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The use of efficiency measures to compute welfare improving: an application for competition policy

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Abstract

Purpose – Merger approving focuses on both market power and welfare gains. In general, the approval process does not include a comparative efficiency analysis. This paper aims to introduce this dimension and show its potential.

Design/methodology/approach – Based on the analysis of past bank mergers, the authors examine expected and actual efficiency gains. This paper measures the potential (ex ante) and ex post efficiency gains of bank mergers by using data envelopment analysis (DEA).

Findings – The authors find some (approved) mergers were promised and yielded efficiency gains while others did not.

Research limitations/implications – DEA does not allow testing statistically the significance of the presumed relationship between variables.

Practical implications – The authors conclude that some mergers that took place would not have been approved had an efficiency analysis been made.

Social implications – Regulators and/or competition authorities could approve mergers which do not increase efficiency.

Originality/value – To date, efficiency frontier analysis has not been performed for merger approval. It implies that the regulator or competition authority could allow mergers with no clear social gains.

Keywords Efficiency, Mergers and acquisitions, Banking regulation, Competition policy

Paper type Research paper

1. Introduction

Merger approval in competition policy focuses on two important issues once the relevant market has been defined: first, whether the merger increases market power (and the condition of price setter for the merged firms), and second, whether the merger can increase social welfare through cost savings. Mergers are customarily justified as their (potential) efficiency gains are passed on to consumers, but they usually face objections for their effects on concentration in the market under analysis. Welfare gains are usually estimated by means of the incremental consumer plus producer surpluses in a partial equilibrium analysis, before and after the merger. The use of an efficiency frontier analysis can potentially improve the understanding of the efficiency gains owing to the merger, comparing both ex ante and ex post efficiency gains. The efficiency frontier analysis can also prevent a merger if efficiency gains are not expected.

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Bank mergers can roughly be classified as those with a macroeconomic origin and those with a microeconomic motivation. The former is common during financial crises, when the objective to absorb insolvent entities facing bankruptcy is to save the integrity of the market from systemic risks. The latter, occurring in normal times, is to achieve market and cost synergies.

Macroeconomic-type mergers of banks could be linked to the standard failing firm defence argument. During economic crises, some financially distressed companies will seek to improve their condition by merging with healthier competitors. Competition agencies may therefore face an increasing number of merger reviews involving financially troubled firms, some of which may be true failing firms while others may simply be weak competitors. In some of the cases, parties may put the failing firm defence forward as an argument in favour of approving their transaction. Some countries do not consider that mergers involving failing financial institutions should be treated differently. Others, however, do treat mergers different amongst financial institutions when bank failure is a possibility (OECD, 2010). As Norris (2010) highlights, referring to merger guidelines in the USA, the rationale behind the defence argument is that "a merger *is not likely to create or enhance market power or to facilitate its exercise* (our Italics), if imminent failure [. . .] of one of the merging firms would cause the assets of that firm to exit the relevant market." The failing firm defence argument originated in the 1930s; nevertheless, its practical application has been limited to selected cases (Fina and Mehta (2011).

We have analyzed microeconomic-type mergers in the Argentine banking system in recent years. This paper measures the potential (ex ante) and actual (ex post) efficiency gains of bank mergers by using data envelopment analysis (DEA) in the period of 2005-11. We apply DEA to the financial system and decompose the potential efficiency gains in pure technical efficiency, scope and scale gains. We find mergers that improved (ex post) efficiency and some that did not. Of the latter groups, some did not even assure potential (ex ante) efficiency gains.

The Argentine financial system has a stable number of entities following a consolidation via some mergers that reduced the total number of entities by 10 per cent after the 2001-02 financial crisis. The industry – as in the rest of the world – is heavily regulated and mergers have to be approved both by the Central Bank and the National Competition Authority (CNDC). Following the procedure established by Law 25,156, the entities under study reported their operations for economic concentration, and the Secretary of Trade concluded that they did not intend to or have the effect of "restricting or distorting competition so as to harm general economic interests". This finding, in turn, enabled them to merge. Opinions issued by the CNDC, which is a dependence of the Secretary of Trade, are an integral part of the approval document.

Following this introduction, Section II reviews the literature on bank mergers and their relationship to efficiency. Section III presents the mergers under review. Section IV describes the methodology and data, and Sections V and VI present the results and conclusions, respectively.

2. Literature on banking mergers and their relationship with efficiency

2.1 Context of the discussion

To contextualize the performance of the Argentine banking system in recent years, we present a brief historical review of the past four decades. Summarizing, as in other developing countries, local financial system followed a financial repression type of organization after the Second World War. Financial liberalization in the 1970s was followed by 1980 idiosyncratic financial crack, and macroeconomic shocks impacting on the sector,

such as 1982 (debt crisis) or 1989-90 (hyperinflation). In the 1990s, two severe financial crises took place because of external shocks in a context of openness to international capital flows and sovereign liquidity (1995 following Mexican crisis) and solvency problems (2001-2002, following 1997 Asian crisis, 1998 Russian crisis and 1999 Brazilian devaluation). In each one of those events, dozens of local banks failed. The resolution process, in each crisis, included interventions, bankruptcies and mergers. This latter solution was the preferred in the 1995 and 2001-2002 financial crack.

From April 1991 to January 2002, a fixed exchange rate (known as the "convertibility" regime) was implemented and the inflation rate stabilized. Halfway through the period, a severe financial crisis shook the economy as a result of the Mexican devaluation of 1995, causing 30 entities to close. An increasingly severe recession followed from 1998 on. As a consequence, the banks' balance sheets deteriorated along with capital flight and runs on deposits. In anticipation of currency devaluation, two-thirds of the central bank's international reserves were lost between March and November 2001. In late 2001, the central bank set a limit on cash withdrawals ("playpen"), and in early 2002, after a severe institutional crisis, the local currency was finally devaluated. Banks' dollar assets were converted at a 1:1 parity, and liabilities were converted at a 1.4:1 parity. In turn, the frozen deposits and savings were rescheduled for certain amounts (the second or large "playpen"). Both "pesified" components were indexed, and frozen deposits were then voluntarily redeemed for government bonds. The process involