess cartel profits can be also supported by the following intuition. On one hand, by imposing fines competition authorities try to deter formation of cartels or make it more risky for existing collusion to continue, expecting that a more severe penalty rule to result in a stronger deterrence effect. On the other hand, too high penalty can undermine the firm's ability to be an efficient market player that goes against the initial goal of restitution of the fair competition. If cartel was operating on the market for many years, it might be impossible for the firms to pay back all the extra profits that they have obtained by overcharging. The fact that competition authorities try to balance these two effects in different ways justifies the diversification of the penalty-excess profits ratios among countries.

The present study does not aim at assessing whether penalty rules in developing countries are optimal or not, nor it claims that they should follow the example of developed antitrust jurisdictions. What we want to highlight here, is that factors that define the optimal antitrust policy are quite numerous, starting from the very definition of the optimality that every competition authority decides on its own. Therefore, the effective penalty rule indeed can (and, most probably, should) be country-specific.

It could be expected that a weaker antitrust enforcement provides cartels with incentives to set higher prices. Our collected sample does not provide any strong support to this intuition. As can be seen from Table 2 below, the median price overcharge rate for our sample is of the same range as the one experienced by the E.U. countries (20% versus 19.5-22.48%) and is only slightly higher than 16.7-19% estimated for the U.S. and Canada.

**Table 2: Comparison of cartel price overcharges from existing studies (in %)**

| Country/group | # obs. | Mean | Median |
|---|---|---|---|
| Developing countries (our sample), 1995-2013[6] : | 83 | 23.1 | 20.0 |
| Developing countries (Connor (2010b)), 2000-2009: | 33 | n/a | n/a |
| China | 2 | 17.42 | 17.42 |
| Egypt | 4 | 20.26 | 19.61 |
| India | 1 | 16.67 | 16.67 |
| Korea | 22 | 24.01 | 14.89 |
| Mexico | 1 | 15.25 | 15.25 |
| Pakistan | 1 | 42.53 | 42.53 |
| Turkey | 2 | 53.49 | 53.49 |
| EU (Connor (2011b), 1990-2010 | 105 | n/a | 19.5 |
| EU (Connor (2010b), 1990-2009 | 11 | 28.16 | 22.48 |
| US (Connor (2011b), 1990-2010 | 97 | n/a | 19 |
| US and Canada, (Connor, 2010b), 1990-2009 | 29 | 39.61 | 16.67 |

*Table 2:* Estimates from Connor (2010b) were originally provided with respect to a 'but-for' prices, therefore they were recalculated with respect to the cartel price to be comparable with the other data from the table.

[6] Our sample contains cases that were *prosecuted* from 1995 to 2013, but could have existed before.

***Estimation of price overcharges –methodology and results***

In our study data on price overcharges constitute a departure point towards the measure of the aggregated economic harm induced by cartelization. We acknowledge that in the context of developing countries estimations of price overcharges appear to be very scarce. One of the reasons is that this kind of estimations might be very demanding in terms of time and expertise that represent a serious constraint for a young competition authority. Besides, to condemn a cartel they mostly rely on the evidence on coordination activities (such as phone calls, meeting notes etc.) rather than the economic one (such as parallel pricing or constant market shares, etc.). To address this issue and to fill some of the missing estimates out, we have developed an original methodology that is simple enough to implement while well economically grounded.

The methodology employs the following approach that is applied on a case-by-case basis. Based on the collected cartel data one first performs the calibration of the supply and demand parameters on the cartelized market. If cartel operates on several markets calibration should be performed for each of them separately, if collected data allow doing so. Having the estimated parameters at hand, one then proceeds with the simulation of hypothetical (counterfactual) competitive equilibrium, i.e. market state absent cartelization. Finally, by comparing cartelized and counterfactual (competitive) states, one can calculate price overcharges and corresponding losses in the output and the consumers' welfare.

To perform the calibration of market parameters, we consider a model that describes the equilibrium outcomes on the differentiated product market, where firms compete in prices (differentiating product characteristics are assumed to be fixed). Demand and supply are modeled separately in order to recover equilibrium outcomes.

Precisely, market demand is derived from a general class of discrete choice models of consumer behavior. LOGIT specification that we have chosen is simple and good enough to obtain the desirable structure of demand and, most importantly, it allows explicit calculation of the consumers' surplus in money terms. We assume that there are N potential consumers on the market, each of them considers buying one unit of the product from one of J firms that form a cartel. Consumer can also choose the so called 'outside option', denoted with index "0". Outside option may represent a substitute offered by other firms (not participating in the cartel) as well as consumer's decision not to buy at all.

The utility of consumer *i* buying product $j$ is defined as $U_{ij} = \delta_j - \alpha p_j + \upsilon_{ij}$, where $\delta_j, j = \overline{1, J}$ are parameters of differentiation (e.g. quality of the product or services offered) that are specific to each product and $p_j$ is the price of product $j$. $\alpha$ is the marginal utility of money common for all products and consumers that reflects the sensitivity of consumers to the price relative to how they value quality. Higher $\alpha$ would mean that consumers take their decision mostly according to the price of the product, rather than its quality characteristic. $\upsilon_{ij}$ is the consumer *i*'s idiosyncratic utility component that is specific to product $j$. It is assumed to be identically and independently distributed across consumers and products.

Consumer *i* chooses product *j* if it maximizes her expected utility, such that $U_{ij} > U_{ij'} \forall j' \neq j$. According to Berry (1994), demand associated with the alternative *j* can, therefore, be represented by the following equation:

$$\ln(s_j(p)) = \ln(s_0(p)) + \delta_j - \alpha p_j \qquad (1)$$

where $s_j$ is a market share of the firm *j* and $s_0$ is the share of the outside option and $p = (p_{1,} p_2, ...., p_J)$ is the price vector.

Or, eventually, by

$$s_j(p) = \frac{\exp(\delta_j - \alpha p_j)}{1 + \sum_{i=1}^{J} \exp(\delta_i - \alpha p_i)}, \quad \forall j = \overline{1, J} \qquad (2)$$

where the utility of the outside option is normalized to zero ( $U_{0i} = 0, \forall i = \overline{1, N}$ )

Note, that since the size of the market is fixed to N, market shares can be easily interpreted in terms of sold quantities and vice versa.

In such framework, profit of each firm *j* is defined by the function $\pi_j(p) = (p_j - c_j) * s_j(p) * N$, where $c_j$ are marginal costs that are assumed to be constant.

Further we employ several hypotheses that help to simplify the model and recover unknown market parameters. We first presume that cartel participants act under perfect collusion, choosing prices that maximize the joint profit of the cartel. Second, we assume that cartel members agree to fix their gross margins to a certain value that is constant for all firms, such that $(p_j - c_j) = const$, $\forall j = \overline{1,J}$. Under these assumptions, from the cartel's joint profit maximization problem it is easy to obtain the following cartel equilibrium condition:

$$(p_j - c_j) = 1/\alpha s_0 \, , \forall j = \overline{1,J} \qquad (3)$$

System of equations that includes (2) and (3), therefore, fully describes the cartelized market equilibrium $(p_j^{cartel}, s_j^{cartel})$, $\forall j = \overline{1,J}$. Cartel's prices and market shares one can recover from factual market data related to the period of cartelization. Note, however, that market shares that are employed in the model ( $s_j^{cartel}$) are not the same as those observed from the market data (denoted as $\bar{s}_j^{cartel}$). The latter ones stand for the market shares within the cartel, while the former take into account the presence of the outside option, such that $\bar{s}_j^{cartel} = \frac{s_j^{cartel}}{(1-s_0)}$ and $\sum_{j=1}^{J} \bar{s}_j^{cartel} = 1$.

To be able to solve the system of equations composed of (2) and (3), and by doing so recover the unknown market parameters, one would need to set two of them exogenously. One of the parameters that we initially choose to fix is the gross cartel margin $(p_j^{cartel} - c_j)$, $\forall j = \overline{1,J}$. Note, that this is equivalent to choosing the average cartel margin $AM \equiv \sum_{j=1}^{J} \bar{s}_j^{cartel} \frac{(p_j^{cartel} - c_j)}{p_j^{cartel}}$.[7] Because the latter is a relative measure and therefore can be much easier to interpret we finally choose the average cartel margin as one of the exogenous parameters for the calibration procedure. The second parameter is the share of the outside option $s_0$.

Firms gross margins could be extracted from the colluding companies' annual reports, even if often only approximately. In contrast, it becomes much more complicated when it comes to the estimates of the share of the outside option. There is no standard procedure to define the potential market size, and methodology might differ significantly depending on the product and market considered. However, independently on the procedure chosen, the sum of

[7]Recall that margin constant for all cartel participants is one of the basic assumptions of the methodology. Keeping this in mind, when market shares and prices are known, it is easy to recover average cartel margin from the standard ones, and vice versa:

$$AM \equiv \sum_{j=1}^{J} \bar{s}_j^{cartel} \frac{(p_j^{cartel} - c_j)}{p_j^{cartel}} = \underbrace{(p_j^{cartel} - c_j)}_{constant\ for\ all\ j} \sum_{j=1}^{J} \frac{\bar{s}_j^{cartel}}{p_j^{cartel}}$$

all market shares, including the one of the outside option, must be always equal to one, i.e. $\sum_{j=1}^{J} s_j^{cartel} + s_0 = 1$.

Having set exogenously average cartel margin and share of the outside option we first recover parameter $\alpha$ from equation (3):

$$\alpha = \frac{1}{s_0 ( p_j^{cartel} - c_j )} = \frac{\sum_{j=1}^{J} \frac{\bar{s}_j^{cartel}}{p_j^{cartel}}}{AM * s_0} \qquad (4)$$

In the list of the parameters set exogenously one can choose to replace cartel's margin or the share of the outside option with marginal costs if they are known. In this case equation (4) will remain valid and further steps of the methodology will not be affected.

Now we have all required information to recover the parameters of differentiation $\delta_j$ from equation (1). Marginal costs can , therefore, be recovered from the values of margins, either average for the cartel or firm-specific gross margins.

While choosing values of exogenous parameters, one needs to make sure that obtained values of marginal costs and parameter of sensitivity to the price $\alpha$ are non-negative. Note, that there are no sign restrictions to the values of $\delta_j$.

At this point, one is able to calculate the set of own- and cross-price elasticities (correspondingly):

$$\varepsilon_{jj} = -\alpha p_j^{cartel} (1 - s_j^{cartel} ), \quad \forall j = \overline{1, J} \qquad (5)$$

$$\varepsilon_{ji} = \alpha s_i^{cartel} p_i^{cartel}, \forall j, i = \overline{1, J}, i \neq j \qquad (6)$$

Obtained estimates can be compared with existing ones from the other sources. This may be seen as an additional cross-validation for the values of exogenous parameters and may result in corresponding corrections.

At the end of the calibration procedure one has all missing market parameters $(\alpha, \delta_j \text{ and } c_j, \forall j = \overline{1, J})$ recovered. They are assumed to remain the same whether the market is cartelized or not. And now we are ready to proceed with the simulation of the counterfactual (competitive) state of the market.

In the absence of collusion each firm would take a decision on its own price to maximize own profits, taking into account own marginal costs and expected pricing strategy of competitors. A standard solution for each firm's profit maximization problem would be:

$$p_j - c_j = \frac{1}{\alpha(1-s_j)}, \ \forall j = \overline{1,J} \tag{7}$$

while (2) remains valid.

As a solution of the system of equations (7) and (2) we obtain counterfactual (competitive) prices $p_j^c, j = \overline{1,J}$ and market shares $s_j^c, j = \overline{1,J}$. By comparing cartel's and competitive prices we can calculate price overcharge for every cartel member as well as cartel's average price overcharge:

$$\Delta P\% = \sum_{j=1}^{J} \bar{s}_j^{cartel} \frac{(p_j^{cartel} - p_j^c)}{p_j^{cartel}} \cdot 100 \tag{8}$$

Formula in (8) gives a price overcharge estimate in percentage, but it can easily be transformed into money terms by multiplying firm specific price overcharges on the corresponding cartel member sales.

Moreover, employed demand model allows explicit calculation of the consumers' welfare (surplus) losses, both in percentage and in money terms. We make use of the formula, proposed in Anderson et al. (1992)):

$$CS = \frac{1}{\alpha} \ln\left(1 + \sum_{j=1}^{J} \exp(\delta_j - \alpha p_j)\right) \tag{9}$$

Hence, relative consumers' welfare losses caused by collusive practices could be calculated as following:

$$Welfare\ losses(\%) = \frac{\left(\ln\left(1 + \exp\sum_{j=1}^{J}(\delta_j - \alpha p_j^c)\right) - \ln\left(1 + \sum_{j=1}^{J}\exp(\delta_j - \alpha p_j^{cartel})\right)\right)}{\ln\left(1 + \exp\sum_{j=1}^{J}(\delta_j - \alpha p_j^c)\right)} \cdot 100 \tag{10}$$

On one hand, an obvious advantage of our methodology is that it requires very limited data to be implemented: it can be employed only with information on prices and observed market shares of colluding companies at least for one period of cartel existence. On the other hand, it is based on a relatively simple model and uses a few assumptions that result in certain limitations. We discuss them below.

First, demand is designed from a simple LOGIT model, which is quite flexible but has a specific property of Independence of Irrelevant Alternatives. In a nutshell, this model generates a particular consumers' behavior pattern: motivated by a price increase consumers would switch to the product with the maximal market share, but not the one with closest quality characteristics. Indeed, it may not be a true behavioral pattern in reality.

Second, our methodology is based on assumption about the perfect collusion among cartel participants while real level of coordination among firms could be much weaker. Under these conditions, obtained estimates of price overcharge and consumers' welfare losses are the maximal ones for the assumed levels of cartel's margin and share of the outside option.

Third, when one changes assumptions about cartel margin and/or share of the outside option, then values of calibrated market parameters and, ultimately, final estimates of the interest also change. For this reason it makes sense to consider not the exact values but rather a reasonable range for each of exogenous parameters, based on the common sense and available market data. Sensitivity of estimation results with respect to the parameters that are set exogenously differs in each particular market. Considering reasonable ranges for external parameters rather than exact values shall help in assessing the robustness of obtained results. Additional market expertise, when available, could also help to narrow down the range of calibrated market parameters and, eventually, obtain more precise estimations of price overcharge and consumers' welfare losses.

In the Appendix C we illustrate application of the proposed methodology on the price-fixing cartel between civil airlines in Brazil.

It is unfortunate to acknowledge that competition authorities in developing countries often do not possess even the minimal economic data required to employ the methodology. Or, even if they do, it is often considered as confidential. Due to this reason, it was possible to perform estimations only in eleven cases. Results are provided in Table 3.

**Table 3: Estimates of price overcharges and output losses obtained with the use of the developed methodology**

| Industry (country) | Period of existence | Min $\Delta p\%$ | Max $\Delta p\%$ | Min $\Delta q\%$ [8] | Max $\Delta q\%$ |
|---|---|---|---|---|---|
| Civil airlines (Brazil) | Jan'99-Mar'03 | 3.20% | 33.90% | 10.00% | 24.2% |
| Crushed rock (Brazil) | Dec'99-Jun'03 | 3.40% | 11.25% | 15.69% | 25.80% |
| Security guard services (Brazil) | 1990-2003 | 4.80% | 27.84% | 14.93% | 23.15% |
| Industrial gas (Brazil) | 1998-Mar'04 | 4.12% | 29.96% | 5.00% | 22.77% |
| Steel bars (Brazil) | 1998-Nov'1999 | 5.49% | 37.84% | 10.99% | 27.81% |
| Steel (Brazil) | 1994-Dec'99 | 13.55% | 40.13% | 5.00% | 29.22% |
| Medical gases (Chile) | 2001-2004 | 37.50% | 49.40% | 2.00% | 14.93% |
| Petroleum products (Chile) | Feb'01-Sep'02 | 4.57% | 9.90% | 10.43% | 23.35% |
| Construction materials (Chile) | 20 Oct'06 | 47.78% | 83.48% | 7.24% | 22.95% |
| Petroleum products II (Chile) | Mar'08-Dec'08 | 1.78% | 11.13% | 9.63% | 18.99% |
| Cement (Egypt) | Jan'03-Dec'06 | 28.20% | 39.3% | 5.00% | 10.00% |
| Average for the category | | 14.04% | 34.01% | 8.68% | 21.94% |
| Average | | 24.02% | | 15.41% | |
| Median | | 18.6% | | 16.9% | |

*Table 3*: Price overcharge is measured with respect to the cartelized price, while losses in the output with respect to the counterfactual (competitive) state.

Obtained average and median price overcharge rate of 24.21% and 18.6% correspondingly are of the same magnitude as for the rest of the sample (23.1% and 20%, see Table 1). We acknowledge, however, that the difference between the estimated maximal and minimal bounds of price overcharges and output losses is often large. A competition authority that wants to implement the proposed methodology would certainly obtain a greater precision provided it uses the best information on the input parameters. Further analysis in Section 3 includes these additional estimations.

## 3. Aggregated cartels' effects

Overall, the descriptive statistics of the collected data demonstrate that the anticompetitive impact in terms of price overcharges is at least similar to that in developed countries, which calls for adequate antitrust measures. Young competition authorities, that

[8] Minimal and maximal estimated output losses can appear rounded. This is a results of some particularities of the methodology employed , particularly because some parameters need to be set exogenously.

often lack resources to efficiently fight against collusive practices are having hard times lobbing for a greater budget and, therefore, are constantly looking for strong and motivating evidence of the benefits that their existence brings. We believe that the latter could be provided by looking at the aggregate measures of cartelization harm that we provide in this section. The approach that we use consists in summing up the obtained cartel case-specific impact estimates in money terms and assessing their significance on the macro-economic level.

Precisely, in our analysis we focus on several aggregate indicators. First, inspired by Levenstein, Suslow and Oswald (2003) we find it appropriate to consider aggregated sales that were affected by collusive behavior, i.e. total revenues received by cartel members. More innovatively, we also assess the aggregate cartel damage in terms of excess profits. Both measures are summed up for all cartels in each particular country and related to the GDP. We supplement the discussion with a sort of "cost-benefit" analysis of the antitrust enforcement by relating the aggregated excess profits to the budget of the corresponding competition authority ("CA Budget").

In order to obtain more comprehensive aggregated estimates we first fill the remaining data gaps in by applying an additional treatment to the originally collected data.

For those countries where competition authority sets maximal penalty as percentage of cartel's sales (like, for instance, in Brazil, South Korea, Ukraine, South Africa, etc.), we approximate the missing cartel sales as the respective penalty in money terms divided by the maximal penalty rate.[9] Note that this approach provides an estimate of the minimal level of cartel's sales. The penalty in those cases is set based on the sales recorded in the year preceding the one where the court decision on the case was made. Therefore, the minimal approximated cartel sales need to be further multiplied by cartel duration in years. When price overcharge was unknown and it was not possible to employ the proposed methodology to estimate it, we roughly approximated the excess cartel's excess profits by multiplying the sample median overcharge rate and cartel sales. In case cartel sales were missing, we first assumed the cartel's excess profits as equal to applied penalties. Recall that, according to Table 1, applied penalties do not in average compensate for the excess profits gained by cartel

[9] For example, if a cartel was fined for 100 USD and the maximal penalty rate is 10% of cartel's sales, then minimal bound for cartel's sales can be estimated as 100/0.1=1000 USD. Because percentage penalty rule is sometimes applied to company's total sales, we have employed, where needed and where possible, a coefficient that corresponds to the share of sales on the relevant market in total company sales.

members, therefore this approximation provides a minimal level of cartel's excess profits. Knowing the minimal level of cartel's excess profits allowed, in turn, recovering back the missing cartel sales by applying the median price overcharge rate.

Finally, to make the nominal values, such as sales, excess profits, penalties and competition authorities' budgets comparable among different years, we apply relevant denominators to translate them into the currency of the last year of the considered period (specific for each country).

Aggregated harm was calculated separately for countries with sufficient data, namely Brazil, Chile, Colombia, Indonesia, South Africa, Mexico, Pakistan, Peru, Russia, South Korea, Ukraine and Zambia. The selection criterion is basically the availability of quantified impacts of cartels that represent a significant part of all detected cases in the country. Except for Zambia, whose only quantified cartel had a tremendous economic impact.

For these countries in Table 4 below we provide the breakdown of recorded cartel cases indicating the number of quantified ones. Information in brackets refers to number of cases for which corresponding missing inputs were approximated by means of the above treatment. We employ the term 'allocated' for those cartels when we were able to associate sales and excess profits with a certain year, i.e. only those when at least cartel's beginning or breakdown year was known.

**Table 4: Availability of quantified impacts of detected cartels (numbers)**

| Country (period) | # of cartels recorded | # of cartels with data on sales | # of cartels with data on overcharges | # of 'allocated' cartels |
|---|---|---|---|---|
| Brazil (1995-2005) | 18 | 17(1) | 17(3) | 17 |
| Chile (2001-2009) | 17 | 16(6) | 16(7) | 16 |
| Colombia (1997-2012) | 18 | 17(17) | 17(17) | 17 |
| Indonesia (2000-2009) | 12 | 8(0) | 8(1) | 7 |
| Mexico (2002-2011) | 17 | 17(9) | 17 (11) | 17 |
| Pakistan (2003-2011) | 14 | 14(6) | 14(9) | 14 |
| Peru (1995-2009) | 11 | 10(2) | 10(2) | 10 |
| Russia (2005-2013) | 15 | 11(10) | 11(11) | 11 |
| South Africa (2000-2009) | 37 | 23(7) | 23(18) | 23 |
| South Korea (1998-2006) | 26 | 26(0) | 26(8) | 26 |
| Ukraine (2003-2012) | 7 | 7(6) | 7(7) | 3 |
| Zambia (2007-2012) | 7 | 1(0) | 1(0) | 1 |

The two aggregated indicators of the interest we first calculate as an average for the considered period. Looking at the year-to-year dynamics would be misleading because both ends of the period have a high risk of not being representative - either because of a low activity of the competition authority in the beginning or because the end of the period is often characterized by multiple ongoing cartel investigations. Absent final decision made on the case corresponding price overcharges and other data cannot be included into the database. Because of these reasons even average for the period estimates can be biased, thus we find it important to report also the maximal value together with the year that it corresponds to. Table 5 summarizes obtained results.

**Table 5: Aggregated indicators**

| Country | Aggregated excess profits / GDP, % | | Affected sales/ GDP, % | | Aggregated excess profits / CA Budget | |
|---|---|---|---|---|---|---|
| | Average | Max (year) | Average | Max (year) | Average | Max (year) |
| Brazil (1995-2005) | 0.21% | 0.43% (1999) | 0.89% | 1.86% (1999) | 308 | 1232 (1998) |
| Chile (2001-2009) | 0.06% | 0.23% (2008) | 0.92% | 2.63% (2008) | 23 | 91 (2008) |
| Colombia (1997-2012) | 0.001% | 0.002%(2011) | 0.01% | 0.01% (2011) | 7 | 36 (2006) |
| Indonesia (2000-2009) | 0.04% | 0.09% (2006) | 0.50% | 1.14% (2006) | 29 | 58 (2004) |
| Mexico (2002-2011) | 0.01% | 0.02% (2011) | 0.05% | 0.11% (2011) | 7 | 19 (2011) |
| Pakistan (2003-2011) | 0.22% | 0.56% (2009) | 1.08% | 2.59% (2009) | 245 | 518 (2008) |
| Peru (1995-2009) | 0.002% | 0.007%(2002) | 0.01% | 0.023% (2002) | 6.44 | 25 (2004) |
| Russia (2005-2013) | 0.05% | 0.12% (2012) | 0.24% | 0.67% (2012) | 0.58 | 1.45 (2008) |
| South Africa (2000-2009) | 0.49% | 0.81% (2002) | 3.74% | 6.38% (2002) | 124 | 214 (2005) |
| South Korea (1998-2006) | 0.53% | 0.77% (2004) | 3.00% | 4.38% (2004) | 144 | 214 (2004) |
| Ukraine (2003-2012) | 0.03% | 0.03% (2011) | 0.15% | 0.16% (2011) | 0.84 | 0.88 (2011) |
| Zambia (2007-2012) | 0.07% | 0.09% (2007) | 0.18% | 0.24% (2007) | 11 | 27 (2007) |
| Average | 0.14% | | 0.9% | | 76 | |

Our results confirm that cartels` impact in developing economies can indeed be substantial. In terms of affected sales related to GDP, it varies among countries from 0.01% to 3.74% on average for the considered periods, while its maximal value reaches up to 6.38% for South Africa in 2002. Remarkably, calculations for Zambia are based on only one cartel for which data are available (market of fertilizers, 2007-2012), but even taking this into consideration the impact is not negligible (0.24% of GDP in terms of affected sales). Actual harm in terms of aggregated cartels' excess profits is also significant, with maximal rates reaching almost 1% in terms of GDP for South Korea in 2004 and South Africa in 2002.

The cost-benefit analysis performed for selected competition authorities demonstrates that potential benefits of having an antitrust division (or alternative costs of not having it) measured as aggregated cartel excess profits exceed the competition authorities' budgets on average 76 times and can reach up to 1232 times (see the last two columns in Table 5).[10] Here we assume that a cartel would exist for at least as long as it already did before being discovered. Data on budgets that we have collected comprise expenses for all activities of the competition enforcement unit, including merger investigations that are traditionally highly demanding in terms of resources. Therefore, the cartel-specific efficiency rate can turn out significantly higher.

Our estimates can be considered as a very minimal bound for the economic harm caused by collusive behaviour because of multiple reasons. First of all, the collected data on detected cartels remain very limited. Even though some competition authorities agreed to cooperate, we have to acknowledge that the list of prosecuted 'hard – core' cartels for every country is still not complete, nor were all the required data obtained for each of the cases. Out of 249 defined cases only 83 have data on price overcharges, 175 on applied penalties and 114 on cartel's sales. As Table 4 above illustrates, many of recorded cases were excluded from calculations of the aggregate effects because of missing data. On top of this there is another reason, t hat may in fact be a principal one - some of the existing cartels remain uncovered.

[10] Here we assume that when cartel breaks down then firms come back to their competitive equilibrium strategies. As a consequence of this, firms are supposed to low down prices to a pre-cartel level. Evidence on post-cartel behavior collected by Connor (2010a) and Sproul (1993) indicates that this assumption might not be always valid. Given that for our sample very limited price data were available even for the period of cartel existence, and no data at all are available for post-cartel periods, we should admit that this is almost impossible to test whether the assumption in question holds for our sample of cartels.

Note that a high level of excess cartel profits related to the competition authority budget does not necessarily witness for the efficiency of the antitrust enforcement. Firstly, a low level of the ratio in question can result from a high efficiency of the competition authority if the latter focuses rather on cartel deterrence (education through mass media or higher penalties, etc.) than cartel detection. Low number of detections or lower excess profits can simply reflect the fact that there exist fewer cartels or that they are weaker. Second reason is that competition authorities can 'free ride' on the experience of the other ones. By 'free riding' we mean a situation when a cartel case already went through an examination in one of the competition authorities, and the others use this fact to trigger its own investigation or even use the already extracted evidence. Therefore a competition authority can win the case without investing too much. As the collected sample demonstrates, 'free riding' can indeed take in place - the same cartels are often found in a large number of (often neighboring) countries. For example, this is the case of industrial gas distribution cartels in Latin America or cement cartels in Africa. Although, 'free riding' can potentially be considered as a sort of efficiency as it is a way of 'economizing' the resources.

To assess how far (or how close) we are from understanding the real scale of the damage, in the next section we estimate the deterrence rate, i.e., the annual probability of a cartel to be detected. To our knowledge this is the first attempt to do so on a sample of cartels detected in developing countries.

## 4. Estimation of the deterrence rate

To estimate the deterrence rate we have adopted the approach proposed in Combe et al (2008). We did not modify their methodology, therefore only a brief description of the main idea and results of its application on our database will be provided. In a nutshell, authors consider a markovian process with two elements that are related to the cartel birth and its' death that is associated with detection. Cartels inter-arrival time and duration between their birth and detection - are both random variables distributed exponentially and independently across cartels.[11] The model allows calculating instantaneous probability of cartel detection through the maximum likelihood estimation method. Because the sample naturally contains only cartels that were detected, the estimated probability is *conditional on that the cartel will be eventually detected.* This value, in turn, represents the *maximal* bound of the global instantaneous probability of cartel detection (the sought-for deterrence rate).

For our sample the estimated maximal annual probability of detection equals to 24%. It is significantly higher than the upper bound of the same variable estimated by Combe et al. (2008) for the E.U. cartels prosecuted from 1969 to 2007 (12.9-13.3%%) that apparently witness for a more efficient antitrust enforcement in developing countries.[12] A lower rate for the E.U. can be explained by inclusion into consideration of earlier years that are characterized with a weaker antitrust enforcement. An additional explanation can be also offered. When cartel members are international corporations they often enter collusive agreements in several, often neighboring developing countries. Apart of the famous vitamins cartel, our sample includes, for instance, medical gas distribution cartels, prosecuted in Argentina, Brazil, Chile, Colombia and Mexico in late 90s-early 2000s, or cement cartels that

[11] Because the cartel duration in our database is often not precise (for example, the year only was reported) we take the maximal duration for each of the cartels that contains complete months/years, unless a more precise information is available. To see whether our data fit model assumption of independency and exponential distribution we performed the same testing as in Bryant and Eckard (1991). Corresponding estimation results and graphs are available upon request.

[12] Estimates for the E.U. are taken from Combe et al (2008) and cover cartels prosecuted from 1969 to 2007. The maximal bound for the annual deterrence rate of 13% - 17% was estimated with a similar methodology for a set of U.S. cartels. (See Bryant and Eckard (1991).) However these result should not be compared with the one from our study as situation in the antitrust enforcement has significantly changed since the period that was considered by authors (from 1961 to 1988).

took place over the last 30 years in South Africa, Argentina, Egypt, Korea, Mexico and other developing countries. Evidence provided by other countries may serve as a trigger for local investigations and can facilitate the cartel detection, increasing, therefore, the deterrence rate.

A maximal deterrence rate of 24% basically means that *at least* 3 out of 4 existing cartels remain uncovered. Therefore, we suggest that the actual economic harm caused by 'hard-core' cartels in developing countries exceeds our estimations from the previous section at least fourfold.

## 5. Conclusions and policy implications

The competition policy implementation and enforcement, including cartel investigations, require substantial investments. Therefore, it is important to measure to which extent those expenditures are compensated in terms of prevented consumers' damages. Especially this is relevant for developing competition authorities that often experience tough budget constraints. To provide the required evidence we have collected an original dataset that contains information on 249 major 'hard-core' cartels that were prosecuted in more than 20 developing countries from 1995 to 2013.

Descriptive statistics of our dataset of cartels do not bring any strong evidence to the widespread idea that developing countries are exposed to a higher cartel price overcharges than the developed ones. However, we do show that price overcharges are at least similar, which calls for adequate antitrust measures. We also show that the aggregated impact can be substantial. In terms of affected sales related to GDP the maximal rate reaches up to 6.38% (South Africa in 2002). The actual damage in terms of cartels' excess profits is also significant, with maximal rates reaching almost 1% of GDP (South Korea in 2004 and South Africa in 2002).

Study of Boyer and Kotchoni (2014) demonstrates on the sample from Connor (2010b) that data on price overcharges obtained from different methodologies, sources and contexts are asymmetric and heterogeneous, and therefore, are subject to a significant estimation bias. Non-biased estimates are, in fact, lower than simple medians calculated from the raw data. For example, bias correction reduces median price overcharge for the E.U. countries from 22.48% to 14.04% and from 16.67% to 13.58% for the U.S. and Canada.[13]

[13]Estimates from Boyer and Kotchoni (2014) were originally provided with respect to a 'but-for' prices, therefore they were recalculated with respect to the cartel price to be comparable with the other estimates in the paper.

Therefore, ideally, our own sample would require similar corrections to be made. We, nevertheless, insist that our aggregate damage estimates correspond to the very minimal bound of cartels' effects. This is so because of at least six reasons.

First, present study only takes into consideration cartel cases that are already closed. It, therefore, does not take into account neither cases under investigation nor those for which competition authority failed to prove its existence.

Second reason is that economic data on convicted cartels are very poor. This is so because to condemn a cartel competition authorities rely mostly on the evidence of coordination activities rather than the economic one. Coupled with confidentiality issues, this reason resulted in elimination of multiple recorded cases from calculation of aggregate effects.

Third, collusive practices harm consumers not only in terms of inflationary effects, but also because they limit consumption. Our analysis demonstrates that, on average, a cartel decreases the production level by about 15% on the concerned market (see Table 3). Taking into account these output effects would provide more accuracy for our estimations. Our methodology allows one to calculate the losses in consumers' surplus that could serve to measure both changes - in prices and in quantities. However, in our sample its' application is limited to only a few cartel cases with sufficient data.

On top of this, our estimates do not take into account neither price umbrella effects[14] nor possible degradation in quality.[15]

Fifth reason is that many of the cartelized industries produce intermediary goods, such as, for instant, cement or gas. Therefore the consequent price overcharge may proliferate further on other economic sectors, increasing the final impact manifold. By employing the country level input-output matrixes and corresponding industry pass-through rates together with estimated cartel excess profits one would be able to i) assess the potential impact of those proliferations, and ii) define a set of industries that have the highest damaging potential and therefore deserve a special attention from the competition authority. We find it as a very promising area for further development.

[14]Cartels can potentially cause a price umbrella effect as remaining firms could have more incentives to charge higher prices facing a price increase from cartel members.
[15]Even though our model does not allow the quality characteristics to change, the degradations in quality can still appear as colluding firms may have less incentive to maintain it.

The final, but probably the most important reason for our estimates to reflect only the minimal bound, is the hidden nature of cartels. As we estimate the maximal annual probability of uncovering an existing cartel to be around 24%, we suggest that the actual economic damage resulting from collusive practices in developing countries is at least 4 times bigger that suggested by our estimations.

We have also demonstrated that even this minimal estimated economic harm for the majority of considered countries significantly exceeds the expenditures to maintain the functionality of the relevant antitrust body. This may serve as a sought-for evidence for the competition authorities who wish to justify the requirement for an additional budget to improve the cartel deterrence and detection. More than that, developing competition authorities may wish to take advantage of the proposed methodology for their own cartel investigations as it will reduce the data required to estimate the economic damages. The efficiency of the penalty rule can be then assessed by comparing the imposed fines with cartels' excess profits. Actual penalty - excess profits rates could be compared against relevant benchmarks that are considered by the competition authority as optimal.

The last, but not the least, the created cartels database may be seen as a reference list containing industries that are potentially vulnerable to collusive behavior. Cartel members often enter into collusive agreements in multiple, often neighboring, economies. Therefore, evidence from other countries can (and should) be employed by competition authorities in local investigations. This may encourage countries to create a worldwide platform that would allow sharing and maintaining the common cartel database, for instance, on the basis of the International Competition Network (ICN).

# CHAPTER 2

# Assessing the accuracy of merger guidelines' screening tools

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# 1. Introduction

To assess whether a merger between two competitors can potentially generate significant anticompetitive effects, including price increases, competition authorities bring the merger proposal through a merger evaluation process. This process can appear to be very costly both for the competition authorities and the parties involved. In this perspective, countries adopt merger guidelines with recommended rules and procedures simple enough to facilitate the merger control process and improve its' efficiency.

Given the diversity and different levels of development of merger guidelines among countries, we base our discussion on the most recent ones enacted in 2004 in the E.U. and in 2010 in the U.S. Among the proposed tools that aim at gauging the possible anticompetitive post-merger effects, the European guidelines offer the so called SIEC ("significant impediment to effective competition") test. Though the description of the SIEC test is quite extensive, no particular procedures are recommended. To date, the most advanced tool that can be used for implementation of this test that allows assessing the post-merger price changes involves simulation of a merger based on an economic model of competition. Parameters of this model are either calibrated from different and often incomplete sources to match with the real market data, or estimated based on datasets that permit applying statistical estimation methods. This method requires not only a large amount of data, but also substantial expertise. That is why competition authorities constantly seek for less sophisticated methods, which along with their simplicity would provide a sufficient level of accuracy. Recently proposed by Farrell and Shapiro (2010) the Upward Pricing Pressure (UPP) test is intended to fit these requirements. It already features in the U.S. merger guidelines of 2010 and some elements of it are as well present in the U.K. merger guidelines of 2010. It is now under a heavy discussion whether it could be a good alternative to merger simulations. Among the other 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.

Based on distinct economic models and underlying assumptions, the HHI and the UPP tests could naturally differ in their predictive power. Our purpose is to test the accuracy of these tools and, more importantly, to characterize economic situations that lead to wrong predictions. For both tests the accuracy can be measured in terms of type-I and type-II errors. Type–I error is associated with the case when a test flags merger as potentially detrimental for consumers (e.g. causing significant price increase), while it is actually not. In turn, type-II error occurs when the test failed to diagnose a merger that is indeed harmful. It is important to track both types of errors. If these tests are used as screening tools, then a type-I error leads to unjustified budget expenses as it triggers the phase-II of the merger assessment procedure, while a type-II one results in consumers' welfare losses.

To reach the goal set above, one can proceed in several possible ways. For example, a set of realized mergers could be analyzed. Then the actual post-merger effects could be revealed by comparing pre-and post-merger data. Type-II error level for each of the tests can be further estimated by matching these observations with decisions based on merger-assessing tools. This type of approach has been used, for example, by Okpanachi (2011), Kwoka (2012), Neven and Roller (2000). There are, however, at least two potential problems that this method entails. Evaluating merger decisions by comparing pre- and post-merger data can be misleading because new elements may blur the environment that was prevailing when the merger happened. Besides, it only allows one to assess the accuracy of the tests in terms of type-II error.

Our approach is aimed at avoiding these drawbacks. We create, by implementing Monte Carlo simulations, a large sample of economies that is further used as a *workbench* to measure the effects of mergers and to evaluate how the chosen tools perform. A great advantage of this approach is that it provides all the information about the economies and its agents and, therefore, allows controlling for the pre- and post-merger economic environment.

Precisely, we simulate 100,000 economies, each comprising i) consumers whose preferences are generated by a random utility model and ii) an oligopoly market structure with single-product firms producing differentiated products and compete à la Bertrand-Nash. Number of firms is set to nine as the lowest one that allows obtaining a sufficient number of observation with post-merger HHI levels below and above the current US guidelines' thresholds. Marginal costs are assumed to be constant. A sampling process, therefore, involves distributions for products' characteristics, consumers' preferences and firms' costs elements. Distributions' parameters vary from one economy to another that allows generating highly heterogeneous economic situations.

The simulation process follows these steps: i) the nature draws the quality of products including the quality of the outside good that is not sold by any firm present on the market, consumer tastes and cost components; ii) firms compute expected market shares and compete in prices; iii) the Nash equilibrium is solved for prices; iv) consumers make their final choice given prices. Then we use this setup to merge firms and to compute *ex post* merger equilibria. We assume, without loss of generality, that a merger takes place between the first two firms and that the merger does not generate any cost efficiencies.

From the initially generated sample we have removed observations that contained elasticity outliers as well as those that did not satisfy the equilibrium second order conditions or where our algorithm did not converge while solving for the equilibrium. This leaves us with a final sample composed of 41851 economies. A more detailed description of the simulation and cleaning processes are provided in Appendix D.

Given the assumptions underlying the simulation process, in particular, distributional assumptions, it is needed to evaluate its capacity to provide reasonably "realistic" economies. We find that the extreme values of main economic variables in the final sample, such as elasticities or market shares, lie in reasonable ranges, while providing sufficient differentiation (see Table 1). For instance, values taken by the aggregate demand elasticity show that we span a large range of economies with demands varying from highly inelastic (-0.0001) to highly elastic one (-15.87).

In real economic environment some potential consumers can be present on the market without buying any of *J* products. The model that we have chosen to create the workbench incorporates this possibility – it allows consumers to chose the so-called 'outside option', including not buying at all. The share of the outside option is denoted as $s_0$. Therefore, in our analysis we make a distinction between the market shares that do take into account the 'outside option' and those that don't. The former we call *'true'* market shares ($s$), for the latter we employed an upper bar and further call them '*observed*' ($\bar{s}$).[16] In our sample, the observed market share of the first merging firm varies from 0,01% to 93.6%, and similar for the second one, providing various levels of pre- and post-merger market concentration.

[16] If $s_0$ is the market share of the outside option, then observed and true market shares of product *j* are linked in the following way: $s_j = \bar{s}_j(1 - s_0)$.

**Table 1: Descriptive statistics of main parameters of the economic model (0% cost efficiency)**

| **Parameters** | **Mean** | **Variance** | **Min** | **Max** |
|---|---|---|---|---|
| Own price demand elasticity, 1st firm | -6.925 | 4.041 | -30.167 | -1.794 |
| Own price demand elasticity, 2nd firm | -6.919 | 4.030 | -30.256 | -1.811 |
| Cross price demand elasticity , $\varepsilon_{12}$ | 0.512 | 0.669 | 0.003 | 6.993 |
| Cross price demand elasticity, $\varepsilon_{21}$ | 0.509 | 0.665 | 0.002 | 6.891 |
| Aggregate demand elasticity | -2.170 | 1.770 | -15.866 | -0.0001 |
| Market share of the outside alternative, $s_0$ | 0.686 | 0.227 | 0.000 | 0.997 |
| Market share of the 1stfirm (true) | 0.034 | 0.039 | 0.0002 | 0.354 |
| Market share of the 2nd firm (true) | 0.034 | 0.040 | 0.0002 | 0.433 |
| Market share of the 1stfirm (observed) | 0.109 | 0.107 | 0.001 | 0.936 |
| Market share of the 2nd firm (observed) | 0.110 | 0.108 | 0.001 | 0.939 |

In contrast with the HHI, the UPP index has an inherit capacity to take into account merger-specific cost efficiencies. As we explain in Section 3, absent cost efficiencies the original UPP test will always flag mergers for further scrutiny. Therefore, to diversify the outcomes of its' implementation we simulate also a second set of economies where mergers generate 2% reduction in marginal costs. We explain our choice regarding the efficiency level in Section 3 of the present chapter devoted to the UPP test. A larger set of descriptive statistics for both samples can be found in Appendix D.

The rest of the paper is organized as following. Section 2 offers a critical appraisal of the HHI test based on the set of simulated economies with no cost efficiencies. Section 3 starts with the definition of the original UPP test and its theoretical background. It also introduces the existing UPP variants. Based on the second workbench with 2% cost efficiencies, we further perform an assessment of the accuracy of the UPP test and some of the considered variants when it is employed to predict the price change direction. We also show a way in which the UPP index can be employed to estimate the price change magnitude and demonstrate which of the considered variants provides the most accurate approximations. Our ultimate task consists in identifying the economic conditions that affect the accuracy of these merger evaluation tools and that can be potentially observed by the analyst in practice. Section 4 concludes the paper.

## 2. The HHI test

The HHI test implementation traditionally requires three elements. The first two are the *post-merger* HHI and the difference of HHI between pre- and post-merger states ($\Delta HHI$). If $J$ is the number of single-product firms identified by the competition authority as those forming the relevant market, then the pre-merger HHI can be calculated in the following way:

$$\text{HHI} = 10000\sum_{j=1}^{J}\bar{s}_j^2 \tag{1}$$

where $\bar{s}_j$, $j=\overline{1,J}$ are the observed market shares. $\Delta\text{HHI}$, in turn, characterizes the increase in market concentration caused by the merger:

$$\Delta\text{HHI} = \text{HHI}_{post-merger} - \text{HHI}_{pre-merger} = 20000\bar{s}_1\bar{s}_2 \tag{2}$$

Calculation of both $\Delta\text{HHI}$ and post-merger HHI presumes that the individual market shares of all firms on the market do not change post-merger. The third element that one needs to implement the test is a set of thresholds for both post-merger HHI and $\Delta HHI$. According to the U.S. merger guidelines of 2010, once one of the thresholds is exceeded, the merger can potentially raise anticompetitive concerns, therefore it cannot be cleared and a further scrutiny is recommended.

In a Cournot model with homogenous products and fixed elasticity of demand the HHI is proportional to the margin over the weighted average of marginal costs of all firms.[17] This property legitimates the HHI as a measure of the market power and as a test to flag potentially harmful mergers. However, it might be then inaccurate when applied to a differentiated product market with Bertrand conduct. Present paper aims at verifying whether it is indeed so.

Let us first discuss some general properties of the HHI test. Consider a market with 2+M firms where, without loss of generality, the first two firms merge. Denote by $C = 100(\bar{s}_1 + \bar{s}_2)$ the *ex-ante* observed market share of the merged entity, where $\bar{s}_1$ and $\bar{s}_2$ are the market shares of firms 1 and 2 correspondingly. Assuming that M remaining *non-merging* firms are symmetric, the post-merger HHI and $\Delta HHI$ can be expressed as:

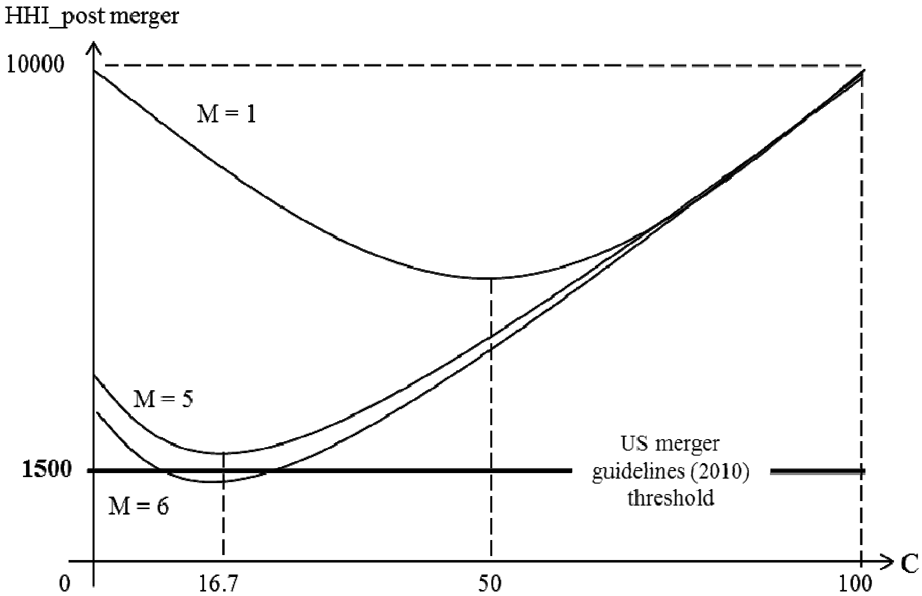
$$\text{HHI}_{post-merger} = C^2 + (100-C)^2 / M \tag{3}$$

[17]Precisely, from the first order conditions of the profit maximization problem one can obtain, $\frac{p-\sum_{j=1}^{J}\bar{s}_j mc_j}{p} = \frac{\sum_{j=1}^{J}\bar{s}_j^2}{\varepsilon} = \frac{\text{HHI}}{10000\varepsilon}$ where $p$ is the market price, $mc_j$ the marginal cost, $\bar{s}_j$ the observed market share of firm $j$ and $\varepsilon$ the aggregate demand elasticity.

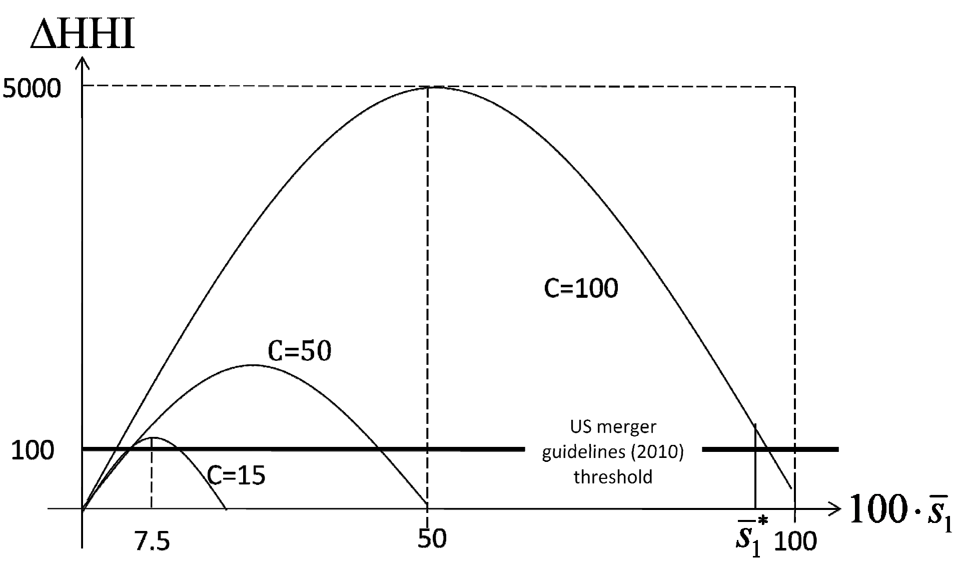
$$\Delta\mathrm{HHI} = 200 \cdot \bar{s}_1 (C - 100\bar{s}_1) \qquad (4)$$

Equation (3) is the formula of a convex parabola with respect to *C*, with the following coordinates of the minimal point: $C_{\min \mathrm{HHI}post} = 100/(1+M)$ and $\mathrm{HHI}_{post.MIN} = 5000/(M \cdot (1+M))$. The function for $\Delta HHI$ in Equation (4) is a reverse parabola with respect to $\bar{s}_1$ and reaches its maximum when the market shares of the merging firms are equal, *C* being fixed. Illustrations for both equations that include current US guidelines thresholds are provided on Graphs 1 and 2 correspondingly.

**Graph 1: Relation of the HHI to the merged entity's market share**




**Graph 2: Relation of change in the HHI to merging firms' market shares.**



Graph 1 suggests that under condition of symmetry of non-merging firms any merger on a market with total number of firms less or equal 7 ($M \leq 5$) will exceed the US guidelines post-merger HHI threshold of 1500, whether the market share of the merging entity C is high or nearly insignificant. Furthermore, according to the Graph 2, similar levels of the $\Delta HHI$ that overpass the threshold of 100 can also correspond to quite distinct cases: for example to a case with a high $s_1^*$ and C=100, as well as to a case where the corresponding market shares are relatively low, e.g. $s_1 = 0.075$ and C=15. These examples suggest that the HHI test has a risk of not being able to differentiate between the situations with quite distinct positioning of the 'to-be merged' entity vis-à-vis competitors (in terms of market shares), while one can expect the latter to be important in defining the potential effects of the proposed merger.

While the illustrations above are informative, a more complex assessment of the ability of the HHI test to identify potentially harmful mergers seems plausible. To do so, we further employ the set of simulated economies with 0% cost efficiencies and apply the thresholds as in the US Merger Guidelines of 2010.

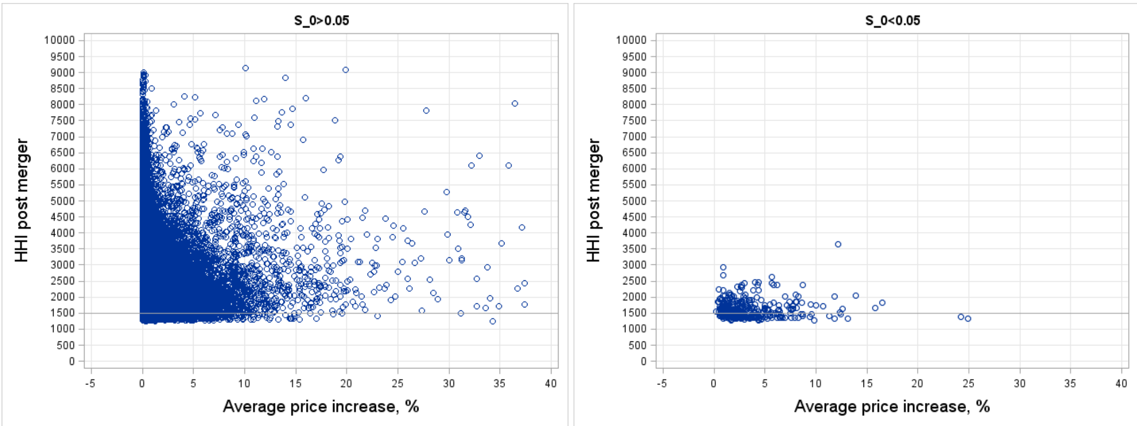
As the HHI by construction is based on observed market shares, therefore it has a built-in sensitivity to the adopted market definition technique. However, we intentionally do not apply any of existing techniques to simulated economies before assessing the accuracy of the HHI test. The range of possible market definition approaches is sufficiently vast and can potentially result in quite distinct outcomes. Adopting just one of them could put under risk the robustness of our results. Our simulated workbench could enable one to assess the consistency of all existing techniques, but this deserves to be a subject rather of a distinct comprehensive study.

It remains helpful, however, to assess the HHI performance in 'ideal' conditions, i.e. when observed market shares coincide with the true ones. If we consider the share of the 'outside option' as a measure of the quality of the market definition procedure, then a market with $s_0$ less than, let's say, 0.05, can be considered as properly delineated. 0.8% of cases from our sample meet this requirement. We compared the results for sub-sample of economics with those obtained for the rest of the sample and summarized the results of the performed analysis below.

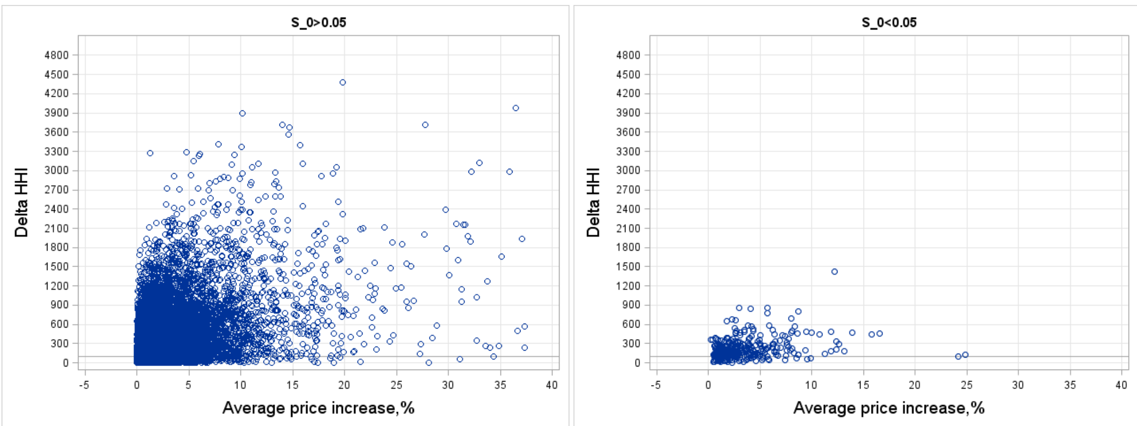
***Result 1:*** *Being applied to a differentiated product market the Herfindahl-Hirschman Index (HHI) has a weak performance in identifying the potential for the post-merger price increase, whether the market is properly delineated or not.*

To illustrate this point we first plot on Graphs 3 and 4 below post-merger HHI and $\Delta HHI$ against the simulated price change (average for merging firms). Reference lines reflect 2010 US merger guidelines thresholds. A simple visual plot analysis shows no robust relationship between the post merger price change and any of the two HHI components, even for the sub-sample of economies with properly delineated markets.

**Graph 3: Post merger HHI versus average price change of merging firms**




**Graph 4: $\Delta HHI$ versus average price change of merging firms**




One can easily observe that high post-merger HHI values match with any kind of price changes, both high and low. The economic intuition behind the HHI suggests that higher market shares of the merging firms might be a result of a higher market power, thus a stronger ability of firms to raise prices. Therefore, since ΔHHI by construction depends on the proportion of *merging firms'* market shares (in contrast with the post-merger HHI that covers the whole market), in our experiment we should track some positive relationship between $\Delta HHI$ and post-merger price change. However, on the Graph 4 one can easily find cases where this intuition is not supported.

The main criticism of the HHI test as a merger assessment tool, along with ignorance of cost efficiencies and sensitivity to the market definition technique, is that it was developed for homogeneous good markets and so does not take into account any of the product differentiation effects. When a merger happens on a differentiated product market, it is not the size of market shares but rather the substitutability between merging firms' products and corresponding markups define the incentives to increase prices post-merger. (See, for instance, Farrell and Shapiro (2010)). We demonstrate this idea in more detail in the next section that is devoted to the UPP test. All those factors constitute a basis for misleading predictions of the HHI test and, therefore, reduce its' accuracy. We measure the latter in terms of produced type-I and type-II errors.

In order to characterize the 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. Since product quality characteristics are assumed constant, 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. Applying 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 case generated by the HHI test as a situation where average for merging firms price increase is below 2% together with the post-merger HHI greater than 1500 or the ΔHHI greater than 100. A type-II error case for the HHI test occurs when price increase is greater than 2% together with the post-merger HHI less than 1500 and the ΔHHI less than 100. We also name as "predicted anticompetitive" a case when the HHI test well predicts detrimental merger and as "predicted pro-competitive" a case when the HHI test correctly identifies a non detrimental merger. In Table 2 below we display descriptive statistics for the main economic variables for these four sub-samples.

Here we do not apply any restriction on the market share of the outside option as it enables us to identify the potential importance of the proper market definition for the HHI test accuracy.

**Table 2: Average values of main economic parameters in different sub-samples**

| **Economic parameters** | **Type-I error** | **Type-II error** | **Predicted pro-competitive** | **Predicted anti-competitive** |
|---|---|---|---|---|
| Markup of the 1st merging firm | 0.171 | 0.297 | 0.182 | 0.270 |
| Markup of the 2nd merging firm | 0.171 | 0.298 | 0.183 | 0.270 |
| Own price demand elasticity, 1st firm ($\varepsilon_{11}$) | -7.552 | -3.790 | -7.233 | -4.397 |
| Own price demand elasticity, 2nd firm ($\varepsilon_{22}$) | -7.549 | -3.807 | -7.088 | -4.394 |
| Cross price demand elasticity ,1st firm ($\varepsilon_{12}$) | 0.426 | 0.513 | 0.311 | 0.885 |
| Cross price demand elasticity, 2nd firm ($\varepsilon_{21}$) | 0.425 | 0.488 | 0.328 | 0.873 |
| Aggregate demand elasticity | -2.447 | -0.618 | -2.225 | -1.063 |
| Share of the outside alternative | 0.725 | 0.358 | 0.612 | 0.541 |
| Market share of the 1st firm, $s_1$ (true) | 0.028 | 0.036 | 0.027 | 0.061 |
| Market share of the 2nd firm, $s_2$ (true) | 0.028 | 0.039 | 0.026 | 0.062 |
| Sum of observed market shares $(\bar{s}_1 + \bar{s}_2)$ | 0.204 | 0.117 | 0.134 | 0.296 |
| Number of observations | 32904 | 217 | 743 | 7987 |

First note that the number of cases in each of the four sub-samples is not informative per se. It depends on the structure of the simulated sample of economies as well as the price increase threshold and the HHI test definition (different in the U.S. and the E.U.). The breakdown 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 sub-sample in order to identify some striking features. We acknowledge that there are not so many observations in type-II error sub-sample, especially because with 9 firms post-merger HHI rarely goes below 1500.

To assess whether the group averages are statistically different and can be employed for identification of the economic conditions that favor type-I and type-II errors we have performed group means comparisons of the parameters presented in Table 2.[18] The results

[18] After checking corresponding datasets for normality we performed t-test for group means comparisons. Both equal (pooled t-test) and non-equal (Cochran-Cox and Satterthwaite t-tests) group variances are assumed. Relevant tables can be provided upon request.

suggests that type-I error cases arise when the merging firms enjoy relatively low markups, high share of the outside option and elastic demands: own-price and aggregate elasticities are quite high (in absolute terms) compared to anti-competitive sub-samples. Relatively high own-price and aggregated demand elasticities explain low markups and justify the fact that merging firms were unable to significantly increase prices post-merger. A strong outside option is consistent with high aggregate elasticity. [19] It also causes the 'observed' market shares that are employed for the HHI test to exceed the 'true' ones significantly, which increases the probability to over-pass the guidelines' thresholds, resulting, thus, in a type-I error. However, similar economic parameters also characterize the predicted pro-competitive sub-sample, that is only different from the type-I error sub-sample in its observed concentration level - the sum of market shares of merging firms in predicted pro-competitive cases is significantly lower (13.4% against 20.4%, see Table 2). A conclusion that can be drawn from this analysis is that risk of producing a type-I error does not depend on the economic environment of the merger, but rather on the adopted concentration threshold.

Type-II errors, in turn, are associated with the lowest share of the outside option and inelastic demand - this sub-sample displays the lowest (in absolute terms) aggregate elasticity. Merging firms have low true market shares and own-price elasticities, also quite high markups which reveal them as 'niche' players and increase firms' incentives to increase prices (see Farrell and Shapiro (2010)). Because of the weak outside option observed market shares of merging products are not overestimated and remain low, which, together with relatively low market share of the merged firm, explains why HHI thresholds were not over-passed. Therefore, even when relevant market is better delineated (i.e. share of the outside option is the lowest among the four considered groups), the HHI test seems to remain 'blind' for the economic effects that drive the post-merger price dynamics on a differentiated products market where firms compete a la Bertrand.

In part because of the drawbacks of the HHI test and also because full merger simulation methods are often deemed too sophisticated, the Upward Pricing Pressure (UPP) test was proposed by Farrell and Shapiro (2010) as a tool to flag potentially harmful mergers. A newly designed instrument is simple enough to be easily implemented while well economically grounded.

[19] Share of the outside option is not directly observable by competition authorities, therefore in practice one can refer to the aggregate elasticity, since both variables are strongly linked. Otherwise, for several demand systems that allow for an outside option, including some discrete choice demand models, this dependence can often take a form of a closed-form function that can be used to estimate the sought-for parameter.

## 3. The UPP test

### 3.1 Definition and variants

A key question that the original UPP test is aimed to answer is whether a merger gives to the merging firm in question an incentive to increase its price or not. The implementation procedure consists in comparing two controversial effects that a merger creates: a loss in competition between merging firms that pushes the price upwards, and generated (if any) cost efficiencies that offset the first effect. Farrell and Shapiro (2010) propose a way of measuring these two effects so that they can be compared in a simple manner. Precisely, they suggest that the net upward pricing pressure for the firm *i* when merging with the firm *j*, denoted as $UPP_i^1$, can be calculated as follows:

$$UPP_i^1 = D_{ij}^*(p_j^* - c_j^*) - E_i c_i^* \qquad (5)$$

where $D_{ij}^*$ is the ***pre-merger*** diversion ratio (a positive value) from product *i* to product *j* when price of product *i* increases, $p_j^*$ and $c_j^*$ are the pre-merger price and (constant) marginal costs of product *j*. $E_i$ is a constant fraction of marginal costs. The first element in the formula, $D_{ij}^*(p_j^* - c_j^*)$, accounts for the positive pricing pressure, while $E_i c_i^*$ reflects the offsetting effect of merger-specific cost efficiencies that can be delivered by the firm *i*. Note that the upper-index in $\mathrm{UPP}_i^1$ is used to distinguish herein different variants of the UPP value. We introduce them below in the section.

Farrell and Shapiro suggest the following implementation of the test: the merging firm *i* has an incentive to increase its price whenever $\mathrm{UPP}_i^1$ is positive. To explain the intuition behind we should refer to their Proposition 2 where it is stated that the pricing effects of a horizontal merger are similar to those when each of merging firms is simultaneously imposed a certain per-unit firm–specific tax. The value of this tax for the firm *i* merging with firm *j* should be computed in the following way:

$$t_i^m = D_{ij}^m(p_j^m - c_j^m) \qquad (6)$$

where $D_{ij}^m$ is a *post-merger* diversion ratio of product *i* to product *j*, $p_j^m$ and $c_j^m$ are *post-merger* price and marginal costs of the firm *j* ( subscript *m* is referred to the post-merger equilibrium). Hereinafter we call these specific values “merger taxes”.

Finding an analogy between the structural industry change such as merger and introduction of firm-specific taxes is quite intuitive. A horizontal merger indeed creates an opportunity cost for merging partners if they keep their prices on the pre-merger level. This opportunity cost arises because a possible shift in prices could have raised total profits of the merged entity: now if consumers would switch to the partner then revenues would still remain within the merged firm. The merger tax is the exact measure of these alternative costs that are specific to each of the merging partners. Using the analogy with a cost shock, a firm facing a positive merger tax has an incentive to increase its own price.[20]

The Proposition 2 in Farrell and Shapiro (2010) was derived for a case of a duopoly and was not tied to any particular competition mode, be it Cournot or Bertrand. Jaffe and Weyl (2011) illustrate that this intuition is also valid for a more general case with non-constant marginal costs and for any market larger than a duopoly. Note that the original formula from Farrell and Shapiro (2010) that is given in (6) does not account for possible post-merger cost efficiencies. When they are present, one should take them into account in the similar manner as in (5), such that:

$$t_i^m = D_{ij}^m (p_j^m - c_j^m) - E_i c_i^m \tag{6.1}$$

An attentive reader could have already noticed that the computation of the merger tax requires the knowledge of the variable of the interest, namely the post-merger price. Farrell and Shapiro (2010) address this issue by proposing an approximation of the merger tax that uses only pre-merger data – the $\text{UPP}^1$ as defined in (5). The main criticism of the $\text{UPP}^1$ is that it can only be considered as a first round approximation of the merger tax, i.e. when the prices of the other firms remain fixed on the pre-merger level. In other words, it ignores the feedback of the other market agents and therefore can potentially require less efficiency to eliminate the price pressure.

To incorporate some of the missing feedbacks, a modification of the original $\text{UPP}_i^1$ formula was proposed by Schmalensee (2009). It takes into account the fact that cost efficiencies of the second merging firm will increase its margin, thus increasing further pricing pressure of the first firm:

$$\text{UPP}_i^{SHM} = D_{ij}^* (p_j^* - (1 - E_j) c_j^*) - E_i c_i^* \tag{7}$$

[20] This might not be true in a perfect competition model, where firm’s price would remain unchanged. Because perfect competition is rather a theoretical concept, we exclude it from consideration and assume that a firm facing a cost shock would have an incentive to change her price at least slightly.

Farrell and Shapiro (2010) went even further in including possible feedbacks. Building on the work of Werden (1996), and assuming that marginal costs and diversion ratios are constant, they have derived an even more complex version of the UPP value, denoted further as $UPP^2$:

$$\text{UPP}_i^2 = D_{ij}{}^*(p_j^* - c_j^*) - E_i \cdot c_i^* + D_{ij}{}^* D_{ji}{}^*[p_i^* - c_i^*(1-E_i)], \quad i, j = 1,2 \qquad (8)$$

Or alternatively

$$\text{UPP}_i^2 = UPP_i^1 + D_{ij}{}^* D_{ji}{}^*[p_i^* - c_i^*(1-E_i)], \quad i, j = 1,2 \qquad (9)$$

Note, that by construction both $\text{UPP}^2$ and $\text{UPP}^{SHM}$ are always larger than $\text{UPP}^1$, therefore they would require more cost efficiencies to offset the pricing pressure. This would potentially result in more mergers being flagged for further scrutiny, increasing thus probability of a type-I error and decreasing that of a type-II one.

A great advantage of any UPP-like test against a full merger simulation is that it allows getting along without any structural demand and cost function estimation and market definition procedures. Epstein and Rubinfeld (2010) constructed a UPP index that, while keeping these advantages, represents a special case of merger simulation and indicate the same price change sign if calibrated consistently. Saying this implies that the new index incorporates the link between change in the price of product 2 and the change in the price of product 1 that determines the post-merger equilibrium, i.e. the "feedback" that is missing in the original UPP of Farrell and Shapiro (2010). According to Epstein and Rubinfeld (2010), for a merger that involves two single-product firms that are Bertrand competitors, assuming that marginal costs and diversion ratios are constant, the upward pricing pressure for the firm *i* shall be calculated as following:

$$\text{UPP}_i^{ER} = \frac{D_{ij}^*(p_j^* - c_j^*) + D_{ij}^* D_{ji}^*(p_i^* - c_{i\,j}^{**})}{1 - D_{ij}^* D_{ji}^*} - E_i c_i^* \qquad (10)$$

It is easy to show that $\text{UPP}^2$ and $\text{UPP}^{ER}$ are linearly dependent:

$$\text{UPP}_i^{ER} = \frac{\text{UPP}_i^2}{1 - D_{ij}^* D_{ji}^*} \qquad (11)$$

and therefore they always agree in sign (as the diversion ratio never exceeds 1). Consequently, it does not matter which of the two variants one uses to predict the price change sign.

Interestingly, $UPP^2$ and $UPP^{ER}$ differ in magnitudes even though they were derived in a similar manner and under the same set of assumptions. Both values were extracted from the inequality that defines the absolute efficiency level that is *still* needed to leave the price on the pre-merger level. The word 'still' is employed because the efficiencies that the merger is supposed to generate were already taken into account in the UPP values. This approach suggests that when $UPP^2$ or $UPP^{ER}$ is positive, then assumed cost efficiencies are not enough to offset the pricing pressure, and therefore merging firms have incentives to increase their prices. While the magnitude of $UPP^{ER}$ corresponds to the magnitude of these 'still needed' efficiencies, magnitude of the $UPP^2$ does not have any similar reference because both sides of the underlying inequality were divided by a positive constant.

Unlike the HHI test, the UPP test in all variants has an inherent capacity to take into account cost efficiencies generated by the merger. The UPP value in its original version ($UPP^1$), absent cost efficiencies will always take positive values, thus will always flag a merger for further scrutiny.[21] Therefore, to assess the UPP test performance in this section we will use the second sample of economies where merging firms enjoy the 2% efficiency gains level applied to pre-merger marginal costs. We intentionally avoid setting a higher efficiency level. As the true values of pre-merger marginal costs are assumed to be known, therefore, the component of the UPP that is responsible for the downward pricing pressure is exactly the same as in the respective merger tax. Hence, the risk of the UPP value to deviate from the merger tax appears due to the component that reflects the upward pricing pressure. Assuming a sufficiently low level of generated cost efficiencies prevents it from being a dominant component of the UPP value and reinforces the role of the other one.

Since cost efficiencies have an offsetting effect on the price pressure experienced by merging firms in the second sample we observe lower levels of the post-merger price change: 0.413% against 1.914% in average for the first merging firm with the minimal level of -2.778% against -0.427%.[22] This is a desirable feature as we want to test the ability of the

[21] $UPP^2$ and $UPP^{SHM}$ would also take only positive values as they by construction exceed the $UPP^1$.
[22] Negative price changes for a merging firm can appear in mergers even absent cost efficiencies in the presence of negative cross pass –through rates. For more details see Chapter 3 of the present thesis.

UPP test to predict both positive and negative price changes. A full set of descriptive characteristics of the sample of simulated economies is provided in Table D-2 in Appendix D.

## 3.2 Limitations of the existing UPP-like tests

UPP test was intended to be a simple tool that catches the essence of the unilateral effects of mergers. Indeed, its calculation for any of the considered above four variants requires only the knowledge of diversion ratios, pre-merger markups and assumed level of cost efficiencies. Not surprisingly it arouses a huge interest of competition authorities that often struggle to find the relevant expertise or sufficient resources to perform a full merger simulation. However, the implementation of the UPP test in practice is still subject to extensive critics. We discuss the most important issues just below.

First, all considered above UPP formulas are designed for a single-product case. To address this issue, Jaffe and Weyl (2011) extend the $UPP^1$ formula to the multiproduct setting, although it increases significantly the amount of required data. Because our simulations are restricted to a single-product case, we omit this UPP variant in further analysis.

Second, when estimates of diversion ratios or marginal costs are not available to a competition authority they need to be approximated. A possible solution could be to make assumptions on demand or cost structure and obtain simple formulas to calculate the unknown parameters. Some examples of such assumptions and resulting approximations can be found, for instance, in Cheung (2011), Hausman, Moresi, and Rainey (2010)) or Jaffer and Weyl (2011). As we demonstrate in Section 3.4, approximations and simplifications often come at a cost of significant reductions in test's accuracy.

After all, being basically a 'thumb up' rule, the UPP test still misses one important property when compared to a merger simulation - the ability to predict magnitude of the price change. As demonstrated in the following sub-section, the link can still be provided. This is an important practical issue as competition authorities may wish to adopt price increase tolerance levels that are distinct from zero.

## 3.3 Relation between the UPP and magnitude of post-merger prices changes

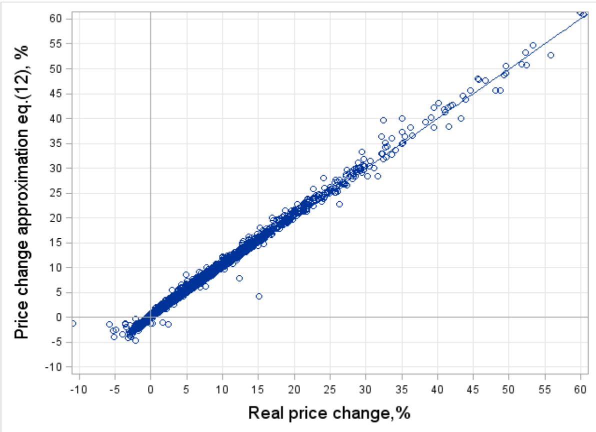
As we highlighted in the Section 3.1, a horizontal merger in terms of price effects is equivalent to a simultaneous introduction of per-unit merger taxes for both merging entities.

Just as if merging partners instead of actually merging would experience certain simultaneous firm-specific per-unit cost shocks. As demonstrated later in Chapter 3 of the present thesis, the final impact that it would have on the price of the firm *i* merging with firm *j* can be approximated as following:[23]

$$dp_i \approx m_{ii}t_i^m + m_{ij}t_j^m \qquad (12)$$

where $m_{ii}$ and $m_{ij}$ are the *pre-merger* own and cross pass-through rates correspondingly.[24] From our sample we are able to recover precise values of merger taxes and corresponding pass-through rates and, therefore, compare the true price change and its' linear approximation as in (12). The Graph 5 below establishes a high level of fit.

**Graph 5: Comparison of the real price change and its linear approximation**




Note that in practice the values of the required merger taxes are not known. As motivated above, one instead can use the respective UPP values. Therefore, for each of the merging firms the post-merger price change approximation $dp_i^{approx(1)}$ can be calculated as follows:

$$dp_i^{approx(1)} = m_{ii}UPP_i^{\bullet} + m_{ij}UPP_j^{\bullet} \qquad (13)$$

where $UPP^{\bullet}$ stands for any of the considered UPP variants that approximate the magnitude of the merger tax.[25]

[23] It is essentially a linear approximation around the pre-merger equilibrium.

[24] Own pass - through rate measures the extent to which the firm passes its cost shock on consumers (in terms of price change). 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. Cross pass-through rate, in turn, reflects the impact of the competitor's cost shock on own price after re-equilibration of the economy.

[25] Recall that, in contrast with the $UPP^{ER}$, magnitude of the $UPP^2$ cannot be treated as the absolute cost efficiencies that are required to leave the prices on the pre-merger level. Therefore, magnitude s of the $UPP^2$ and

The idea to employ own pass-through rate together with the own UPP level to approximate price change is not new and was already proposed and discussed by some researchers in the field (see, for instance Farrell and Shapiro (2010), Simons and Coate (2010) and Jaffe and Weyl (2011)). In contrast with the existing literature, we insist that the UPP of the second merging firm shall be also taken into account together with the relevant cross pass-through rate, in the manner suggested by the equation (13). We illustrate this and the other important points regarding the UPP test performance in the next section.

## 3.4 Performance of the UPP test

While theoretical discussions around the UPP test are quite extensive, still only few researchers focused on the empirical estimation of its performance, especially on the test implementation issues when data are scarce. The most relevant work, performed by Cheung (2011), assesses the ability of $\mathrm{UPP}^1$ test both as a “thumb up” rule and as a predictor of the price change magnitude. On a sample of 256 overlapping routes in the America West - US Airways merger that was completed in 2005 she demonstrates that, when structural demand estimation is used to calculate the UPP index, it generally provides accurate predictions in sign of a price change for a large range of cost efficiencies.[26] Precisely, it gives wrong sign predictions for about 10% of observations. Following ideas of Farrell and Shapiro (2010), Simons and Coate (2010) and Jaffe and Weyl (2011), she approximates the magnitude of the price change as a product of the $\mathrm{UPP}^1$ and the corresponding own pass-through rate. She finds that, on average, for the whole range of considered cost efficiencies the UPP value is higher than the one predicted by the simulation model and that the two variables have a correlation of 0.89-0.93, depending on the efficiency level assumed. Analysis of formulas in (12) and (13) from the Section 3.3 in the present paper suggest that the observed by Cheung (2011) trend for price change overestimation is a natural result in the presence of significant negative cross-pass through rates that the author also reports. More valuable from the practical point of view, Cheung (2011) also estimates the impact of approximations of the test’s ingredients on its accuracy. First, following the proposition of Pakes (2010), author uses $\mathrm{UPP}^1$ level itself to approximate the magnitude of the price change, which is equivalent assuming the own pass-through rate equal to one. She found that the correlation between the magnitude of the UPP and price change has lowered, but remained quite high (0.8 - 0.87).

the corresponding merger tax cannot be compared. The last point makes the predictions obtained on the basis of the $UPP^2$ potentially unreliable.

[26] Cheung uses a discrete-type random coefficient nested Logit model to estimate the demand system.

Second, assuming that demand is drawn from a simple Logit model, she calculated the diversion ratio using only the observed market shares.[27] This approximation resulted in wrong sign predictions and poorer correlation to a much larger extent. The Independence of Irrelevant Alternatives that the Logit model features is a very specific behavioral pattern that might not be true in general. This particularity, along with adoption of the observed market shares instead of the true ones, may explain the drastic decrease in the accuracy of test.

In the following sub-section we analyze the UPP performances on a larger and more differentiated set of economies that, as we expect, would provide more robustness to the results. Our approach allows assessing all the UPP variants mentioned above, namely the ones proposed by Farrell and Shapiro ($\mathrm{UPP}^1, \mathrm{UPP}^2$), Schmalensee ($\mathrm{UPP}^{SHM}$) and Epstein and Rubinfeld ($\mathrm{UPP}^{ER}$). Similarly to Cheung (2011) we consider UPP application for both price change sign and magnitude and assess the test performance when true and approximated values of the test ingredients are available. We adopt, however, a different way of measuring the accuracy of the predictions when it comes to the price change magnitude as we demonstrate that the correlation coefficient is not the most appropriate measure in this case. More innovatively, sub-section 3.4.3 offers an analysis of economic conditions that favor the test to produce misleading predictions.

### *3.4.1 Ability to predict the sign and magnitude of changes in price*

In this section we re-define type-I error (false positive) as a case when the calculated UPP value is positive, while the firm has actually decreased its price post-merger. Correspondingly, type-II error (false negative) occurs when UPP is negative while we observed a price increase. When UPP test is employed as a screening tool, therefore it is more important to avoid type-II errors, as possible false-positive mistakes could be corrected on the second phase of merger investigation. In turn, type-I errors would entail an unjustified waste of budget and time resources. We also test the ability of the UPP to predict the price change magnitude in a way suggested by equation (13) and offer a specific way of measuring the accuracy in this case.

In Table 3 below we display recorded type-I and type-II errors for all considered UPP test variants ($\mathrm{UPP}^1, \mathrm{UPP}^2, \mathrm{UPP}^{SHM}$ or $\mathrm{UPP}^{ER}$). Errors are measured in percentage with

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[27] For a simple logit demand system, the diversion ratio from product i to product j can be calculated as $D_{ij}^{\log it} = s_j \big/ (1 - s_i)$, where $s_j$ and $s_i$ are the 'true' market shares of the firm *j* and *i* correspondingly (Willig (1991)). In practice true market shares are often replaced by 'observed' ones.

respect to the whole sample size. At first we provide results for test implementation when true values of all ingredients are known. The corresponding line is denoted as '$UPP_1^{\bullet}{}_{true}$'. We also consider implementation of the UPP test with logit approximation of the diversion ratio (denoted as $UPP_1^{\bullet}{}_{\log it}$). Because true market shares may not be known by the merger analyst, therefore we find it appropriate to consider also a diversion ratio approximation that uses the observed markets shares instead.

**Table 3: Assessment of the predictability of the price change sign by UPP test variants**

| Assumptions | Error type | Variants of the UPP test: $UPP^1$ | $UPP^2$ or $UPP^{ER}$ (*) | $UPP^{SHM}$ |
|---|---|---|---|---|
| $UPP_1^{\bullet}{}_{true}$ | Type-I | 0.03% | 0.51% | 0.19% |
| | Type-II | 2.59% | 0.77% | 0.27% |
| $UPP_1^{\bullet}{}_{\log it}$ (true market shares) | Type-I | 2.65% | 3.07% | 3.01% |
| | Type-II | 19.22% | 18.49% | 18.37% |
| $UPP_1^{\bullet}{}_{\log it}$ (observed market shares) | Type-I | 16.45% | 20.14% | 19.13% |
| | Type-II | 4.27% | 3.39% | 3.50% |

*Notes:* (*) We provide results for $UPP^2$ and $UPP^{ER}$ together because by construction they always predict the same sign changes direction.

Note that one should not refer to absolute levels of type-I and type-II errors from Table 3 and make a reference to the real world as these percentage breakdowns hold for our sample only. Nevertheless, these results can be used to compare the relative performance of different UPP test variants and to assess the impact of approximations of the diversion ratio.

We summarize the most striking result in the following statement.

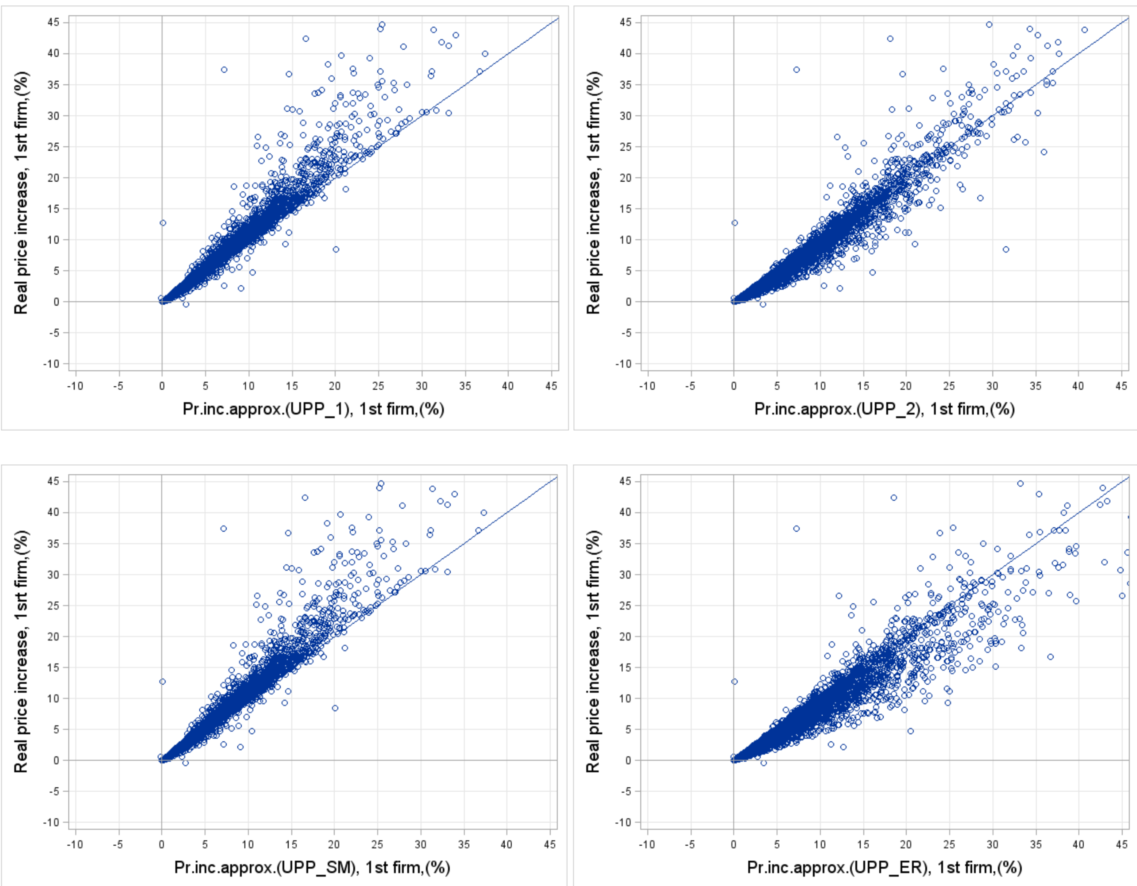
***Result 3:*** *Original* $UPP^1$ *provides the minimal level of type-I error, but the maximal level of type-II one. This remains valid whether one employs true values for diversion ratio or its approximations.*

Already by construction $UPP^2$ and $UPP^{SHM}$ are larger than the original $UPP^1$ that results in a higher probability of type-I error and a lower probability of type-II ones. As a consequence of the Logit approximation of diversion ratio accuracy of all the variants is reduced significantly both in terms of type-I and type-II errors. The employment of the observed market shares instead of the true ones increases the probability of type-I error even more, while decreasing the type-II one. Last observation can be explained by a simple fact that true market shares never exceed the observed ones, therefore diversion ratio (and, therefore, the corresponding UPP) becomes larger.

Before moving to the formal analysis of the accuracy of predictions for the price change magnitude, it is useful to perform a visual assessment of the approximations suggested by (13). For this purpose, on the Graph 6 below where we plot the real price changes against those approximated as in (13) with different UPP variants. Inasmuch as simulated economies are diversified in scale, we display the data in %, rather than in absolute values. In this part of the analysis it would make sense to measure the accuracy of price change predictions in terms of closeness of the observations to the $95^0$ reference line.

**Graph 6: Real versus approximated price change based on different UPP variants**

$$\left( dp_1^{approx(1)} = m_{11} \cdot UPP_1^{\bullet}{}_{true} + m_{12} \cdot UPP_2^{\bullet}{}_{true} \right)$$




The visual assessment suggests that, while all price approximations can deviate significantly from the real price increase, $UPP^1$ and $UPP^{SHM}$ tend to rather underestimate it.

Inasmuch as in some areas of the graph the concentration of the observations is too high, further quantitative assessment seems plausible.

It appears to be quite challenging to find an ideal way to quantify the accuracy of the UPP –based predictions for the price change magnitude. The type-I and type-II errors approach can be too sensitive to the adopted price increase tolerance threshold. In turn, Mean Square Errors are scale dependent and the Pierson correlation coefficient does not ‘catch’ the slope distortion, nor it is sensitive to a possible constant bias.[28] To verify whether the bias is indeed present, we ran a linear regression for the real price change as dependent variable and its UPP-based approximations as explanatory ones, i.e. $dp_1 = \beta_0 + \beta \cdot dp_1^{approx(1)} + \varepsilon$. We found that estimated intercepts are very small but always statistically significant, which indeed confirms that the correlation coefficient is not a credible measure of accuracy.[29] $R^2$ originating from this regression cannot be employed for comparisons neither because it assumes that one would include an intercept (bias) while calculating the price change approximation, which is not supposed to be the case.

Considering the discussed drawbacks, Pierson correlation coefficient, mean square errors, and even $R^2$ originating from the linear regression above would be only helpful to compare the performance of the UPP variants among themselves. All parameters would provide the same ranking, but, none of them would be helpful to answer the key question on *how close* those approximations would be to the factual observations. Finally, we considered a regression without intercept, i.e. $dp_1 = \beta \cdot dp_1^{approx} + \varepsilon$. Even though for this regression $R^2$ becomes not informative as such, an analysis of $\beta$ estimates can potentially bring some interesting results. We suggest that in such a regression the closer the $\beta$ estimate gets to the unit, the most accurate the employed approximation is.

Table 4 below contains $\beta$ estimates for the considered UPP variants and various price change approximations. First line provides estimates assuming that price change approximation is build according to the equation (13) and all required data are known ($dp_1^{approx(1)}$). From the practical point of view, it also makes sense to consider price change approximations when input data are limited. For this reason we also look at the approximation that ignores the cross pass through effect, such that $dp_1^{approx(2)} = m_{11} \cdot UPP_1^{\bullet}{}_{true}$. Furthermore,

[28] For example, a price change approximation that is always three times as large as the true price change would have a correlation coefficient equal to 1, while those predictions cannot be considered as accurate.
[29] Respective tables can be provided upon request.

following the proposition of Pakes (2010) we assume the own pass through equals to one, and so $dp_1^{approx(3)} = UPP_{1\ true}^{\bullet}$. As in the previous sub-section we also test the impact of the logit approximation of the diversion ratio with the use of true and observed market shares. Without loss of generality, estimations are performed for the first merging firm only.

**Table 4: Regression of the real price increase on its' approximation (estimates of $\beta$ coefficient, standard deviation in brackets)**

| | Variants of UPP test | | | |
|---|---|---|---|---|
| **Assumptions** | $\text{UPP}^1$ | $UPP^2$ | $\text{UPP}^{SHM}$ | $\text{UPP}^{ER}$ |
| $dp_1^{approx(1)} = m_{11} \cdot UPP_{1\ true}^{\bullet} + m_{12} \cdot UPP_{2\ true}^{\bullet}$ | 1.265*<br>(0.003) | 1.068*<br>(0.003) | 1.218*<br>(0.003) | 0.960*<br>(0.009) |
| $dp_1^{approx(2)} = m_{11} \cdot UPP_{1\ true}^{\bullet}$ | 1.276*<br>(0.004) | 1.096*<br>(0.003) | 0.931*<br>(0.009) | 0.927*<br>(0.002) |
| $dp_1^{approx(3)} = UPP_{1\ true}^{\bullet}$ | 1.305*<br>(0.004) | 1.095*<br>(0.003) | 1.257*<br>(0.004) | 0.954*<br>(0.003) |
| $dp_1^{approx(4)} = UPP_{1\ \log it}^{\bullet}$ (true market shares) | 0.927*<br>(0.009) | 0.926*<br>(0.009) | 0.931*<br>(0.009) | 0.920*<br>(0.009) |
| $dp_1^{approx(5)} = UPP_{1\ \log it}^{\bullet}$ (observed market shares) | 0.442*<br>(0.003) | 0.424*<br>(0.003) | 0.422*<br>(0.003) | 0.363*<br>(0.003) |

* - significant on 99% level

Analysis of Table 4 suggests that ignorance of cross pass through effects reduces accuracy of the price change approximations for all he variants, except $\text{UPP}^{SHM}$ - $\beta$ estimates deviate further from the unit. Whether the diversion ratio needs to be approximated with its logit analog, the UPP test performance becomes extremely poor.

In accordance with what could have been expected by looking at Graph 6, price change approximations based on $UPP^1$ and $UPP^{SHM}$ tend to underestimate the real price change – their $\beta$ estimates both exceed the unit. It also becomes evident that that price change approximations based on $UPP^{ER}$ and $UPP^2$ can be considered as the most accurate ones, even though none of 99% confidence intervals for their $\beta$ includes the unit.[30] This can be explained, in part, by a higher proximity of those UPP variants with the merger tax. To illustrate this point, we run the following regressions:

$$t_1^m = \alpha \cdot UPP_1^{\bullet} + \varepsilon \qquad (14)$$

[30] As standard deviations are extremely low (see Table 4), it assures that the confidence intervals for the respective estimates are very narrow even on 99% confidence level. Relevant calculations can be provided upon request.

We suggest that the closer $\alpha$ estimate gets to the unit, the better UPP variant approximates the respective merger tax. Table 5 provides obtained estimations.

**Table 5: Regression of the merger tax on the corresponding UPP values (estimates of $\alpha$ coefficient)**

| | **Variants of UPP test** | | | |
|---|---|---|---|---|
| **Parameter** | $UPP^1$ | $UPP^2$ | $UPP^{SHM}$ | $UPP^{ER}$ |
| $\alpha$ estimate | 0.687* | 0.954* | 1.147* | 0.89* |
| St. dev. | ( 0.004) | (0.002) | ( 0.002) | (0.001) |

* - significant on 99% level

The following statement summarizes the results of the above analysis.

***Result 5:*** *$UPP^{ER}$ and the $UPP^2$ variants, when employed as proposed in formula (13), provide the most accurate price change approximations.*

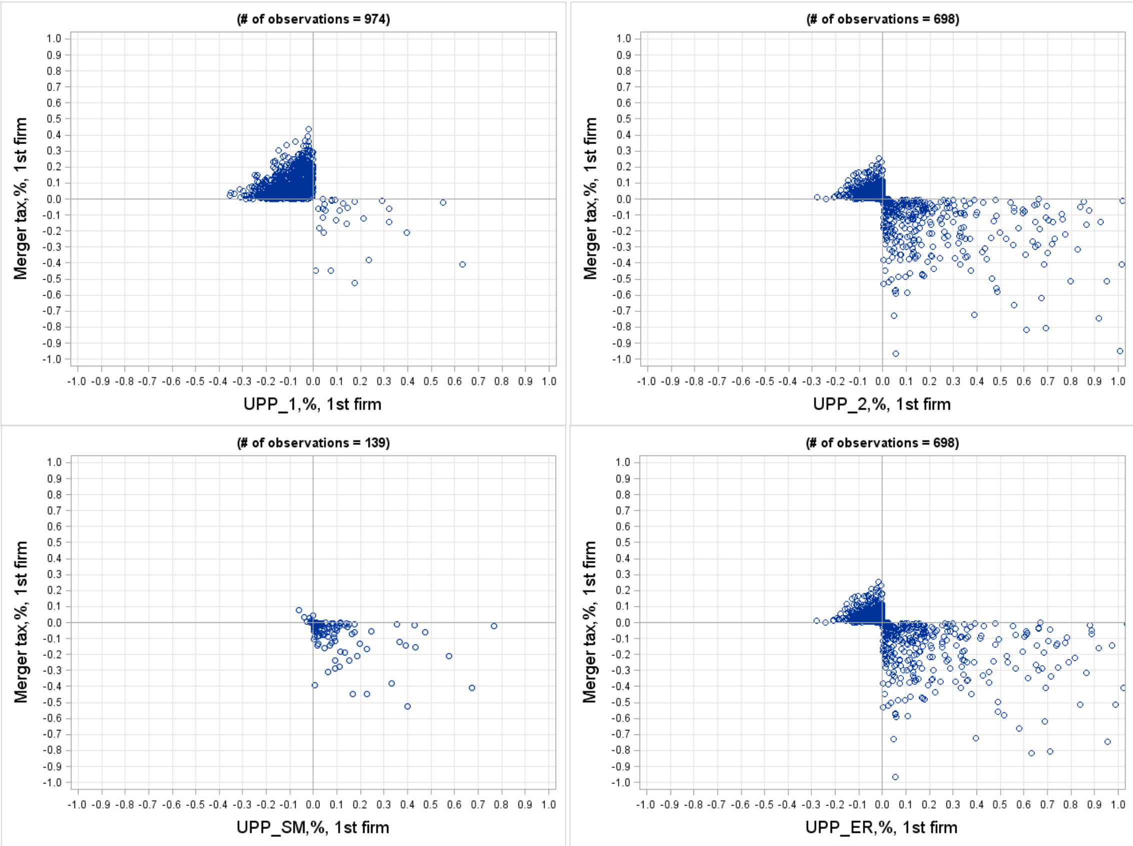
### *3.4.2 Economic conditions affecting the accuracy of the UPP test*

It remains important to understand the economic conditions that favor the UPP test to produce misleading predictions. Being aware and verifying them, where possible, risks of committing a mistake can be eliminated or, at least, reduced.

To result in a type-I error, the sign of the UPP should be positive, while the post-merger price is actually decreasing. Analysis of equation (12) suggests some intuition of why it may happen. If we assume that own pass through is never negative, therefore there are two possible reasons for the type-I error that one may consider – i) the UPP value and the relevant merger tax disagree in sign, and/or ii) second term in (12), that remains ignored in the original formulation of the UPP test, is negative and significant enough to offset the first term. Similar reasoning can be applied for the type-II errors.

Our sample indeed contains observations where the merger tax and the UPP value in all variants do not have the same sign. We plot them on the Graph 7 below. For the sake of comparability we consider merger taxes and UPP values in percentage of the relevant price. Without loss of generality, we only focus on the first merging firm.

**Graph 7: Comparison of sub-samples where merger tax disagree in sign with the UPP value (1st merging firm)**




First striking observation is that sign disagreement generally occurs when both variables are nearly insignificant – for majority of the observations the merger tax corresponds to less than 1% of the relevant price, especially for $UPP^1$ and $UPP^{SHM}$. It has an important implication for the practical implementation of the UPP test. If a competition authority sets a non-zero price tolerance level, let's say, 2%, then the sign disagreement between UPP and merger tax will not play any significant role in the formation of errors.

Second observation concerns the difference in sign disagreement pattern. For example, in contrast with the other variants, the $UPP^1$ features the sign disagreement with the merger tax mostly when it (UPP) is negative. Therefore, this variant can potentially induce a higher probability of type-II error than type-I one, that we indeed notice from Table 3 above.

In Table 6 below we provide a tabulation of the considered sub-samples with sign disagreements: we separate cases according to the signs of the UPP value and corresponding merger tax. For these sub-samples we also provide information on cases that feature type-I or type-II error.

**Table 6: Tabulation of observations according to selected criteria (% of the total sample)**

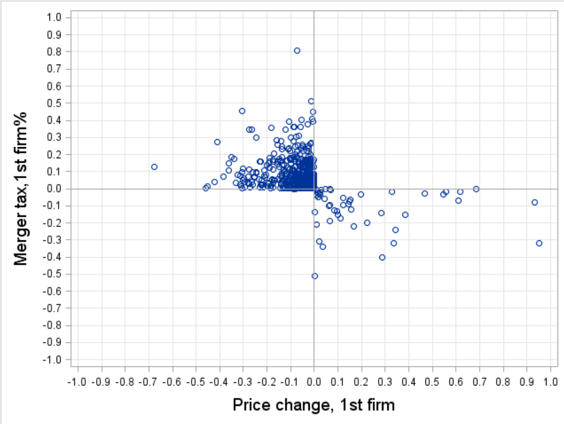
| | Variants of UPP test | | |
|---|---|---|---|
| **Sample selection criteria** | $UPP^1$ | $UPP^{ER}$ / $UPP^2$ | $UPP^{SHM}$ |
| Sample with $sign(UPP_1^{\bullet}) \neq sign(t_1^m)$ | 2.34% | 1.7% | 0.32% |
| Sub- sample with $UPP_1^{\bullet} < 0$ and $t_1^m > 0$ | 2.26% | 0.79% | 0.023% |
| Including type-II errors | 2.21% | 0.75% | 0.019% |
| Sub- sample with $UPP_1^{\bullet} > 0$ and $t_1^m < 0$ | 0.067% | 0.89% | 0.3% |
| Including type-I errors | 0.012% | 0.49% | 0.13% |

It appears that for negative UPP values in all variants sign disagreement with the merger tax transforms into a type-II error in majority of cases (2.21% out of 2.26% for $UPP^1$, 0.75% out of 0.79% for $UPP^{ER}$ and $UPP^2$, 0.019% out of 0.023% for $UPP^{SHM}$). While for positive UPP values, sign disagreement with the merger tax transforms into type-I error only in some cases.

Comparison of the results from Table 6 with Table 3 suggests that for $UPP^1$, $UPP^2$ and $UPP^{ER}$ variants sign disagreement between values and corresponding merger tax explains the majority of generated type-II error cases. Precisely, it explains 85% (2.21% out of 2.59% in terms of total sample) of type-II error cases for $UPP^1$ and 97% of cases for $UPP^2/UPP^{ER}$ (0.75% out of 0.77%). As for type-I error, sign disagreement is present in 40%, 96% and 68% false positive cases for $UPP^1$, $UPP^2/UPP^{ER}$ and $UPP^{SHM}$ correspondingly.

Interestingly, even if the UPP would perfectly approximate (be equal to) the merger tax, one still would not be able to predict the sign of the price change with 100% accuracy. On Graph 8 below we plot observations from our sample where merger tax and corresponding price change are not of the same sign. Therefore, there is still a need to look for other sources of the UPP test failure.

**Graph 8: Sub-sample of cases where the merger tax and real price change disagree in sign, 1st merging firm**




This brings us back to the equation (12) and its second term that, as we have explained above, can also be a cause of the type-I error when it is negative, or type-II one when positive. Type-I error, thus, may occur when the cross pass through and merger tax of the partner do not have the same sign. Note that this condition is rather necessary, but is not always sufficient. Alternatively, one can think of conditions under which the error never appears.[31] For instance, when UPP values (and corresponding merger taxes) for both merging firms are positive (negative), then type-I error (type-II error) will not occur if the respective cross pass–through rate is positive.

Analysis of our workbench provides support to this intuition. We looked through the sample for cases where both UPP would be of the same sign, condition on the cross pass-through sign would be satisfied but the test would still result in either type-I or type-II error. To focus on the cross pass-through effect we have eliminated observations where UPP and corresponding merger tax disagreed in sign. As before, we considered the test application for the first merging firm only. For none of the UPP variants we have recorded more than 2 cases and no observations were recorded for $UPP^1$. The fact that we still have observed some cases that disagree with theoretical predictions we attribute to the fact that the post-merger price

[31] Farrell and Shapiro (2010) end up a similar theoretical result for the $UPP^1$ and a particular case of a duopoly. Cheung (2011) suggests that for their results to hold in case when economy is larger than a duopoly, all cross pass-through rates should meet these assumptions, and not only those of merging firms' products. In turn, as equation (12) implies, it is, in fact, sufficient to be aware of only own and cross pass-through rates of merging firms whenever employed UPPs correspond in sign with merger taxes.

change in (12) that we use as a base for the analysis is still an approximation and does not provide a 100% accurate fit to the real price change (see Graph 5).

The statement below summarizes our findings.

***Result 6:*** *The UPP test in its original formulation has two main sources of type-I and type-II errors. First is a sign disagreement between the UPP value and the respective merger tax. Second reason is the cross-pass through effect that remains ignored in the original formulation of the test. The higher the competition authority sets the price increase tolerance level, the less important becomes the first source.*

Intuitively it follows that both closeness of the UPP value to the merger tax and cross pass through effect affect also the accuracy of approximation of the price change magnitude expressed in (13). Even though we acknowledge an appealing demand for further research of conditions of the sign agreement and magnitude proximity between the UPP and the merger tax, we do not aim at covering this issue in the present paper. When it comes to the cross pass-through effects, Table 4 indeed illustrates that taking them into account improves the price change approximations. This result coupled with the analysis that we have performed just above raises the demand for understanding the conditions that determine the sign and the magnitude of the pass-through rates.

Those conditions are hard to derive explicitly on the theoretical level, especially for the industry with many firms. This complexity is related, in part, to the required inversion of corresponding matrices. (See, for example, Jaffe and Weyl (2011)). Nevertheless, existing literatures offers some intuition. Chapter 3 of the present thesis summarizes the existing knowledge on this issue and offers a derivation of these conditions for a setting that is not limited to a particular demand or supply system. [32] It finds the following:

i) Increasing (decreasing) marginal costs favor positive (negative) cross pass through;
ii) Demand which elasticity decreases (increases) with respect to the price of the respective competitor favors cross pass through to be positive (negative).

Unfortunately, none of the two above conditions alone is generally sufficient to be sure about the sign of the cross pass through. Moreover, the latter one is extremely difficult to verify in practice. Nevertheless, it is demonstrated that some simplifying assumptions may facilitate the practical implementation of these results. For example, when firms are

[32] In Chapter 3 it is required that firms compete a-la Bertrand. This assumption, however, does not really limit the applicability of the results to our analysis as merger simulations often adopt this particular competition mode.

symmetric, it suffices to make sure that these two conditions above are satisfied to be confident about the sign of the cross pass through. Consequently, if marginal costs are constant, one only needs to verify the condition related to the demand elasticity. Moreover, under symmetry the significance of the cross pass through rate relative to the own pass through (in terms of magnitude) decreases with the number of firms on the market. The last result has a direct implication for the UPP test. With less number of firms cross pass-through effects would be stronger and the UPP test, therefore, can be expected to be less accurate.

Recall that our simulation procedure takes marginal costs as constant. It is done so with a purpose to meet the assumption under which each of the UPP variants was developed. This allowed us to assess the performance of the test and identify its drawbacks in the most favorable conditions. Results from Chapter 3 of the present thesis suggest that if marginal costs would be increasing, simulated economies would have a higher chance to feature positive cross pass -through rates, that in turn should decrease the probability of type-I and type-II errors. However, considering non-constant marginal costs would not only affect the cross-pass through rate, but also how well each of the UPP variants approximates the corresponding merger tax. And the latter, again, deserves to be a subject of a separate study.

There are two last remarks that we find important to mention.

First, some of our results from Section 3 can be attributed to a rather restrictive pass-through matrix pattern of the simulated sample - own pass trough rates are concentrated around one and cross-pass through are nearly insignificant in most cases. (See Graph 9 and Table 7 below)

**Graph 9: Distribution histograms for own and cross pass through rates, 1st merging firm (sample with 2% cost efficiencies)**

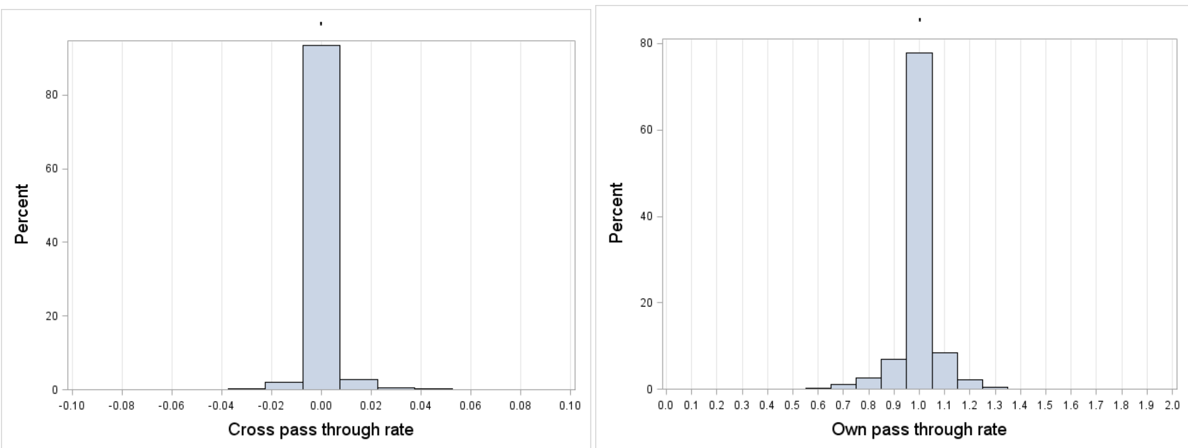


**Table 7: Descriptive statistics for own and cross pass through rates, 1st merging firm**

| | Mean | Std Dev | Minimum | Maximum |
|---|---|---|---|---|
| **Own pass through rate** | 0.997 | 0.081 | 0.269 | 6.043 |
| **Cross pass through rate** | 0.001 | 0.012 | -0.411 | 0.424 |

This explains why the absolute levels of both type-I and type-II errors in our sample are quite low and why logit approximation of the diversion ratio was more detrimental for the test accuracy than any of considered approximations of pass-through rates. Furthermore, a rougher approximation of the own pass through with the unit in $dp_1^{approx(3)}$ resulted for some variants in better price change approximations than the one that employs the true value of the pass through ($dp_1^{approx(2)}$). This is the result of the own pass through being in average slightly less than unit in our sample, therefore its approximation with the higher value compensated for the strategic component that has been ignored in both $dp_1^{approx(3)}$ and $dp_1^{approx(2)}$. Similarly to our case, Froeb et al. (2005) obtain small cross-pass through rates (compared to the own pass through) in their merger simulation examples with various demand models. In Chapter 3 of the present thesis it is illustrated on a theoretical example with quite general demand and supply systems that the fact that cross pass-through rates are of second-order relative to own-pass through rates is rather a common rule, especially in an industry with many firms.[33]

Second remark refers to the concordance of the cross pass through signs pre- and post-merger. Jeffe and Weyl (2011) highlight that pass-through matrix elements can change both in sign and magnitude post-merger. Indeed, in 82% of economies in our sample at least one of the cross pass-through rates of merging firms changed its sign from positive to negative. However, as equation (12) implies, the knowledge of only *pre-merger* pass-through rates is enough to define potential impact of the merger on prices.

## 4. Conclusions

Present study aims at assessing the accuracy of two screening instruments proposed in the US merger guidelines (2010) and featuring in some other advance guidelines around the world. Precisely, it deals with the Herfindahl-Hirschman Index (*HHI*) and the Upward Pricing Pressure (UPP) test that was developed by Farrell and Shapiro (2010). For this purpose we

[33] It follows directly from the equilibrium second order conditions.

have created by Monte-Carlo simulations two sets of heterogeneous and sufficiently realistic economies that were used as a workbench to measure the effects of mergers and to evaluate the performance of the selected tests.

Our results confirm how misleading the use of the HHI can be when applied to an industry with differentiated products and Bertrand conduct. We find that the HHI test seems to be ‘blind’ for the economic effects that drive the post-merger price dynamics and therefore type-I and type-II error levels depend rather on the adopted thresholds.

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. In contrast with the HHI, the UPP test not only takes into account possible cost efficiencies, but also by construction deals with economic effects arising on a differentiated products market when a merger takes place. It is based on the idea that each of the merging firms faces a pricing pressure because of arising firm-specific alternative costs that the merger creates, that we call ‘merger taxes’. UPP values calculated for those firms are approximations of the corresponding merger taxes. Out of all considered UPP variants, the most accurate merger tax approximations in terms of magnitude and sign are provided by the $UPP^{ER}$ and $UPP^{2}$. When employed together with corresponding pass through rates, as suggested by formulae (13), they provide also the most accurate approximations of the post–merger price change magnitude.

When the UPP test is employed to assess the price change sign, the original $UPP^{1}$ variant demonstrates the minimal level of type-I error, but the maximal level of type-II one. This remains valid whether one employs true values for diversion ratio or its approximations. We show that the UPP test has two main features that cause both type-I and type-II errors for all variants.

First feature is a possible sign disagreement between the UPP value and the respective merger tax. We find that it can indeed be the case and that it explains the majority of type II errors. We also find that sign disagreement appears mostly when both variables are extremely small with respect to the post-merger price change (less that 1% for all UPP variants). Therefore, if a competition authority sets a non-zero price tolerance level, let’s say, 2%, then this occurrence alone, even if eventually happens, has a very low risk to affect the test performance.

Second feature is the ignorance of the cross-pass through effect that is assumed in the original formulation of the UPP test. Nevertheless, we illustrate that when UPP values of both merging partners and the respective merger taxes are of the same sign, then positive cross pass-through rates guarantee that the risk of generating a type-I or a type-II error is eliminated. Despite the fact that the sign of the cross pass through can change post-merger, our analysis suggest that one only needs to define it pre-merger.

Even though the present study focuses only on single-product firms, it seems also plausible from the practical point of view to consider multi-product settings, including cases where some of the products can be considered as complements. A helping hand comes from Jaffe and Weyl (2011) who propose a multi-product UPP formula that could be employed in this case. To our knowledge, there are no studies that would cover the UPP performance in a multi-product environment; therefore, we see it as a very promising area for further research. Among the other possible extensions we can envision introducing the Cournot conduct, vertical relationships, etc. It would be also useful to assess the sensitivity of the type-I and type-II errors to adopted thresholds (i.e. price tolerance level, cost efficiency rate, etc.) by building correspondent distributions. The developed simulation tool is flexible enough to serve well in assessing the performance of the chosen for the present study merger guidelines tools (and not only) in all those cases.

# CHAPTER 3

# The role of the cross pass-through effects in merger analysis

## 1. Introduction

A question of whether the proposed merger can potentially cause price increases traditionally remains in the core of merger investigations. Mostly because pricing effects can be measured in money terms and, therefore, they represent a direct and clear impact on consumers. To date, the merger simulation is the most advanced tool that competition authorities can employ to assess these effects. It is build out of three main components: demand and supply systems and competitive interaction between firms. Based on a consistent oligopoly model calibrated to fit the observed premerger equilibrium, this procedure is employed to predict post-merger prices, outputs and other variables of the possible interest (for instance, change in consumers' welfare). While being generally flexible and well economically grounded, merger simulation procedure has a significant drawback. By changing the underlying assumptions one is able to predict virtually any post-merger prices between marginal costs and the monopoly price. An example of such variations in predictions can be found in Froeb et al. (2005) who have performed a series of merger simulations for an (abandoned) WorldCom-Sprint merger. They have employed three different and commonly used demand systems - linear, constant elasticity and almost ideal (AIDS) demand systems - and demonstrated that price change predictions can vary significantly depending on the demand system chosen: from 2.3% for linear demand to 16.4% for isoelastic one. On a set of 3000 mergers simulated via Monte-Carlo method, Crooke, Froeb, Tschantz and Werden (1999) also found that post-merger price predictions are very sensitive to the adopted demand system. Linear demand provided the lower price increase, following by the logit and AIDS demands. Log-linear configuration resulted in the highest price increase that was three time as big as the one associated with the linear demand. While these illustrations are informative, it is hard to understand the sources of such differences because considered models differ in many respects, including assumptions on marginal costs and demand parameters. Having a clear idea about what these sources are could help to discriminate between different merger simulation settings and to verify whether the chosen one does not restrict *a priori* the expected post-merger price change.

Literature on the subject suggests that demand's curvature is one of the key determinants of the post-merger price change. Precisely, Crooke, Froeb, Tschantz and Werden

(1999)) found that convex demand functions generate highest post-merger price increases, while concave ones generate the lowest. However, their study is silent about the sensitivity of results with respect to the form of the cost function. Intuitively, one would expect that both demand and supply systems characteristics play a role. In support for the latter idea, the mentioned above study of Froeb et al. (2005) empirically demonstrates that the magnitude of the post-merger price increase is positively correlated with the own pass-through rate. Own pass - through rate measures the extent to which the firm passes its cost shock on consumers (in terms of price change) and is indeed a function of both demand and supply system parameters (see, for instance, Weyl and Fabinger (2009)). [34] This explains also the results of Crooke, Froeb, Tschantz and Werden (1999)) as demand's curvature is, in fact, one of the parameters affecting the own pass-through. Precisely, the class of 'cost amplifying' demand systems, i.e. those with the own pass through exceeding 1, includes those with log-convex functions, for example, constant elasticity demand. In turn, 'cost absorbing' demands functions (with the own pass through below 1) are log-concave as, for example, linear and homogeneous logit.[35]

A theoretical support for the empirical findings from above comes from Jaffe and Weyl (2011) who have explained the role of the pass-through matrix in the post-merger price formation, elaborating on the first order conditions of the pre-merger equilibrium. Pass-through matrix has own pass –through rates on diagonal, and cross pass- through rates below and above the diagonal, where cross pass - through rates measures the extent to which the firms' own prices react on a cost shock of the competitor (after re-equilibration of the economy). Their result remains valid for an arbitrary conduct and cost functions.

Note that the mentioned above empirical studies focus only on the own pass-through rate, while Jaffe and Weyl (2011) talk about the whole pass through matrix. As the present study demonstrates, ignorance of the role of the cross pass-through rate increases the risk of committing a mistake on various stages of the merger evaluation process, including market definition and assessment of unilateral and coordinated effects.

[34] For instance, if price increases on 5 units due to a 10 units cost increase (positive cost shock), then the own pass-through rate is equal to 5/10=0.5.

[35]The log - convexity/concavity of demand was established as a factor affecting the own pass-through of a monopoly facing constant marginal costs (see, for instance, Tyagi (1999)). Demand function $d_i(p)$ is said to be log concave if $\log(d_i(p))'' < 0$ , and log convex otherwise. Intuitively, this result can be applied in a multi-firms market as each of them can be seen as monopolist facing its own residual demand.

The paper will stick to the following outline. Section 2 introduces the adopted theoretical framework and illustrates how exactly the cross-pass through rate participates in the post-merger price formation. It also offers some examples illustrating how the neglecting of the cross-pass through sign and magnitude could lead to misleading conclusion on various stages of merger evaluation process. Section 3 provides a literature review regarding the economic conditions affecting the sign and magnitude of the cross pass-through rate. In Section 4 I perform a comprehensive analysis to examine the theoretical properties of the pass-through matrix derived for the setting from Section 2. I particularly focus on the cross pass-through rate and define demand and supply properties that affect its' sign and magnitude. As results coming from the existing literature as well as those obtained in Section 4 often require symmetry, in Section 5 I test whether they hold, at least to some extent, in a non symmetric environment. For this purpose I create by means of Monte-Carlo simulations 100,000 sufficiently differentiated, realistic and non-symmetric economies and perform and empirical assessment of obtained theoretical results. Section 6 concludes the paper.

## 2. The role of the cross-pass through rate in merger assessment

It is a more common practice to use a Bertrand competitive interaction in merger simulations. This is so, in part, because the majority of markets can be seen as those with differentiated products, or those with homogenous products coupled with differentiated services. Therefore, present paper will adopt this setting too. For the sake of simplicity only horizontal merger between two single-product competitors are considered, assuming that this business arrangement does not generate any merger-specific cost efficiencies.[36]

More formally, I consider an industry with J single product firms that produce substitutes and compete in prices to maximize their own profits $\pi_j(p) = [p_j - c_j(d_j(p))] \cdot d_j(p), \quad j = \overline{1, J}$, where $d_j(p)$ is a residual demand function for product *j*, such that $\frac{\partial d_j(p)}{\partial p_j} \leq 0$ and $\frac{\partial d_j(p)}{\partial p_i} \geq 0, \forall i \neq j$, $c_j(d_j(p))$ is a per-unit cost function and $p = (p_1, p_2 ... p_J)$ is the price vector. To improve the representation further in the paper explanatory variables will be omitted, unless their presence makes sense. No other specific restrictions are imposed on demand or cost functions, except that both are (at least twice) differentiable. Without loss of generality, I assume that the first two firms merge.

[36] Cost reductions due to economies of scale are still possible if allowed by the relevant cost functions.

Farrell and Shapiro (2010) in their Proposition 2 state that under assumption of constant marginal costs a horizontal merger has the same price effects as if both merging firms would be simultaneously exposed to specific per-unit taxes. Hereinafter I call them 'merger taxes'. This result was derived for a case of a duopoly, but it was not tied to any particular competition mode, be it Cournot or Bertrand. Jaffe and Weyl (2011) illustrate that this proposition is also valid for a more general case with non-constant marginal costs and for any market larger than a duopoly. A horizontal merger indeed creates an opportunity cost for both merging parties if they keep their prices on the pre-merger level – changing prices post-merger could have raised total profits of the merged entity because some of the consumers would not be lost as they would switch to the partner. The 'merger tax' is a precise measure of these alternative costs that are specific to each of the merging firms.

In other words, post-merger firms set their prices as if they would simply face certain cost shocks. This allows for a linearization around the pre-merger equilibrium and, as a result, makes it possible to derive the following approximations for the post-merger price increases (see Appendix E for derivations):

$$dp_1 \approx m_{11}t_1^m + m_{12}t_2^m \qquad (1)$$

$$dp_2 \approx m_{22}t_2^m + m_{21}t_1^m \qquad (2)$$

$$dp_i \approx m_{i1}t_1^m + m_{i2}t_2^m \ , \quad i = \overline{3, J} \qquad (3)$$

where $m_{ii}, i = \overline{1, J}$ are own pass-through rates and $m_{ij}, i, j = \overline{1, J}$ are cross pass-through rates (price reaction of firm *i* on a cost shock of firm *j*), $t_1^m$ and $t_2^m$ are the 'merger taxes' for the firm 1 and firm 2 correspondingly.

There exist several approximations for the 'merger tax', including the pioneering UPP index, developed by Farrell and Shapiro (2010). See Chapter 2 for an overview of some of the existing approximations. Nonetheless, to date, there is no study that would explicitly consider properties of the 'merger tax' itself. In fact, different economic setting may imply significantly different values of this variable. What one can be sure about is that absent cost efficiencies it always takes positive values as it represents simply a product of a diversion ratio and a post-merger markup (see Jaffe and Weyl (2011)).[37] Therefore, as equations (1) and (2) suggest, all other things equal, own pass-through rate and predicted post merger price increase are indeed positively linked. However, as the examples below illustrate, cross-pass-through effects are not negligible neither.

First, while own pass-through is never negative, cross pass-through rate has no sign restrictions. (See, for instance, Chapter 2 of the present thesis, Froeb et al. (2005) or Besanko et al (2005) for empirical evidence.) A simple analysis of equations (1) or (2) suggests that when cross pass-through is significant it can override the impact of the own pass-through and revert the sign of the price change. Therefore, price decrease is theoretically possible even in the absence of any merger specific cost efficiencies. In a very extensive set of simulated mergers presented in Chapter 2 of the present thesis one indeed can observe some cases with price decrease for one of the merging firms. Different oligopoly settings adopted in merger simulations often restrict the cross pass-through pattern, affecting therefore the range of predicted post-merger prices and even their signs.

Second, the accuracy of the implementation of the merger screening tools, such as, for instance, the UPP test, can also be affected. The UPP test was designed by Farrell and Shapiro (2010) to diagnose merging firms' incentives to increase their prices. The UPP value should be calculated for each of merging firms and, as was already mentioned above, appears to be an approximation of their specific 'merger tax'. By analogy with analysis of the impact of the cost shock on price, whenever UPP value is positive the firm is said to have incentives to increase its price post-merger. However, the formulation of the test ignores the fact that second merging firm is also 'exposed' to a tax and, therefore, cross pass-through effects are present. Hence, positive UPP may not necessarily correspond to a positive post-merger price change whenever cross pass-through effect drives the price down. This implication is illustrated and discussed in more detail in Chapter 2 of the present thesis.

Third, negative cross pass-through rates being featured by non-merging firms would result in their post-merger price decrease (see equations in (3)). Drop in prices causes a positive impact on consumers' surplus and in some cases can even override the negative effect caused by excessive pricing by merging firms. One can refer to the example in Higgins et al. (2005) that demonstrates that due to this effect, a merger can indeed benefit consumers,

[37] We reasonably assume that diversion ratios are not equal to zero, otherwise considered products cannot be seen as substitutes. We also assume that firms always enjoy a positive markup, i.e. " perfectly competitive" markets are excluded from consideration.

even if it does not generate any merger-specific cost efficiencies. Technically, authors do not operate in terms of cross pass-through rates, but rather in terms of strategic relationship between prices.[38] These two concepts are inextricably linked – under some conditions a negative (positive) cross pass-through implies strategic substitutability (complementarity) of prices and vice versa. I discuss on this issue in more detail in the next section, nonetheless, I use this connection between the two concepts here to motivate the next points.

Forth, the strategic substitutability may render inaccurate the price correlation approach that is sometimes used to define the relevant market. This approach looks at how price series evolve over time. There exist several price correlations tests, but all of them are based on a general idea that prices of goods from the same market would tend to move in the same directions (see Stigler and Sherwin (1985)). Therefore, the higher is price correlation, the most probably the considered goods are within the same market. If prices of two conventional substitutes are strategic substitutes, therefore, over time they may move in different directions. As this may exclude certain products from consideration, relevant market may appear too narrow, and, as a results of it, observed market shares will be overestimated. As a consequence, the HHI test, that still plays role in merger assessment practices, or any other concentration based test, would produce more false positives, i.e. flag the merger in question as possibly harmful, while it is not. The example from Higgins et al. (2005) indeed illustrates that mergers on markets with strategic substitutes can be socially beneficial because firms face downward pricing effects.

Finally, Potters and Suetens (2006) found experimental evidence that there is significantly more cooperation when agents' actions exhibit strategic complementarities than in the case of strategic substitutes. They propose the following intuition. In case of strategic complements even a self-interested agent will partially follow a cooperative move made by another agent because the best response function has a positive slope. In case of strategic substitutes, an agent would at least partially off-set a cooperative move because the slope of the best response function is negative. When applied to the merger analysis, this result suggests that coordinated effects are weaker if firms see prices as strategic substitutes.

To check whether the considered market features negative cross-pass through rates and whether they are significant relative to the own pass-through, one could perform an empirical

[38] A notion of "strategic substitutability" and "strategic complementarity" was introduced by Bulow et al (1983). Prices are said to be strategic substitutes (complements) if corresponding reaction curve slope is negative (positive).

estimation of the whole pass-through matrix. However, doing so even for a part of it could appear very challenging. Instead, understanding the general economic conditions that influence the sign and magnitude of its elements would already be helpful.

Existing literature that covers pass-through issues has a rather limited relevance to our problematic - it either deals with the own pass-through rate only or, if actually tackles the cross pass through, is often tailored to a particular setting and therefore cannot be employed in the present study.[39] Nevertheless, some intuition that can still be gained from the few relevant existing theoretical and empirical studies that are discussed below.

## 3. Literature review

Assuming symmetry, constant marginal costs and a horizontal demand system, Weyl and Fabinger (2009) establish an explicit relationship between the magnitude of the own pass-through and the sign of the cross pass-through rates. They demonstrate that the sign of $(m_{ii}-1)$ is opposite to the sign of $m_{ji}, i, j=\overline{1,J}$.[40] In other words, if firm's residual demand is 'cost amplifying' $(m_{ii}>1)$, then all relevant cross pass-through rates of competitors should be negative, and positive for a 'cost absorbing' demand $(m_{ii}\le 1)$.[41]

While it is common to assume that marginal costs are constant, not all of the traditionally employed in merger simulations demand functions imply horizontality. The class of horizontal demand systems includes, for example, linear demand systems and as a generalization of this, Horizontal Constant Pass-through Demand System (HCoPaDS), developed by Weyl and Fabinger (2009). Jaffe and Weyl (2011) argue that results of Gabaix et al. (2009) and Quint (2010) applied under symmetry imply horizontality as well for some general discreet choice models.

Required symmetry, demand horizontality and rigidity of marginal costs remain an unfortunate limitation for the practical applicability of the results from Weyl and Fabinger (2009). Nevertheless, some empirical studies based on non symmetric markets end up with similar, though not exactly the same, conclusions. For instance, on a dataset of prices for a major U.S. supermarket chain Besanko et al (2005) investigated how manufacturers' trade

[39] For example, Loomis (1997) studies cross pass through effects that arise when firms compete in multiple markets, or Sudhir (2001) who considers pass-through effects when firms are interacting vertically.
[40] A demand system is called 'horizontal' if the price of a substitutable (complementary) good raises (lowers) a uniform upward (downward) shift in the own inverse demand.
[41] By 'relevant' cross pass-through here should be understood the reactions of all other firms on a cost shock of a given firm.

promotions are passed on the retailers' prices. Not only the own-brand, but also cross-brand retail pass-through rates were considered. A reduced-form approach that was employed allowed getting along without constraints that are usually imposed by structural models and therefore provided results that are less sensitive to the adopted framework. Authors found that brands with high own pass-through are more likely to generate negative cross-brand pass-through for their competitors.[42]

Next section of the paper contributes to the existing knowledge on the issues. It offers a comprehensive theoretical examination of the properties of the pass-through matrix derived for the setting presented in Section 2. As motivated above, cross pass-through rate will be kept in the focus as well as conditions affecting its sign and magnitude.

## 4. General properties of the pass-through matrix

Consider a (pre-merger) pass-through matrix $M$ derived for the setting from Section 2. (See Appendix E for the derivations.) It is a $J \times J$ matrix, with own pass-through rates $m_{ii}, i = \overline{1, J}$ on the diagonal and cross pass-through rates $m_{ij}$ in the upper and lower triangular parts. $m_{ij}$ stands for the cross pass-through rate that represents the reaction of firm *i* on the cost shock of firm *j*. First and second order conditions of the pre-merger equilibrium determine several interesting properties of the pass-through matrix. I discuss these and the other findings below, leaving all the technical details for the Appendix F.

First, it is easy to show that the second order conditions of the pre-merger equilibrium ensure that all own pass-through rates are positive. Therefore, if the industry in question does not experience any cross pass-through effects, then a merger with positive merger taxes would certainly result in a price increase for both merging firms. This result follows directly from the analysis of equations (1)-(3) above. Recall that if the merger generates no cost efficiencies then the respective merger taxes are always positive.

Second, the same equilibrium conditions cause the own cross pass-through rates to weakly dominate the cross pass-through ones, such that $\max \left| m_{ij} \right| \leq \max( m_{ii}, m_{jj} ),\ i, j = \overline{1, J}$. An empirical evidence for this finding can be found, for instance, in Chapter 2 of the present thesis, in Froeb et al. (2005) or Besanko et al (2005). It is sometimes argued that this property might be a result of a particular demand or supply system that was adopted for merger

[42] Even though authors consider vertical relationship, their result is relevant for the present study as retailers take input prices as fixed.

simulations. In Appendix F of the present study I show that for the setting employed this is rather a common rule. Even though this property restricts the possible impact of cross pass-through effects on post-merger prices, it should not be neglected, as various examples from Section 2 demonstrate.

Third observation, that may not appear obvious, is that the pass-through matrix is generally not symmetric. In other words, $m_{ij}$ and $m_{ji}$ are not necessarily of the same magnitude, nor of the same sign. This is an unfortunate feature for a merger analyst who wants to take into account possible cross pass-through effects, especially when number of firms on the market is high. More than that, as Jaffe and Weyl (2011) have highlighted, pre-merger matrix is not generally equivalent to the post-merger one. Not simply because the latter shall be estimated at different (post-merger) price level, but also because of the structural changes that a merger causes. In fact, some of cross pass-through rates can even change the sign to the opposite. While theoretical framework employed in the present study implies that one only needs the pre-merger pass-through rates to approximate the post-merger price changes, this property can imply large complexities if the analyst intends to take into account cost efficiencies that are supposed to materialize at some point post-merger.[43] Whenever a cross pass-through becomes negative post-merger it may lead to counter-intuitive and, moreover, undesirable upward pricing pressure effects following from those cost savings. More than that, existing literature indeed shows that negative cross pass-through has a higher probability to be present if related products remain under common ownership (or managed together). See, for instance, Besanko et al (2005) or Chapter 2 of the present thesis. Even though the present study does not intend to cover this problematic, it remains an appealing topic that deserves further exploration.

The last two matrix properties were derived for symmetric markets only.

The magnitude of the cross pass-through rate relative to the own pass-through $m_{ij}/m_{ii}, \forall i, j = \overline{1, J}$ decreases with the number of firms on the market, all other industry parameters kept equal.[44] Of course, the more general property

[43] So called "dynamic efficiencies" indeed come into effect during relatively long period post-merger and may have, in fact, a more significant impact than standard short term (or instantaneous) cost savings.
[44] Similar result was derived by Weyl and Fabinger (2009) for a cross pass-through relative to the own pass-through, although it was restricted for horizontal demand systems and constant marginal costs and also required symmetry.

$\max\left|m_{ij}\right| \leq \max(m_{ii}, m_{jj}),\ i,\ j = \overline{1, J}$ remains valid too. As a consequence, a stronger downward post-merger pricing pressure due to a negative cross pass-through is more likely to appear on the market with fewer firms. This may be seen counterintuitive as a higher market concentration is usually associated with a stronger market power and thus a more significant post-merger price increase. Therefore this property may contribute to the decrease in the accuracy of the HHI test, or any other concentration-based test, whenever a negative cross pass-through is present.

The final property of the pass-through matrix that arises under symmetry is that the sign of the cross pass-through $m_{ij}$ corresponds to the sign of the cross derivative of the profit function $\partial^2 \pi_i / \partial p_i \partial p_j$.[45] This finding allows deriving explicit conditions driving the sign of the cross pass-through rate. It is easy to show that:

$$\partial^2 \pi_i / \partial p_i \partial p_j = \underbrace{\frac{\partial^2 d_i}{\partial p_i \partial p_j}\left[p_i - c_i - d_i \frac{\partial c_i}{\partial d_i}\right] + \frac{\partial d_i}{\partial p_j}}_{\equiv -\frac{\partial \varepsilon_{ii}}{\partial p_j}\cdot\frac{d_i}{\varepsilon_{ii}}} - \underbrace{\frac{\partial d_i}{\partial p_i}\cdot\frac{\partial d_i}{\partial p_j}}_{<0}\underbrace{\left[2\frac{\partial c_i}{\partial d_i} + d_i \cdot \frac{\partial^2 c_i}{\partial d_i \partial d_i}\right]}_{\equiv \frac{\partial mc_i}{\partial d_i}} \quad (4)$$

Once all sign constraints imposed on demand function derivatives are taken into account, one can detect two elements of the formula that don't have sign constraints and therefore can potentially be positive or negative.

First element, $\frac{\partial mc_i}{\partial d_i}$, takes negative (positive) values when marginal costs decrease (increase) with quantity. This elements enters (4) with the coefficient $-\frac{\partial d_i}{\partial p_i}\cdot\frac{\partial d_i}{\partial p_j}$ that is always positive under the adopted assumptions on demand functions. All other parameters equal, the more sensitive is the demand to the competitor's price increase (the higher is $\partial d_i / \partial p_j$) the higher is the potential benefit (loss) of the firm due to decreasing(increasing) marginal costs when it changes the output, and therefore the stronger its incentive to decrease (increase) price.

[45] In case of duopoly this result remains valid without requiring the symmetry.

Second element, $-\frac{\partial \varepsilon_{ii}}{\partial p_j} \cdot \frac{d_i}{\varepsilon_{ii}}$, is negative (positive) if own residual demand becomes more elastic when competitor's price rises, i.e. when $\frac{\partial \varepsilon_{ii}}{\partial p_j} < 0$ [46] The intuition that links this property with the price change direction is quite simple. Let us consider a situation when a competitor raises its price due to an own positive cost shock. Then the firm in question would face an increase in demand reverted from the competitor. If this makes own residual demand more elastic, than it becomes more profitable for this firm not to increase own price in response, but on the contrary, to decrease it. Hence, one would observe a negative cross pass-through. This phenomenon has already featured in Higgins et al.(2005) where it was used to explain the post-merger price decrease by non-merging firms.[47] Authors do not make a reference to the cross pass-through rate, but rather operate in terms of strategic relationship between prices. Indeed, if $\partial^2 \pi_i / \partial p_i \partial p_j > 0$, reaction curve $p_i(p,c)$ would have a positive slope and prices would be seen as strategic complements, and strategic substitutes otherwise. [48]

Note, that $-\frac{\partial \varepsilon_{ii}}{\partial p_j}$ can only be negative if $\frac{\partial^2 d_i}{\partial p_i \partial p_j} < 0$[49]. In other words, elasticity can only rise after the competitor's price increase if the demand slope does too (all in absolute values). This last property might be easier to verify empirically or theoretically according to the demand function chosen, however it is only a necessary conditions for the elasticity to increase, but not a sufficient one.

To summarize the findings from Section 3 and 4, assuming that the underlying assumptions are met, there are three 'determinants' affecting the sign of the $m_{ij}$: the

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46 $sign(-\frac{\partial \varepsilon_{ii}}{\partial p_j} \cdot \frac{d_i}{\varepsilon_{ii}}) = sign(\frac{\partial \varepsilon_{ii}}{\partial p_j})$ as $\varepsilon_{ii} < 0$ and $d_i \geq 0$.

47 Authors assume that marginal costs are constant, therefore only demand side effects were present.

48 Recall that the link between the sign of the cross pass-through and strategic relationship was derived under the assumption of symmetry. Alternatively, this requirement can be substituted by the assumption of consistent conjectures. If $p_i(p,c)$ is the reaction curve of the firm i, then consistent conjectures would imply that $\frac{\partial p_i}{\partial p_j} = \frac{\partial p_i}{\partial c_j} \Big/ \frac{\partial p_j}{\partial c_j} = m_{ij} / m_{ii}$. The slope of the reaction curve therefore would strictly depend then on the sign of the cross pass-through rate $m_{ij}$. For more information on consistent conjectures see Jaffe and Weyl (2011).

49 It follows directly from the $= \frac{\partial \varepsilon_{ii}}{\partial p_j} \cdot \frac{d_i}{\varepsilon_{ii}} = \frac{\partial^2 d_i}{\partial p_i \partial p_j}\left[p_i - c_i - d_i \frac{\partial c_i}{\partial d_i}\right] + \frac{\partial d_i}{\partial p_j}$, given $\frac{\partial d_i}{\partial p_j} > 0$ and the following sign constraint implied by the equilibrium first order conditions $(p_i - c_i - d_i \frac{\partial c_i}{\partial d_i}) = (p_i - mc_i) > 0$.

magnitude of the own pass-through of the respective competitor $(m_{jj})$, the own demand elasticity with respect to the price of the competitor $\left(\frac{\partial \varepsilon_{ii}(p)}{\partial p_j}\right)$ and the slope of the marginal costs curve with respect to own production quantity.

On one hand, it is very convenient that all the required curvatures and slopes in (4) should be estimated at pre-merger state of the market. If underlying assumption are met, then if pre-merger marginal costs are increasing (decreasing) and competitor's' price increase does not make own residual demand more (less) elastic, one can be sure that cross pass-through is positive (negative). On the other hand, no robust conclusion can be made if the two elements in question are of different signs because relative importance of each of them is case specific. Moreover, practical verification of the signs and magnitudes of these determinants may be as complex as a full merger simulation. I suggest that these findings should be employed is the step of the merger assessment when the simulation framework is only being designed. Verifying whether the chosen demand and supply systems (before being calibrated or estimated) are flexible enough to allow the determinants in question to be of any sign, removes the ad hoc constraints on the cross pass-through pattern. If the underlying setting was proved to be flexible and the resulting pass-through matrix appears to contain some negative elements, then this knowledge can be employed in other areas of merger investigation, for example in the assessment of coordinated effects or market definition (see Section 2 for the examples).

However, the practical applicability of these results may seem limited as all determinants were derived for symmetric industries, while the one related to the magnitude of the own pass-through from Weyl and Fabinger (2009), in addition, is valid only for horizontal demands and constant marginal costs. In the next section I empirically verify whether these results can be, at least to some extent, generalized to a non-symmetric case with no additional restrictions on demand or slope of the marginal costs curve.

## 5. Empirical analysis

***Dataset***

To verify whether the theoretical findings from the previous section would still hold when underlying assumptions are relaxed, I create a set of 100,000 economies by using the Monte Carlo simulation tool designed in Chapter 2 of the present thesis.[50] Each of generated economies comprises J (J=10) single product firms that compete a la Bertrand-Nash and produce differentiated products, as well as consumers whose preferences are generated by a random coefficient model. I do not modify the demand and supply systems, but unlike the original study, I do not impose any restriction on the cost function so that both increasing and decreasing marginal costs can be present within the same economy. A sampling process involves distributions for products' characteristics, consumers' preferences and firms' costs elements. Distributions of certain parameters vary from one economy to another that allows generating highly heterogeneous economic situations. Recovering of the equilibrium outcomes employs the fixed-point algorithm that does not always converge. Therefore, non-converged economies, as well as those with zero market shares and extreme elasticity values are removed from the sample.[51] It reduces the initial sample to 52748 observations. More details on the simulation procedure can be found in the Chapter 2 of the present thesis.

A great advantage of the simulation approach is that all required information concerning the slopes and derivatives of demand and supply functions can be easily recovered as one possesses the full information about economic agents. Equally important, generated sample is sufficiently differentiated and at the same time realistic. Tables 1-3 below illustrate this point. For example, first firm's own demand elasticity varies from -26.9 to -0.05, its market share also has quite a wide range from almost zero to 74% (see Table 1). In fact, all the considered economic variables vary within quite large, but realistic intervals, while meeting the sign restrictions. Without loss of generality I restrict the demonstration to the first firm only.

[50] I employ SAS statistical programs and routines.

[51] Precisely, I remove economies with demand elasticities lying below 1 percentile and above 99 percentile. Cases with zero market shares are removed to maintain the number of firms constant for comparability.

**Table 1: Descriptive statistics of main economic parameters of the simulated economies (total number of observations =52748)**

| Parameters | Mean | Variance | Min | Max |
|---|---|---|---|---|
| Own price demand elasticity, $\varepsilon_{11}$ | -11.08 | 5.42 | -27.00 | -1.00 |
| Cross price demand elasticity, $\varepsilon_{12}$ | 0.32 | 0.64 | 0.00 | 25.09 |
| Aggregate demand elasticity | -0.75 | 1.17 | -8.79 | -0.00 |
| Own pass-through, $m_{11}$ | 1.04 | 0.25 | 0.01 | 3.97 |
| Cross pass-through, $m_{12}$ | 0.00 | 0.02 | -0.73 | 0.77 |
| Markup ( %), 1$^{st}$ firm | 12.67 | 10.58 | 0.01 | 98.43 |
| Market share (%),1$^{st}$ firm[52] | 2.68 | 5.69 | 0.02 | 74.72 |

While it is relatively easy to demonstrate that the cost function employed for simulations allows for both increasing and decreasing marginal costs, the analysis of the discreet choice demand system can be much more challenging, especially if one needs to verify such a complex property as sensitivity of own demand elasticity with respect to the price of competitors. The choice of a discreet choice model for the present study was motivated by the following consideration. As it follows from Gabaix et al. (2009), log-curvature of distributions of preference parameters impacts the demand log-curvature, therefore discreet choice models can potentially generate any desirable demand shape. To demonstrate this, in Table 2 I provide the breakdown of the simulated economies according to the sign of the variables of the interest defined in the previous section, where the “elasticity shift” stands for the change in demand elasticity of the first firm with respect to the price of the second firm and “demand curvature” is defined for the first firm. Overall the number of observations with all desirable slopes and curvatures is sufficient to obtain robust estimations.

[52] Discreet choice models assume the existence of the ‘outside option’ that corresponds to a situation when consumer decides to buy a good outside of the considered basket of J goods or does not buy at all. Market shares are, therefore, calculated with respect to a market size that comprises this ‘outside option’.

**Table 2: Breakdown of simulated economies according to selected properties (total number of observations =52748)**

| Variable/characteristic | Breakdown | |
|---|---|---|
| $m_{12}$ | Negative<br>43% | Positive<br>57% |
| $m_{22}$ | >1[53]<br>54% | <1<br>46% |
| $mc_1$ | Decreasing<br>47% | Increasing<br>53% |
| Elasticity shift (in absolute values) | Decreasing<br>81% | Increasing<br>19% |
| Demand curvature | Log concave<br>4% | Log convex<br>96% |

The created dataset was then employed to estimate the significance of each of the three selected determinants of the sign of the cross pass-through. But before proceeding with a formal empirical estimation results, it could be useful to take a look at the tabulation of the cases from the sample according to the state of selected determinants and the sign of the cross pass-through. Table 3 below, that provides the required breakdown, offers some interesting observations. A simple overview suggests that nor the magnitude of the own pass-through neither the 'elasticity shift' factor have any significant impact on the sign of the cross pass-through – number of cases between with positive and negative cross pass-through is similar regardless whether the determinant in question is favoring this sign or not. In turn, marginal costs' slope has quite a clear effect – negative cross pass- through is mostly recorded when marginal costs are decreasing.

**Table 3: Tabulation of the sample according to selected properties (total number of observations =52748)**

| Properties | Own pass-through | | Elasticity shift (abs.) | | Marginal costs | |
|---|---|---|---|---|---|---|
| | >1 | <1 | Decreasing | Increasing | Decreasing | Increasing |
| $m_{12} > 0$ | 27.0% | 29.6% | 49.3% | 7.2% | 6.3% | 50.3% |
| $m_{12} < 0$ | 21.3% | 22.1% | 35.6% | 7.9% | 40.6% | 2.8% |

[53] A threshold of "1" arises naturally from previous theoretical results. See, for instance, Weyl and Fabinger (2009).

However, this kind of analysis is not enough for a definitive conclusion as all of the determinants contribute simultaneously and may do so in opposite directions. Therefore, below I perform an assessment of the relevant importance of each of the determinants in a more comprehensive way.

***Estimation of the probit model***

Put it in a nut shell, what needs to be tested is whether the probability of facing a negative (positive) cross pass-through $m_{ij}$ is higher when i) the own pass-through of the relevant competitor $(m_{jj})$ is above (below) one, and/or ii) own demand becomes more (less) elastic with competitor's price increase, and/or iii) own marginal costs are decreasing (increasing) in quantity. Ideally, the chosen econometric tool should be able to predict the probability of having a negative (positive) cross pass-through when all of the three conditions, or at least some of them, are satisfied.

The most convenient model that fits these requirements is a Probit regression in the following specification:[54]

$$\Pr ob(S\_M_{ij} = 0 \mid X_{ij}) = \Phi(X'_{ij}\beta) \qquad (5)$$

where $S\_M_{ij}$ is a binary variable that takes value 0 whenever $m_{ij} \leq 0$, and 1 otherwise and $X_{ij} = \{1, S\_M_{jj}, S\_ES_{ij}, S\_MC_i\}$ is a vector of explanatory variables.[55] $S\_M_{jj}$ takes value 1 if $m_{jj} > 1$ and 0 otherwise. $S\_ES_{ij}$ is a binary variable that takes value 1 when $-\frac{\partial \varepsilon_{ii}}{\partial p_j} > 0$, and zero otherwise. Variable $S\_MC_i$ takes value 1 when marginal costs $mc_i(d_i)$ are decreasing and zero otherwise. $X_{ij}$ also includes a dummy variable '1' to account for the intercept. Finally, $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. $\beta = (\beta_0, \beta_1, \beta_2, \beta_3)$ is therefore a vector of coefficients to be estimated by a maximum likelihood method. $\beta_1, \beta_2, \beta_3$ are expected to be positive, while the intercept coefficient $\beta_0$ has no particular sign constraints.

[54] A Logit regression that also fits model requirements would generally provide similar results.

[55] Distributions of the selected variables were found to be independent. Respective tables can be provided upon request.

As Section 2 motivates, various "counterintuitive" or "unexpected" effects in mergers and merger evaluations appear mostly in the presence of negative cross pass-through rates. Therefore, the probit model was set to estimate the probability of having a negative cross pass-through, and the further analysis will have it in focus as well.

Having the simulated sample on hand, it is now possible to proceed with estimation of the parameters of interest. Without loss of generality I estimate the probit model for the $m_{12}$ only. Results are provided in Table 4 below.

**Table 4: Determinants of the cross pass-through sign**
**(Probit model estimates)**

| Parameter | Estimate | Standard Error | Chi-Square | Pr > ChiSq |
|---|---|---|---|---|
| Intercept | -2.0454 | 0.0195 | 11028.8 | <.0001 |
| $S\_M_{22}$ | 0.00341 | 0.016 | 0.0454 | 0.8312 |
| $S\_ES_{12}$ | 1.2438 | 0.0251 | 2458.15 | <.0001 |
| $S\_MC_1$ | 2.9466 | 0.02 | 21661.5 | <.0001 |
| Testing Global Null Hypothesis: BETA=0 (Wald) | | | Chi-Square | Pr>ChiSq |
| | | | 22763.924 | <0.001 |

Because all explanatory variables are binary, one cannot easily interpret the estimates of the coefficients from Table 3. However, their significance and sign remain extremely informative. For example, the coefficient tied with $S\_M_{22}$ is not significant, therefore having an own pass-through of the competitor above one does not affect the firm's probability of facing a negative cross pass-through. The reason is, most probably, a very restrictive set of assumptions under which this determinant was developed, including symmetry, horizontal demand and constant marginal costs (see Weyl and Fabinger (2009)).

On the other hand, the theoretical intuition for the other two determinants is supported-estimated parameters that are tied to the elasticity and slope of the marginal costs curve are significant and have the expected signs. In Section 4 it was established that if these two determinants both favor a certain cross pass-through sign, then, under symmetry, the sign prediction is always accurate. Our sample is not limited to only symmetric economies; nevertheless, it also demonstrates a very high probability of correct predictions. For example, the probability of facing a negative cross pass-through when both determinants are favorable (e.g. $S\_ES_{12} = S\_MC_1 = 1$ ) is at least 97.6% (see the confidence interval limits in the first line of Table 5).

**Table 5: Predicted probabilities of having a negative cross pass-through for given values of explanatory variables**
**(Probit model estimates)**

| Setting | Probability estimate | St. error. | Confidence limits | | Chi-Square | Pr > ChiSq |
|---|---|---|---|---|---|---|
| $S\_ES_{12} = S\_MC_1 = 1$ | 0.978 | 0.001 | 0.976 | 0.981 | 5987.64 | <.0001 |
| $S\_ES_{12} = 1$ and $S\_MC_1 = 0$ | 0.206 | 0.005 | 0.196 | 0.216 | 5283.67 | <.0001 |
| $S\_ES_{12} = 0$ and $S\_MC_1 = 1$ | 0.796 | 0.003 | 0.790 | 0.802 | 1390.44 | <.0001 |

But what if the determinants in question drive the sign of the cross pass-through in opposite directions? To answer this question it might be useful to establish the relative importance of these two variables. To do so, I calculate the probabilities of having a negative cross pass-through when $S\_ES_{12} \neq S\_MC$. The last two lines in Table 5 provide the sought-for estimations.

When only marginal costs slope is favoring the negative cross pass-through (i.e. $S\_ES_{12} = 0$ and $S\_MC_1 = 1$) then the probability that the first firm is actually facing it is at least 79% (left boundary of the confidence interval). On the other hand, the favoring demand property only generates negative cross pass-through with a probability of maximum 21.6% (upper boundary of the corresponding confidence interval).

It is intuitive to expect that the revealed dominance of the marginal costs in driving the sign of the cross pass-through is not a result of a general rule, but rather a specific feature of the simulated sample. To demonstrate this, probit model estimations were performed on a different sample of economies that is different from the present sample only in a way the marginal costs are generated. Precisely, new sample is generated with a more flat function of marginal costs.[56] All the conclusions made for the original sample remain valid, except that the demand side effects became at least as important as marginal costs in defining the sign of the cross pass-through (see Table 6).

[56] Parameter $\gamma$ that is responsible for the slope of the marginal costs curve was set to 0.0002, instead of 0.002. See Chapter 2 of the present thesis for more details on the cost function design and the simulation procedure.

**Table 6: Predicted probabilities of having a negative cross pass-through for given values of explanatory variables**

**(Probit model estimates, sample with a more flat function of marginal costs)**

| Setting | Probability estimate | St. error. | Confidence limits | | Chi-Square | Pr > ChiSq |
|---|---|---|---|---|---|---|
| $S\_ES_{12}=1$ and $S\_MC_1=1$ | 0.9971 | 0.0017 | 0.9914 | 0.9991 | 206.7356 | <.0001 |
| $S\_ES_{12}=1$ and $S\_MC_1=0$ | 0.5785 | 0.0419 | 0.4951 | 0.6584 | 3.4086 | 0.003 |
| $S\_ES_{12}=0$ and $S\_MC_1=1$ | 0.5566 | 0.0265 | 0.5043 | 0.608 | 4.4968 | <.0001 |

Despite the fact that this exercise witnesses for a certain lack of robustness, results in Table 5 remain extremely important as they illustrate that the assumption of constant marginal costs (that is commonly adopted in merger simulations) may significantly limit the cross pass-through pattern. As was motivated in Section 2, the latter would, in turn, narrow down the possible range for predicted post-merger price changes. It may result, for example, in the exclusion of the possibility of a price decrease either by a merging firm or by non-merging ones, and therefore to render a potentially welfare improving merger as detrimental.

Similar analysis was performed for the samples with different number of firms (J=3 and J=20), as well as with a logit specification of the models instead of the probit. In all cases estimations provided similar results and for this reason will be not presented here.

## 6. Conclusions

As demonstrated in Jaffe and Weyl (2009) and Froeb et al. (2005), the pass-through matrix plays an important role in defining the pricing effects of horizontal mergers. In contrast with existing literature that focuses mostly on the role of the own pass-through rate, the present study demonstrates that role of the cross pass-through can as well be significant. The ignorance of its presence, and particularly of its sign, can lead to various counterintuitive effects and misleading conclusions in merger investigations. Almost all stages of the process are subject to risk, including the market definition procedure and assessment of unilateral and coordinated effects. The issue touches upon not only cross pass-through rates of merging entities but also non-merging ones, as their price reactions arise only from the cross pass-through effects. These firms can find it profitable to decrease prices post-merger and, by doing so, render the merger socially beneficial.

Existing literature that studies the properties of the pass-through focuses mainly on the own pass-through rate and often limits the discussion to a very particular setting that makes the results inapplicable in majority of horizontal merger cases. In contrast, the present study examines the properties of the whole pass-through matrix, as well as determinants of the sign and magnitude of the cross pass-through rate. It is done for a very general framework that is convenient for merger simulations, although restricted to a Bertrand-Nash competition. Among the most striking observations, the present study finds that:

i) cross pass-through effect cannot dominate the own pass-through one and its' relative significance decreases with a higher number of firms, all other parameters being equal. Nevertheless, as Section 2 illustrates, this does not mean that the cross pass-through effect can be neglected in merger investigations, especially when it is negative;

ii) not only demand function shape, but also the slope of marginal costs curve matters for the sign of the cross pass-through. Therefore, the usually adapted assumption of constant marginal costs may significantly limit or even distort the possible outcomes of merger simulations, e.g. render a potentially welfare improving merger as *a priori* detrimental.

Together with merger assessment, derived results could be relevant as well for the other domains of industrial economics, for example, cartel investigations. As the link between strategic relationship and the sign of the cross pass-through rate was revealed, we can apply the results from the study of Potters and Suetens (2006), mentioned in Section 2. Their experimental study finds that market agents have higher incentives for collusion when prices are strategic complements (compared to strategic substitutes). Furthermore, if merger with no cost efficiencies can improve consumers' welfare thanks to negative cross pass-through effects, then a hard-core cartel could do so too. This suggests that the widespread opinion that all hard core cartels are *per se* harmful probably needs to be reconsidered.

An analysis of the pass-through matrix in a more complex environment, such as multi-product ownership, complementary products, Cournot competition, capacity constraints, vertical interactions, etc. is appealing and can be envisioned in the future. The simulation tool developed in Chapter 2 and employed in the present study is flexible enough to account for all mentioned configurations and provides a great way to test any kind of theoretical results or intuitions as practically all information about economic agents is available.

## References

Aghion, P. and P. Howitt (2005) “Appropriate Growth Policy: A Unifying Framework”, paper presented at the OECD Conference on Global convergence scenarios: structural and policy issues, Paris, January 2006.

Aleksandrov, A., O. Bedre-Defoliee (2011) “Asymmetric Demand Effects and Cost Pass-Through”, Simon School Working Paper No. FR 11-12

Allain et al. (2011) “The Determination of Optimal Fines in Cartel Cases: The Myth of Underdeterrence”, Available at SSRN: http://ssrn.com/abstract=1987107 or http://dx.doi.org/10.2139/ssrn.1987107

Anderson et al. (1992) “Discrete Choice Theory of Product Differentiation”, MIT Press, 1992

Baker, J. B (2003) “The Case for Antitrust Enforcement”, Journal of Economic Perspectives, Vol. 17, Number 4, Fall 2003, Pages 27-50

Berry, S.T. (1994) “Estimating Discrete-Choice Models of Product Differentiation, RAND Journal of Economics, vol. 25(2), pages 242-262

Berry, S., J. Levinsohn, and A. Pakes (1995) “Automobile Prices in Market Equilibrium”, Econometrica, 63(4), 841-890

Besanko, D., J.P. Dube and S. Gupta (2005) “Own-Brand and Cross-Brand Retail Pass-Through”, Marketing Science. 24(1): 123-137

Björnerstedt, J.and F. Verboven (2013) “Does Merger Simulation Work? Evidence from the Swedish Analgesics Market”, available at http://www.econ.kuleuven.be/eng/ew/discussionpapers/Dps12/Dps1208.pdf

Boyer, M. and R. Kotchoni (2014) “How Much Do Cartels Overcharge?”, previous (published) version of the paper can be found at http://ssrn.com/abstract=2076055

Bryant, P. and E. W. Eckard (1991), “ Price Fixing: The Probability of Getting Caught”, The Review of Economics and Statistics Vol. 73, No. 3 , pp. 531-536

Buccirossi, P. et al. (2006) “Competition Policy and Productivity Growth: An Empirical Assessment”, Discussion paper, Düsseldorf Institute for Competition Economics (DICE)

Buccirossi, P. al. (2009) "Competition policy and productivity growth: An empirical assessment", CIG Working Papers with number SP II 2009-12.

Bulow,J., J.D. Geanakoplos and P.D. Klemperer (1985) "Multimarket Oligopoly: Strategic Substitutes and Complements", Journal of Political Economy, Vol. 3, #31

Cheung, L. (2011) "The Upward Pricing Pressure Test for Merger Analysis: An Empirical Examination", Job market paper, University of Minnesota

Combe, E. et al. (2008) "Cartels: The Probability of Getting Caught in the European Union", available at SSRN: http://ssrn.com/abstract=1015061

Connor, J.M. (2005) "Price-fixing overcharges: legal and economic evidence", Staff Paper No. 04-17, Purdue University

Connor, J.M. (2010a) "Recidivism Revealed: Private International Cartels 1991-2009", available at SSRN: http://ssrn.com/abstract=1688508 or http://dx.doi.org/10.2139/ssrn.1688508

Connor, J.M. (2010b) "Price-fixing Overcharges, 2nd Edition", available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1610262

Connor, J.M (2011a) "Price Effects of International Cartels in Markets for Primary Products", materials of the Symposium on Trade in primary Product Markets and Competition Policy" at the World Trade Organization, September 22, 2011.

Connor, J.M. (2011b) "Cartels portrayed" working papers series. The American Antitrust Institute, working papers No. 11-06, 11-03, 11-04, 11-05, 11-06 and 11-07.

Connor, J.M. and Y. Bolotova (2006) "Cartel overcharges: Survey and meta-analysis", International Journal of Industrial Organization, 24, 1009-1137.

Crandall, R.W. and C. Winston (2004) "Does Antitrust Policy Improve Consumer Welfare? Assessing the Evidence", The Journal of Economic Perspectives, Vol. 17, No. 4 (Autumn, 2003), pp. 3-26

Crooke, P., Froeb, L.M., Tschantz, S. and Werden, G.J. (1997) "Effects of the Assumed Demand System on Simulated Post-merger Equilibrium", Papers 97-3, U.S. DoJ - Antitrust Division

Epstein, R. J. and D. L. Rubinfeld (2010) "Understanding UPP". Available at SSRN: http://ssrn.com/abstract=1734012

Farrell, J., and C. Shapiro (2010) “Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition”, The BE Journal of Theoretical Economics, 10(1), 9

Farrell, J. and C. Shapiro (1990) "Horizontal Mergers: An Equilibrium Analysis", American Economic Review, American Economic Association, vol. 80(1), pages 107-26, March

Froeb, L.,S. Tschantz, and G.J. Werden (2005) “Pass-Through Rates and the Price Effects of Mergers”, International Journal of Industrial Organization, Volume 23, Issue 9-10, December 2005, Pages 703-715

Gabaix, X., D. Laibson, D. Li, H.Li, S. Resnick and C. G. de Vries (2009) “Extreme Value Theory and the Equilibrium Prices in Large Economies”, available at http://pages.stern.nyu.edu/∼xgabaix/papers/CompetitionEVT.pdf

GrigolonL.andF.Verboven (2011) "Nested logit or random coefficients logit? A comparison of alternative discrete models of product differentiation," Center for Economic Studies - Discussion papers ces11.24, KatholiekeUniversiteit Leuven, Centrum voorEconomischeStudiën

Griffith, R. and R. Harisson (2004) “The link between product market reform and macro-economic performance,” European Economy - Economic Papers 209, Directorate General Economic and Monetary Affairs, European Commission

Hammond, S.D. (2005) “Optimal Sanctions, Optimal Deterrence”, presented at ICN Annual Conference, Bonn, Germany on June 6, 2005

Hausman, J., S. Moresi, and M. Rainey (2010) “Unilateral Effects of Mergers with General Linear Demand”, Economics Letters

Higgins, R.S.,P.A. Johnson and J.T. Sullivan(2005) “Merger of Bertrand Competitors Can Decrease Price”, The Antitrust Bulletin 50, no. 2, 285-97

Jaffe, S. and E. G. Weyl (2011) “The First-Order Approach to Merger Analysis”, Harvard Economics Department Working Paper, available at http://ssrn.com/abstract=1765024

Jenny, F. (2006) “Cartels and Collusion in Developing Countries: Lessons from Empirical Evidence”, World Competition 29(1): 109-137, 2006

Kwoka, John E. Jr. (2012) "Does merger control work? A Retrospective on U.S. Enforcement Actions and Merger Outcomes", Antitrust Law Journal No. 3 (2013), available at http://ssrn.com/abstract=1954849

Levenstein, M.C., V. Y. Suslow, and L. J. Oswald (2003) "Contemporary International Cartels And Developing Countries: Economic Effects And Implications For Competition Policy", Working Paper #03-10

Loomis, D.G. (1997) "Strategic Substitutes and Strategic Complements With Interdependent Demands", Review of Industrial Organization 12: 781–791, 1997

Motta, M. (2004) "Competition Policy: Theory and Practice", Cambridge University Press, 2004

NevenD.J. and L.H. Röller (2000)"Consumer Surplus vs. Welfare Standard in a Political Economy Model of Merger Control," CIG Working Papers FS IV 00-15, Wissenschaftszentrum Berlin (WZB), Research Unit: Competition and Innovation (CIG)

Nicoletti G. and S. Scarpetta(2003) "Regulation, productivity, and growth: OECD evidence", Economic Policy, CEPR & CES & MSH, vol. 18(36), pages 9-72, 04

Okpanachi, J. (2010)"Comparative analysis of the impact of mergers and acquisitions on financial efficiency of banks in Nigeria", Journal of Accounting and Taxation Vol. 3(1), pp. 1-7

Pakes, A. (2010) "Upward Pricing Pressure Screens in the New Merger Guidelines: Some Pro's and Con's", available at http://www.economics.harvard.edu/faculty/pakes/files/SDGcomp.pdf

Potters J. and S. Suetens (2009) "Cooperation in Experimental Games of Strategic Complements and Substitutes", Review of Economic Studies, Oxford University Press, vol. 76(3)

Quint, D. (2010) "Imperfect Competition with Complements and Substitutes", available at

http://www.ssc.wisc.edu/_dquint/papers/quint-vertical-and-horizontal.pdf

Shapiro, C. (2010) "Unilateral Effects Calculations," Working Paper, University of California, Berkeley

Simons, J. J., and M. B. Coate (2010) "Upward Pressure on Price Analysis: Issues and Implications for Merger Policy", European Competition Journal, 6(2), 377-396

Slade, M. E. (2006) “Merger simulations of unilateral effects: what can we learn from the UK brewing industry?”, working paper, University of Warwick -Department of Economics - Warwick economic research papers

Sproul, M. F. (1993) “Antitrust and Prices,” Journal of Political Economy, vol. 101(4), pages 741-54

Stigler, G.J. and Sherwin, R. A. (1985) “The Extent of the Market”, Journal of Law and Economics, University of Chicago Press, vol. 28(3), pages 555-85, October

Sudhir, K. (2001) “Structural analysis of manufacturer pricing in the presence of a strategic retailer”, Marketing Sci. 20(3) 244–264

Varma, G. D. (2009) “Will Use of the Upward Pricing Pressure Test Lead to an Increase in the Level of Merger Enforcement?”, Antitrust, 24(1), 27-32

Weyl, E. G., and M. Fabinger (2009) “Pass-through as an Economic Tool”, available at http://home.uchicago.edu/weyl/Pass-through_10_09.pdf

Willig, R. (1991) “Merger Analysis, Industrial Organization Theory, and Merger Guidelines,” Brookings Papers on Economics Activity, 281-332

# Appendix A - Major 'hard core' cartels prosecuted in selected developing countries (1995-2013)

| Argentina | | Chile (cont.) | |
|---|---|---|---|
| Portland cement | 1981-1999 | Vehicles and spare parts | 11 Aug'06 (bid rigging) |
| Medical gases | n/a-1997 | Publishing services | Mar'08-Apr'08 |
| Healthcare services | n/a | Pharmaceutical (distribution) | Dec'07-Apr'08 |
| Liquid petroleum gas (S.C. Bariloche) | Jan'98-Dec'98 | Public transportation | Oct'06-Nov'07 |
| Sand (Parana city) | Jun'99-Jul'01 | Radio transmission | 2007 |
| Liquid oxygen | Jan'97-Dec'01 | Tourism (agent services) | 2008 |
| Cable TV (Santa Fe city) | Oct'97-Dec'01 | Public transportation (maritime) | 2009 |
| Cable TV service (football transmissions) | Jan'96-Dec'98 | Public transportation (bus) | Feb'07-Mar'09 |
| **Brazil** | | Flat Panel TV | n/a |
| Civil airlines | Jan'99-Mar'03 | **Colombia** | |
| Retail fuel dealers (Goiania) | Apr'99-May'02 | Cement | Feb'06-Jan'10 |
| Retail fuel dealers (Florianopolis ) | 1999-2002 | Mobile phone services | Apr'99-Aug'07 |
| Retail fuel dealers ( Belo Horizonte) | 1999-2002 | Green onions | Feb"07-Jan'09 |
| Retail fuel dealers (Recife) | Apr'99-Feb'02 | Pasteurized milk | Jan'97-n/a |
| Generic drugs | Jul'99-Oct'99 | Green paddy rice | Jan'04-Nov'06 |
| Maritime hose | Jun'99-May'07 | Chocolate and cocoa products | Oct'06-Oct'09 |
| Crushed rocks | Dec'99-Jun'03 | Private security services | Feb'11-Sep'12 |
| Security guard services | 1990-2003 | Services of grade systematization (Bogotá District schools) | Jun'08-Dec'09 |
| Hermetic compressors | 2001-2009 | Milk processing | n/a-2008 |
| Industrial gas | 1998-Mar'04 | Health services | Mar/09-Nov'11 |
| Air cargo | Jul'03-Jul'05 | Oxygen supply | May'05-Mar'11 |
| Transportation | Oct'97-Jan'01 | Road paving | Aug'10-Jan'12 |
| Steel bars | 1998-Nov'99 | Sugar cane remuneration rates | Feb'10-Aug'11 |
| Construction materials (sand) | 1998-Apr'03 | Cars' techno-mechanical and gas review | Mar'10-Oct'11 |
| Steel | 1994-Dec'99 | Cars' techno-mechanical and gas review | Mar'10-Dec'11 |
| Blood products | Jan'03-Dec'03 | Feed ration service for prisons | May'11-Sept'12 |
| Toy manufacturers (imports from China) | 2006-2009 | Cars' techno-mechanical and gas review | Apr'10-Mar'12 |
| **Chile** | | TV advertising market | Apr'10-Apr'11 |
| Petroleum products | Feb'01-Sep'02 | **Egypt** | |
| Medical gases (oxygen) | 2001-2004 | Construction (Egypt Wastewater Plant) | Jun'88-Sept'96 |
| Medical insurance plans | 2002-2004 | Cement | Jan'03-Dec'06 |
| Medical services | May'05-May'06 | **El Salvador** | |
| Construction materials (asphalt) | 20 Oct'06 (bid rigging) | Petroleum products | n/a-2007 |
| Public transportation (bus) | 2006 | **Indonesia** | |
| Public transportation (bus) | Nov'07-May'08 | Mobile phone services | Mar'03-Nov'05 |
| Petroleum products | Mar'08-Dec'08 | SMS | Jan'04-Apr'08 |

| **Indonesia (cont.)** | | **South Korea (cont.)** | |
|---|---|---|---|
| School books | Jan'99- Dec'00 | Elevators and escalators | Apr'96-Apr'06 |
| Cement | n/a-Dec'09 | Toilet roll manufacturing | Mar'97-Jan'98 |
| Airlines | Jan'06-Dec'09 | Coffee | Jul'97-Jan'98 |
| Pharmaceuticals | n/a | **Kenya** | |
| Poultry (day old chicken) | Jan'00-Dec'00 | Coffee producers | n/a |
| Sea cargo ( Jakarta-Pontianak) | Jun'02-Oct'03 | Fertilizers I | n/a-2003 |
| Sea cargo ( Surabaya-Makassar) | Jan'03-Sep'03 | Beer (production) | n/a-2004 |
| Public transportation (city bus) | Sep'01-Oct'03 | Soft drinks | n/a-2004 |
| Salt Trade ( North Sumatra) | Jan'05-Dec'05 | Transportation | n/a |
| Sea Cargo (Sorong Seaport) | Mar'00-Nov'08 | Mechanical engineers services | n/a |
| **Kazakhstan** | | Insurance (transportation sector) | n/a-2002 |
| Petroleum products (brokers) | 2002-2005 | Petroleum (retail) | n/a-2004 |
| **South Korea** | | Fertilizers II | n/a-2011 |
| Batteries manufacturing (auto) | Jun'03-Sep'04 | Tea growers | n/a-2004 |
| Beer | Feb'98-May'99 | Sugar | n/a-2004 |
| Cement | Jan'02-Mar'03 | Port Customs Department auctions | n/a |
| Construction machinery (excavators) | May'01-Nov'04 | **Malawi** | |
| Forklifts manufacturing | Dec'99-Nov'04 | Cotton farmers | n/a |
| Petroleum products (military, wholesale) | 1998-2000 | Tea growers | n/a |
| Telecom services (local, land line) | Jun'03-May'05 | Tobacco growers | n/a |
| Telecom services (long-distance, land line) | Jun'03-May'05 | Bakeries | n/a |
| Telecom services (international, landline) | Jun'03-May'05 | Beer | n/a |
| Broadband Internet service | Jun'03-May'05 | Petroleum sector | n/a |
| Detergent manufacturing | 1998-2006 | **Mauritius** | |
| Telecommunications (mobile services) I | Jun'04-May'06 | Travel agency | 2010 |
| Telecommunications (mobile services) II | Jan'00-Jul'06 | **Mexico** | |
| Gasoline and diesel (refining) | Apr'04-Jun'04 | Gas (liquid propane) | Jan'96-Feb'96 |
| Industrial motors | 1998-2006 | Chemicals (film development) | Jan'98-Dec'00 |
| Polyethylene (low density) | Apr'94-Apr'05 | Poultry | Mar'10-Mar'10 |
| Polypropylene (high density polyethylene) | Apr'94-Apr'05 | Boiled corn and corn tortillas | Mar'11-Jul'12 |
| Movie tickets | Mar'07-Jul'07 | Corn mass and tortillas | May'10-Aug'12 |
| Trunked radio system devices | Dec'03-Feb'06 | Transportation (touristic sector) | Jul'09-Mar'12 |
| Petrochemicals | Sep'00-Jun'05 | Anesthesiology (services) | May'03-May'09 |
| Copy paper imports | Jan'01-Feb'04 | Auto transportation (cargo) I | Jan'10-Sep'11 |
| Soft drink bottling | Feb'08-Feb'09 | Maritime public transportation | Jun'08-Jun'12 |
| Gas (LPG) | Jan'03-Dec'09 | Auto transportation (cargo) II | Sept'08-Jun'10 |

| **Mexico (cont.)** | |
|---|---|
| Healthcare (medical drugs) | 2003-2005 |
| Consulting services (real estate) | Jul'03-Apr'09 |
| Restricted TV signal | Oct'02-Dec'08 |
| Food vouchers | Aug'05-Sept'05 |
| Consulting services (real estate) II | May'03-Jul'09 |
| Railway transportation (cargo) | Nov'05-Jun'09 |
| Cable and cable products | Feb'06-Mar'07 |
| **Pakistan** | |
| Bank interest rates | Nov/07-Apr’08 |
| Cement | Mar’08-Aug’09 |
| Gas (LPG) | n/a-2009 |
| Jute mills | 2003-Jan'11 |
| High and low tension pre-stressed concrete poles | Aug'09-May'11 |
| Poultry and egg industry | 2007-Aug'10 |
| Newspapers | Apr'08-Apr'09 |
| Vessels handling(ships) | 2001-Mar'11 |
| Port construction | May'09-Jul'10 |
| Ghee and cooking oil | Dec'08-Jun'11 |
| Accounting services | Apr'07-Jan'13 |
| LDI operators | Sep'11-Apr'13 |
| GCC approved medical centers | Jan'11-Jun'12 |
| Banking services (1-Link Guarantee Ltd) | Sep'11-Jun'12 |
| **Peru** | |
| Urban public transportation 1 | Aug'08-Oct'08 |
| Urban public transportation 2 | Aug'08-Oct'08 |
| Public notaries | n/a |
| Dock work | Sep'08-May'09 |
| Insurance 1 | Dec'01-Apr'02 |
| Insurance 2 | Oct'00-Jan'03 |
| Poultry | May'95-Jul'96 |
| Wheat flour | Mar'95-Jul'95 |
| Heaters/boilers etc. manufacturing | Oct'95-Mar'96 |
| Oxygen distribution (healthcare) | Jan'99-Jun'04 |
| Freight transport | Nov'04-May'09 |
| **Russia** | |
| Fuel ( gasoline and jet) | Apr’08-Jul’08 |

| **Russia (cont.)** | |
|---|---|
| Laptop computer operating systems | n/a |
| Fuel (petroleum, Krasnodarki krai) | Jan'05-Jul'05 |
| Fuel (petroleum, Rostov-on-Don) | n/a-2005 |
| Airlines (flights between Nizhnevartovsk and Moscow) | n/a-Dec'05 |
| Railway transportation (Kemerovo) | Oct'11-Dec'12 |
| Soda cartel | 2005-2012 |
| Polyvinylchloride cartel | 2005-2009 |
| Pharmaceutical cartel | 2008-2009 |
| Fish cartel (Norway) | Aug'11-Dec'12 |
| Pollock cartel | Apr'06-Dec'12 |
| Fish cartel (Vietnam) | Jun'08-Sept'13 |
| Salt cartel | May'10-May'13 |
| Sausage cartel | Jun'09-Dec'09 |
| Military uniform supply | 2010-Jun'12 |
| **South Africa** | |
| Fertilizers (phosphoric acid) | Jan’03-Dec’07 |
| Airlines (fuel surcharge) | May’04-Mar'05 |
| Airlines (So. Africa-Frankfurt routes) | Jan’99-Dec’02 |
| Milk (farm and retail) | n/a-Jul’06 |
| Bread and flour | 1994-2007 |
| Pharmaceuticals (wholesale distribution) | 1998-2007 |
| Tire manufacturing | 1998-2007 |
| Metal (scrap) | Jan’98-Jul’07 |
| Steel (flat) | 1999-Jun’08 |
| Cement I | 1996-2009 |
| Plastic pipes | 1998-2009 |
| Concrete, precast pipes, culverts, manholes, & sleepers | 1973-2007 |
| Fishing | n/a-2009 |
| Cement II | Jan'04-Jun'09 |
| Construction | n/a-2009 |
| Steel distribution | n/a-2008 |
| Steel (re-bars, rods & sections) | n/a-2008 |
| Steel (wire, wire products) | 2001-2008 |
| Crushed rock | n/a-2008 |
| Bricks | n/a-2008 |
| Steel (tinplate) | Apr’09-Oct’09 |

| | |
|---|---|
| **South Africa (cont.)** | |
| Steel (mining roof bolts) | 2002-2009 |
| Flour milling | 2009-Mar'10 |
| Bitumen | 2000-2009 |
| Poultry | 2005-2009 |
| Polypropylene plastic | 1994-2009 |
| Sugar | 2000-n/a |
| Taxi | n/a |
| Auto dealers | 2005-n/a |
| Healthcare fees | 2002-2007 |
| Pharmaceuticals | n/a-2002 |
| Motor vehicle manufacturers/importers | n/a-2006 |
| Freight forwarding | n/a-2007 |
| Energy/switchgear | n/a-2008 |
| Fertilizer (nitrogen) | 2004-2006 |
| Steel (reinforcing mesh) | 2001-2008 |
| Soda ashes (imports) | 1999-2008 |
| **Tanzania** | |
| Beer | n/a |
| Pipes, culverts, manholes and pre-stressed concrete sleepers | n/a-2009 |
| Petroleum sector | n/a-2000 |
| **Turkey** | |
| Daily newspapers | n/a |
| Traffic lights | n/a |
| Public transportation (buses) | n/a |
| Poultry | n/a |
| Bakeries | n/a |
| Beer | n/a |
| Soft drink | n/a |
| Maritime transport service | n/a-2004 |
| Mechanical engineers | n/a |
| Insurance | n/a-2003 |
| Telecommunications | n/a-2002 |
| Architects' and Engineers' services | n/a-2002 |
| Yeast | n/a |
| Cement | n/a |
| Cement (Aegean region ) | 2002-2004 |
| **Turkey (cont.)** | |
| Accumulators | n/a |
| **Ukraine** | |
| Acquisition of raw timber auctions (furniture) | 2011 |
| Sale of poultry meat | n/a |
| Sale of sugar | n/a |
| Sale of alcohol | n/a |
| Sale of buckwheat | n/a |
| Individual insurance markets | 2003 |
| Market of services on sale of arrested property state | 2004 |
| **Zambia** | |
| Pipes, culverts, manholes and pre-stressed concrete sleepers. | n/a |
| Oil marketing | 2001-2002 |
| Fertilizer | 2007-2013 |
| Grain procurement and marketing (maize-meal) | Mar'04-Jun'04 |
| Public transport | n/a |
| Poultry | 1998-1999 |
| Panel Beating Services | Sep'11-Dec'11 |
| **Zimbabwe** | |
| Bakeries | n/a |

# Appendix B - Questionnaire

## FIRST PART. General questions

1) Annual budget of the competition policy enforcement unit during the period 1995-2013[57] (in local currency);

## SECOND PART. Identification of cartels.

2) Please, provide a list of major “hard core” cartels for the period 1995-2013;
3) For each identified cartel, provide information on:
    a. Relevant market (product, geography, etc);
    b. Names of cartel members;
    c. Period of existence of the cartel (beginning/termination);
    d. Date of discovery of the cartel;
    e. Date of entry of each company in the cartel coalition, if available;
    f. Fines applied, if any (in local currency);
    g. Price overcharge by cartel members, if available (percentage with respect to the cartel price or money terms in local currency)

## THIRD PART. Economic data on each cartel identified in the second section of the questionnaire.

1) At least for one period (month/year) of cartel existence indicate the **market share/volume sold** and **price** (in local currency) of the product/ products for each colluding company;
2) If possible, give an estimation of the average margin for the cartel = (price-marginal costs)/price;
3) Please, provide, whether available, the estimate of the volume of the relevant market (in local currency), if not:
4) According to the good that is analyzed, please provide an estimation of the total market share of the non-cartel members on the relative market;

[57] Time period is subject to change depending on the date when the competition authority started to be functioning.

# Appendix C - Example of the calibration and estimation procedure

Four national airlines, namely Varig, TAM, Transbrasil and VASP, were convicted in collusive price-fixing behavior on the civil air transportation market between Rio de Janeiro (airport Santos Dumont) and San Paolo (airport Congonhas) during the year of 1999. We do not go into details concerning the evidence that the Brazilian competition authority employed to convict a cartel but will rather focus on the estimation of the economic harm to consumers caused by this anticompetitive practice.

Table C-1 below provides the collected data regarding the observed one-way ticket prices charged by cartel members, as well as their observed market shares (based on number of tickets sold). These are the minimal data that are sufficient to implement our methodology and recover the price overcharges.

**Table C-1: Input data (as of July 1999)**

| **Airline** | **Observed market share** | **Average price of a one way ticket, in Reals**[58] |
|---|---|---|
| **VARIG** | 46.6% | 129.32 |
| **TAM** | 41.5% | 124.90 |
| **Transbrasil** | 6.5% | 106.85 |
| **VASP** | 5.4% | 108.03 |

Source: Conselho Administrativo de Defesa Econômica (the competiton authority of Brazil)

We recognize that it would be more correct to separate leisure and business segments of the demand, which would obviously have different sensitivities to price (parameter $\alpha$), however available data did not permit us to do so. Given that the share of business segment on the relevant market reaches up to 70%, we believe that recovered market parameters will correspond mostly to this demand category.

As the developed methodology implies, to perform calibration of supply and demand parameters we need to set the share of the outside alternative ( $s_0$ ) and average cartel margin exogenously. We use additional data on the case to set the admissible ranges for these parameters.

[58] Real – Brazilian national currency

Considered airports are the only ones situated close to the city centers of Rio de Janeiro and Sao Paulo, which makes them especially relevant for business passengers. In addition, there are no convenient substitutes, such as sufficiently fast trains or buses. Airlines that formed the cartel perform nearly 100% of the flights between the mentioned airports. Therefore, one can assume that share of the outside alternative for the business segment cannot be too big. However, presence of the leisure segment and other airports serving the same origin and destination markets suggests that $s_0$ cannot be too low either. We arbitrary choose the admissible range for the share of the outside option as $s_0 \in [10\%, 50\%]$.

As for the second exogenous parameter – average cartel margin, we first make use of the results of Betancor and Nombela (2001), who demonstrate that marginal costs of American and European airlines are at least equal and at most twice higher than their average costs. We assume further that Brazilian airlines' cost structure is not much different from that in Europe and the U.S. Having extracted average costs from the annual reports of the colluding companies, we get 40% as a maximal value for the average margin (when marginal costs are equal to average costs). Given that airlines' activities include also those non-cartelized, we assume that possible margin on the cartelized market could potentially have an upper bound above 40%. After a final check with sign constraints for marginal costs and price sensitivity parameter $\alpha$, we define a permitted range for the average cartel margin as [10%, 45%].

When one changes level of external parameters, then calibrated market parameters also change. Along with the minimal and maximal bounds, considering some intermediary values might be also reasonable if an analyst has an idea about the most probable values of exogenous parameters inside the chosen interval. Therefore, in Table C-2 we provide calibrated price sensitivity $\alpha$ depending on the average cartel margin and share of the outside option: for minimal, maximal and some intermediary values of external parameters. These dependencies are monotonic. We also report corresponding calibrated values of $\delta_{j,}\ j = \overline{1, J}$ in Table C-3.

**Table C-2: Calibrated price sensitivity parameter ($\alpha$)**

| | | Average cartel margin | | | |
|---|---|---|---|---|---|
| | | 10% | 20% | 35% | 45% |
| Share of the outside option (S_0) | **10%** | 0.80 | 0.40 | 0.23 | 0.18 |
| | **20%** | 0.40 | 0.20 | 0.11 | 0.09 |
| | **35%** | 0.23 | 0.11 | 0.07 | 0.05 |
| | **50%** | 0.16 | 0.08 | 0.05 | 0.04 |

Source: Simulations

**Table C-3: Calibrated parameters of differentiation ($\delta_j$)**

| | Average cartel margin/ $s_0$ | | | |
|---|---|---|---|---|
| **Airline** | **10%/10%** | **45%/10%** | **10%/50%** | **45%/50%** |
| **VARIG** | 105.22 | 24.42 | 20.02 | 3.86 |
| **TAM** | 101.66 | 23.62 | 19.19 | 3.58 |
| **Transbrasil** | 85.30 | 18.54 | 14.43 | 1.08 |
| **VASP** | 86.06 | 18.56 | 14.44 | 0.94 |

Source: Simulations

We observe that calibrated parameter $\alpha$ and $\delta_{j,}\ j=\overline{1,J}$ decrease when the share of the outside option increases, margins being fixed. This dependence follows directly from equations C-1 and C-4 and can be explained as following. Lower $\alpha$ indicates that preferences of consumers are mostly driven by the quality rather than prices. Lower $\delta_j$, therefore, results in a higher number of consumers who preferred the outside option as its' utility is normalized and remains fixed. $\alpha$ also decreases with higher cartel's margin - when consumers are less sensitive to the price, cartel members have more incentives to charge a higher price.

For the set of calibrated market parameters we further perform the simulation of the counterfactual (competitive) state.[59] Tables C-4 and C-5 below report the average for the cartel price overcharge rates (formula (8)), and consumers' welfare losses (formula (10)) estimated for a given combination of values of exogenous parameters.

[59]We solve the system of non-linear equations implied by proposed methodology with the use of SAS routines and procedures.

**Table C-4: Estimated price overcharge rate (average for the cartel)**

| | | Average cartel margin | | | |
|---|---|---|---|---|---|
| | | **10%** | **20%** | **35%** | **45%** |
| **Share of the outside option (S0)** | **10%** | 7.3% | 14.7% | 26.2% | 33.9% |
| | **20%** | 4.5% | 9.2% | 13.6% | 21.8% |
| | **35%** | 4.8% | 8.7% | 18.2% | 20.8% |
| | **50%** | 3.2% | 6.5% | 14.2% | 18.9% |

Source: Simulations

**Table C-5: Estimated consumers' welfare losses, %**

| | | Average cartel margin | | | |
|---|---|---|---|---|---|
| | | **10%** | **20%** | **35%** | **45%** |
| **Share of the outside option (S0)** | **10%** | 78.6% | 78.6% | 78.6% | 78.6% |
| | **20%** | 66.1% | 66.1% | 65.8% | 66.2% |
| | **35%** | 50.4% | 48.0% | 52.8% | 49.5% |
| | **50%** | 35.0% | 35.2% | 41.2% | 42.2% |

Source: Simulations

Variations of the obtained estimations of price overcharges and welfare losses according to the level of external parameters are intuitive. On one hand, when cartel margin is being fixed, a high share of the outside option informs the analyst about a high elasticity of demand. In these conditions, the ability of colluding firms' to increase their prices is very limited. Accordingly, welfare losses are also les significant. On another hand, keeping the share of the outside option fixed, higher desired cartel margin naturally transforms into a higher price increase. Though, no definite conclusion can be made concerning the relative change in consumers' welfare.[60]

We acknowledge that variations of the estimates in Table C-4 and C-5 are quite large. Price overcharge varies from 3.2% to 33.9%, while the welfare losses estimates range from 42.2% to 78.6%. A greater precision can be gained provided that more precise inputs are at hands.

[60]Increase in cartel's margin decreases calibrated values of marginal costs (cartel prices are given), and also decreases calibrated price sensitivity $\alpha$ (see equation (3)). Left-hand side of equation (1) remains constant, therefore, to compensate the decrease in $\alpha$, $\delta_j$ should decrease too. In competitive state we cannot predict whether $(\delta_j - \alpha p_j^c)$ will increase or decrease for every product, because all three parameters have lower values. Equation (1) indicates that if market shares in competitive state will be relatively higher with respect to the share of the outside option, then welfare level will be also higher, and vice versa.

# Appendix D - The economic model and the simulation process

In Appendix D we provide a description of the methodology employed to create the two samples of simulated economies well as their descriptive statistics.

***Assumptions***

We build mostly on specification as in Berry, Levinsohn and Pakes (1995) (hereafter BLP) with some deviations. This setup is very general and entails mild assumptions.

Each economy comprises consumers whose preferences are generated by a random utility model and an oligopoly where firms compete a la Bertrand-Nash.

Precisely, 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 product repositioning). These assumptions are not being modified throughout the paper. 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 product j provides the following level of utility to consumer n:

$$U_{nj} = (\beta_1 + \tilde{\beta}_{1n})x_{1j} + (\beta_2 + \tilde{\beta}_{2n})x_{2j} - (\alpha + \tilde{\alpha}_n)p_j + \varepsilon_{nj} \tag{D1}$$

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

$$U_{n0} = x_0 + \tilde{x}_{n0} + \varepsilon_{n0} \tag{D2}$$

Quality of each product is described by two variables $x_{1j}$ and $x_{2j}$, $j = \overline{1,J}$. Values of these attributes for each product are drawn from continuous and discreet distributions correspondingly, such that $x_{1j} \sim F_{1x}(continuous)$ and $x_{2j} \sim F_{2x}(discrete)$, $j = \overline{1,J}$. As for the outside option, common quality characteristic is constant and denoted as $x_0$. Besides, every consumer extracts idiosyncratic utility $\tilde{x}_{n0}$ associated with outside option. Having both continuous and discreet quality attributes gives more generality to the model and allows for a wider range of preferences that cannot be captured otherwise.

In the utility function, $\beta_1, \beta_2$ and $\alpha$ are drawn from $F_\beta$ and $F_\alpha$ respectively, and are common to all products and to all consumers. Idiosyncratic tastes $\tilde{\beta}_{1n}, \tilde{\beta}_{2n}$, $\tilde{\alpha}_n$ and $\tilde{x}_{n0}$ are distributed according to $\tilde{\beta}_{1n}, \tilde{\beta}_{2n} \sim F_{\tilde{\beta}}, \tilde{x}_{n0} \sim F_{\tilde{x}}$ and $\tilde{\alpha}_n \sim F_{\tilde{\alpha}}, \quad \forall n = \overline{1, N}$. Coefficients $(\beta_1 + \tilde{\beta}_{1n})$ and $(\beta_2 + \tilde{\beta}_{2n})$ thus reflect consumers' preferences towards the quality of products, while $(\alpha_1 + \tilde{\alpha}_{1n})$ corresponds to sensitivity to price $p_j$. Finally, $\varepsilon_{nj}$ is an idiosyncratic term related to both product and individual, and drawn from an extreme value distribution denoted by $F_\varepsilon$.

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 $U_{nj} > U_{nj'}$ for all $j' \neq j$.

On the supply side, we assume that the per unit production cost of product *j* is equal to

$$c_j = \exp(\gamma_1 x_{1j} + \gamma_2 x_{2j} + \omega_j + \gamma \cdot q_j) \quad \text{(D3)}$$

where $q_j$ is the quantity sold of product $j, \omega_j$ is a firm-specific cost component, $\gamma_1, \gamma_2$ and $\gamma$ are common to all firms. These parameters are drawn once for all firms in a given economy from $F_{\gamma_{1,2}}, F_\gamma$ and $F_\omega$ respectively.

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

***Sampling procedure***

We generate 100,000 economies using a sampling process involving distributions for the products' characteristics, the consumers' preferences and the firms' cost structure.[61] All distributions *F* introduced above are functions of meta parameters that are fixed to values that allow us generate highly heterogeneous economic situations.

An economy is generated along the following steps:

- The nature draws values for $\beta_1, \beta_2, \alpha, x_0, \gamma_1, \gamma_2$ and $\gamma$;

[61]We use SAS routines and functions.

- The nature draws independently $J$ product qualities from $F_{1x}, F_{2x}$ and $J$ associated costs from $F_{\omega}$ and $F_{\gamma}$, $F_{\gamma_{1,2}}$. Firms observe the whole set of qualities and costs;

- Firms know preferences but they do not observe idiosyncratic tastes $\tilde{\beta}_{1n}, \tilde{\beta}_{2n}, \tilde{\alpha}_{n}, \tilde{x}_{n0}$ and $\varepsilon_{nj}$ 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:

$$s_j(p) = \int \frac{\exp\left[(\beta_1 + \tilde{\beta}_{1n})x_{1j} + (\beta_2 + \tilde{\beta}_{2n})x_{2j} - (\alpha + \tilde{\alpha}_n)p_j\right]}{\exp[x_0 + \tilde{x}_{n0}] + \sum_{k=1}^{J} (\beta_1 + \tilde{\beta}_{1n})x_{1k} + (\beta_2 + \tilde{\beta}_{2n})x_{2k} - (\alpha + \tilde{\alpha}_n)p_k} dF_{\tilde{\alpha}} dF_{\tilde{\beta}_1} dF_{\tilde{\beta}_2} dF_{\tilde{x}} \quad \text{(D4)}$$

- The Nash equilibrium is solved for prices;

- 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 D-1 below provides the lists of parameters for the sampling process.

**Table D-1: Basic setting for simulations**

| Parameter | Basic setting |
|---|---|
| J | Number of products J is fixed to 9 for all economies |
| F | Number of firms F is fixed to 9 for all economies |
| N | Number of consumers is set to 10,000, fixed for all economies |
| $\alpha$ | $\alpha$ 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 $E_{1/\sigma_\alpha}$. Parameter $\sigma_\alpha$ is distributed uniformly $U_{[0,7]}$ among economies |
| $\beta$ | $\beta$ is fixed in each given economy, but varies across economies with uniform distribution $U_{[0,1.1]}$ |
| $\tilde{\beta}_{1n}, \tilde{\beta}_{2n}$ | For a given economy $\tilde{\beta}_{1n}, \tilde{\beta}_{2n}$ vary among consumers with normal distributions $N_{[0,\sigma_{\beta_1}]}$ and $N_{[0,\sigma_{\beta_2}]}$ respectively. Parameters $\sigma_{\beta_1}$ and $\sigma_{\beta_2}$ vary across economies with uniform distribution $U_{[0,5]}$ |
| $\varepsilon_{nj}, \varepsilon_{n0}$ | $\varepsilon_{nj}$ and $\varepsilon_{n0}$ are both drawn from extreme value distribution $F_{[\lambda]}$, where scale parameter $\lambda$ is equal to 0.5 |
| $x_{1j}$ | For each economy $x_{1j} = \exp(\tau \cdot \xi_j)$, where $\tau = 0.3$ and $\xi_j$ are distributed normally with $N_{[2,5]}$ |
| $x_{2j}$ | For each economy $x_{2j} = I(\eta_j > 0)$, where $\eta_j$ are distributed normally with $N_{[0,1]}$ |
| $x_0$ | For a given economy, $x_0$ is drawn from a $N_{[0,5]}$ |
| $\tilde{x}_{n0}$ | For a given economy $\tilde{x}_{n0}$ varies among consumers with normal distribution $N_{[0,\sigma_x]}$. Values of $\sigma_x$ for different economies are drawn from uniform distribution $U_{[0,3]}$. |
| $\omega_j$ | For each economy $\omega_j$ is distributed normally with $N_{[0,0.05]}$. |
| $\gamma_1, \gamma_2$ | Both $\gamma_1$ and $\gamma_2$ are fixed for each given economy, but vary across economies with the same uniform distribution $U_{[0,1]}$ |
| $\gamma$ | $\gamma$ is fixed for each given economy and common for all firms. In present paper $\gamma$ is set to zero as we assume that marginal costs are constant. |

For simplicity, we assume per unit production costs to be constant ($\gamma = 0$) and thus equal to marginal costs. The number of firms is set to 9 to obtain post-merger HHI levels both below and above the current US guidelines' thresholds.

The number of consumers is large enough (N=10,000) in order that expected market shares computed by firms converge to the true ones. As the fixed-point algorithm to solve for the equilibrium does not always converge, we cannot consider the corresponding cases which amount to 16% of the initial sample. In addition, the cases where at least one pre-merger market share is equal to zero and those where equilibrium second order conditions were not satisfied are also removed which reduces the size of the sample by another 41%.[62] Moreover, we delete economies displaying outliers, i.e. economies with extreme values of elasticities. Precisely, we only qualify economies for which the own and cross price elasticities of merging products do not fall below the 1st percentile and above the 99th percentile of the original distributions of these variables. After we simulate a merger in each of economies from the sample, we also remove cases with non-convergence of post-merger equilibrium that leaves us with 41,851 observations.

Because, unlike the UPP index, the HHI does not have an inherent capacity to take into account possible cost efficiencies that might occur post-merger, we find it reasonable to simulate two sets of economies where the only difference between them is the level of post-merger cost efficiencies. All pre-merger characteristics are thus common for both sets.

In Table D-2 below we provide descriptive statistics of the main economic variables of generated economies for both cleaned samples after removing non converging cases, zero market shares and after truncation of the elasticities distributions' tails. All market shares, markups and elasticities in the table correspond to the pre-merger state.

[62] 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.

**Table D-2: Descriptive statistics of main economic parameters: (cleaned samples)**

| Parameters | Mean | Variance | Min | Max |
|---|---|---|---|---|
| Own price demand elasticity, 1st firm | -6.925 | 4.041 | -30.167 | -1.794 |
| Own price demand elasticity, 2nd firm | -6.919 | 4.030 | -30.256 | -1.811 |
| Cross price demand elasticity , $\varepsilon_{12}$ | 0.512 | 0.669 | 0.003 | 6.993 |
| Cross price demand elasticity, $\varepsilon_{21}$ | 0.509 | 0.665 | 0.002 | 6.891 |
| Aggregate demand elasticity | -2.170 | 1.770 | -15.866 | -0.0001 |
| Market share of the outside option, $s_0$ | 0.686 | 0.227 | 0.000 | 0.997 |
| Market share of the 1stfirm (true) | 0.034 | 0.039 | 0.0002 | 0.354 |
| Market share of the 2nd firm (true) | 0.034 | 0.040 | 0.0002 | 0.433 |
| Market share of the 1stfirm (observed) | 0.109 | 0.107 | 0.001 | 0.936 |
| Market share of the 2nd firm (observed) | 0.110 | 0.108 | 0.001 | 0.939 |
| Sum of observed market shares $(\bar{s}_1 + \bar{s}_2)$ | 0.219 | 0.142 | 0.002 | .096 |
| Price change of the 1st firm, % (0% efficiency) | 1.914 | 4.025 | -0.427 | 285.057 |
| Price change of the 2nd firm, % (0% efficiency) | 1.892 | 3.983 | -0.003 | 255.239 |
| Price change of the 1st firm, % (2% efficiency) | 0.413 | 4.039 | -2.778 | 282.669 |
| Price change of the 2nd firm, % (2% efficiency) | 0.393 | 4.012 | -3.860 | 252.231 |
| Post-merger *HHI* | 2403.9 | 978.5 | 1257.4 | 9135.2 |
| $\Delta HHI$ | 213.5 | 296.0 | 0.0 | 4377.3 |

Number of observations: 41851 (0% cost efficiency) and 41771 (2% cost efficiency).

Our economies are sufficiently differentiated in terms of share of the outside option (from 0.0% to 99.7%), aggregate demand elasticity (from -15.886 to -0.0001) and observed market shares of merging firms (from 0.1% to 93.6% 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.

In the sample with no cost efficiencies post-merger price changes of the first firm vary from -0.42% to 285%, and similar for the second one. We also observe sometimes negative changes in prices of non-merging firms, although these changes are very small with respect to their merging rivals. Merger can indeed cause price decreases in some economic settings both for merging and non-merging firms. All those cases are kept in the sample and make a part of the analysis.

## Appendix E - Approximation of the post merger price change

Consider an industry where J single product firms produce substitutes and compete in prices to maximize their own profits $\pi_j(p) = [p_j - c_j(d_j(p))] \cdot d_j(p), \quad j = \overline{1,J}$ , where $d_j(p)$ is a residual demand function for product *j*, such that $\frac{\partial d_j(p)}{\partial p_j} \leq 0$ and $\frac{\partial d_j(p)}{\partial p_i} \geq 0, \forall i \neq j$, $c_j(d_j(p))$ is a per-unit cost function and $p = (p_1, p_2 ... p_J)$ is the price vector. No other specific restrictions are imposed on demand or cost functions, except that both are (at least twice) differentiable. Then suppose that, without loss of generality, firms 1 and 2 merge. As it was established in the main part of the paper, a horizontal merger in terms of price effects is equivalent to an introduction of certain per-unit 'merger taxes'. Those taxes, that can be seen as simple cost shocks, are introduced simultaneously only for merging entities and are firm-specific, so that $t^m = (t_1^m, t_2^m, 0, ..., 0)$, where 't' stands for 'tax' and 'm' stands for 'merger'.

The pre-merger system of first order conditions $F_j(p), j = \overline{1,J}$ is, therefore, described by the following equations:

$$\frac{\partial \pi_j}{\partial p_j} = F_j(p) = \frac{\partial d_j(p)}{\partial p_j} \cdot [p_j - c_j(d_j(p))] + d_j(p) \cdot (1 - \frac{\partial c_j(d_j(p))}{\partial d_j} \cdot \frac{\partial d_j(p)}{\partial p_j}) = 0, \quad j = \overline{1,J} \qquad \text{(E1)}$$

When any arbitrary vector of per-unit firm-specific taxes $t = (t_{1,} t_2, ..., t_J)$ is introduced into the profit function, it would result in a new system of first order conditions, that we denote as $\hat{F}_j(p,t), \overline{j = 1, J}$. As demonstrated in Jaffe and Weyl (2011), the firms' price reactions on these taxes can be derived through a full differentiation of the system of first order conditions $\hat{F}_j(p,t), \overline{j = 1, J}$ around the pre-tax equilibrium (prices $p^*$ and taxes $t^* = (0,0,...0)$ ).

$$d\hat{F}(p,t) \approx \left. \frac{\partial \hat{F}(p,t)}{\partial p} \right|_{p^*,t^*} dp + \left. \frac{\partial \hat{F}(p,t)}{\partial t} \right|_{p^*,t^*} dt \qquad \text{(E2)}$$

By setting the full derivative in (E2) equal to zero and assuming that the matrixes of partial derivatives with respect to *p* and *t* are non-singular, one can obtain the following system of equations that defines the sought-for price reactions:

$$dp = -\underbrace{\left(\frac{\partial \hat{F}(p,t)}{\partial p}\right)^{-1}}_{\equiv \Delta^{-1}(p,t)} \underbrace{\frac{\partial \hat{F}(p,t)}{\partial t}}_{\equiv \Lambda(p,t)}\Bigg|_{p^*,t^*} dt = -\Delta^{-1}(p,t)\cdot \Lambda(p,t)\Big|_{p^*,t^*} dt = M(p,t)\Big|_{p^*,t^*} dt \qquad \text{(E3)}$$

where matrix $M(p,t) = \{m_{ij}(p,t)\}_{\substack{i=\overline{1,J}\\ j=\overline{1,J}}}$ is by definition a pre-tax (pre-merger) pass-through matrix. For simplicity of representation here and further explanatory variables will be omitted. Now recall that in the initial (pre-tax or pre-merger) equilibrium there are no taxes, i.e. $t^* = (0,...,0)$, and hence $dt = t$. Applying this result to a merger case, i.e assuming that $t = t^m$, the post-merger price reaction function of firm *j* can be expressed as following:

$$dp_j = \sum_{i=1}^{J} m_{ji} t_i^m, \quad \forall j = \overline{1,J} \qquad \text{(E4)}$$

Given that merger taxes are only applicable to merging parties, i.e. $t^m = (t_1^m, t_2^m, 0..,0)$, system of equations in (E4) can be simplified to:

$$dp_1 = m_{11} t_1^m + m_{12} t_2^m \qquad \text{(E5)}$$

$$dp_2 = m_{22} t_2^m + m_{21} t_1^m \qquad \text{(E6)}$$

$$dp_i = m_{i1} t_1^m + m_{i2} t_2^m \,, \quad i = \overline{3,J} \qquad \text{(E7)}$$

## Appendix F - Properties of the pass-through matrix

Consider a pre-merger pass-through matrix $M$, as derived in the Appendix E, that is a $J \times J$ matrix, with own pass-through rates $m_{ii}, i = \overline{1, J}$ on the diagonal, and cross pass-through rates in the upper and lower triangular parts. $m_{ij}$ stands for the cross pass-through rate that defines the reaction of firm *i* on the cost shock of firm *j*.

First note, that $\Delta$ in (E3) from Appendix E contains first derivatives of the first order conditions, and therefore is negative definite so that the equilibrium second order conditions are satisfied. Matrix $\Lambda(p,t) \equiv \dfrac{\partial F(p,t)}{\partial t}$ from the same equation has positive elements on the diagonal and zeros below and above diagonal. Altogether, it assures that M is positive definite. The latter, in turn, has two implications. First, all diagonal elements, i.e. the own pass-through rates, are positive. Second, it requires that $\max \left| m_{ij} \right| \leq \max(m_{ii}, m_{jj}),\ i,\ j = \overline{1, J}$ that means that cross pass-through cannot dominate own pass-through.

As it follows from (E3) in Appendix E, calculations of the pass-through matrix involve the inversion of the matrix of second order derivatives. For an arbitrary number of firms analysis of the elements of the matrix or its determinant is a very challenging task as no explicit and easy-to-use formulas exist, even if one assumes symmetry. Alternatively, as demonstrated below, some interesting observations can be made by observing the plotted values of calculated determinants and respective matrix elements.

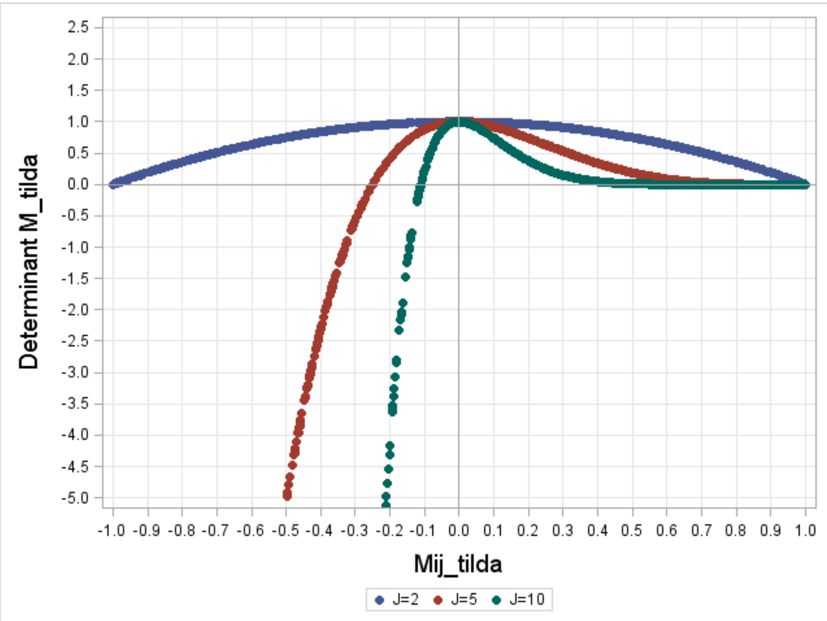
When firms are symmetric the pass-through matrix can be always represented as $M = \alpha \cdot \tilde{M}$, where $\alpha$ is a positive constant and $\tilde{M}$ is a symmetric matrix with '1's on the diagonal and $\tilde{m}_{ij} \equiv \tilde{m}$ below and above diagonal. $\tilde{M}$ is positive definite, because it is a product of a positive constant and a positive definite matrix. Therefore determinants of all of its principal minors should be positive. As I demonstrate below, it imposes some constraints on $\tilde{m}_{ij}$ (and correspondingly on $m_{ij}$) when number of firms increases.

With the use of SAS software I calculate the determinants of $\tilde{M}$ for 2000 different $\tilde{m}$ that vary from -1 to +1. On the Graph F-1 below I plot those determinants as a function of $\tilde{m}$ for three different number of firms: J=2, J=5 and J=10. Number of firms is chosen arbitrary and only serves to illustrate the point as well as to demonstrate that results remain valid whether the number of firms is odd or even. The chosen range for $\tilde{m}$ satisfies the positive sign condition for the determinant of the second principal minor of $\tilde{M}$. One can observe a quite smooth dependence between the two variables and a consistent pattern of its transformation when the number of firms J is changing.

Tracking the signs of determinants of principal minors for different J serves to verify whether the number of firms poses a restriction on $\tilde{m}$. Recall that $\tilde{M}$ is positive definite, therefore all J precedent principal minors should be positive. On the Graf F-1 below one can see that the range of $\tilde{m}$ that allow for (strictly) positive determinants decreases with number of firms. This effect is stronger for negative $\tilde{m}$s.

**Graph F-1: Determinant of $\tilde{M}$ as a function of $\tilde{m}$**

**(symmetric case)**

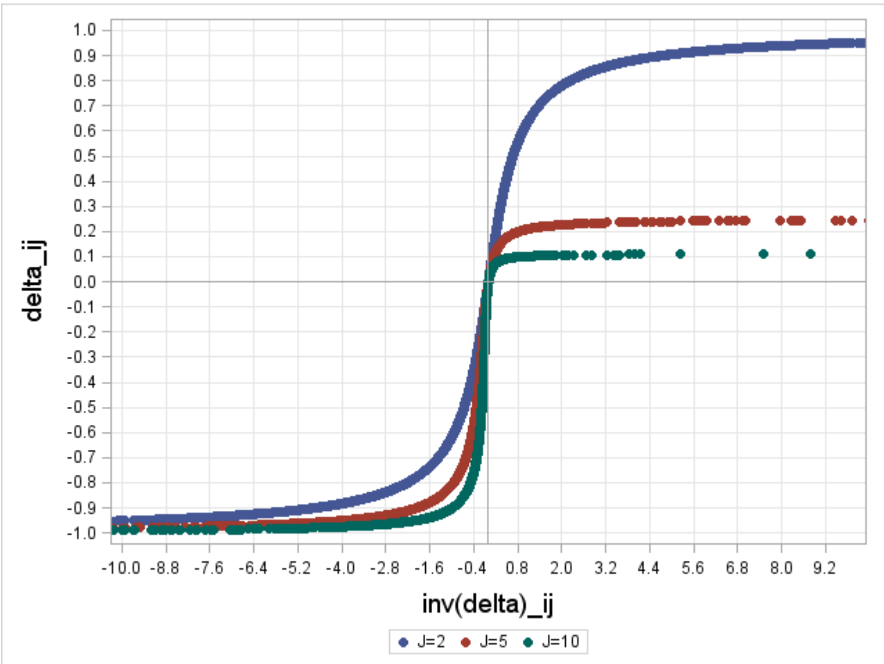



In other words, the analysis suggests that cross pass-through rate can only be less significant *relative to own pass-through* when number of competitors is growing, all other parameters being fixed.

Similarly, under symmetry, the matrix $\Delta$ from (E3) in Appendix E can be represented as $\Delta = \chi \cdot \tilde{\Delta}$, where $\chi$ is a positive constant and $\tilde{\Delta}$ is a matrix with '1' on the diagonal and $\tilde{\delta}$ above and below the diagonal. $\Delta$ is the matrix of first derivatives of the first order conditions, and therefore is negative definite so that the equilibrium second order conditions are satisfied. Therefore $\tilde{\Delta}$ is negative definite too.

On the Gaph F-2 below I plot the $\tilde{\delta}$ as a function of the corresponding off-diagonal element in the inverse matrix $\tilde{\Delta}^{-1}$ for J=2, J=5 and J=10. $\tilde{\delta}$ varies from -1 to +1 to satisfy the sign condition of the second principal minor of $\tilde{\Delta}$. Original sample contained 2000 observations, but was treated to keep only those cases where the pre-merger equilibrium second order conditions are satisfied (the signs of the determinants of principal minors should alternate).

**Graph F-2: Correspondence of non-diagonal elements in $\tilde{\Delta}$ and $\tilde{\Delta}^{-1}$ (symmetric case)**




First observation is that $\tilde{\delta}$ always agrees in sign with the corresponding off-diagonal element in $\tilde{\Delta}^{-1}$. As matrix $\Lambda$ from (E3) has positive elements on the diagonal and zeros below and above diagonal, then off-diagonal elements in M have the same signs as those in $\tilde{\Delta}^{-1}$, and therefore the same as in $\tilde{\Delta}$. Recall that $\Delta_{ij} = \partial \pi_i / \partial p_i \partial p_j$, therefore, the sign of the cross-pass-through rate $m_{ij}$ will always correspond to the sign of $\partial^2 \pi_i / \partial p_i \partial p_j$.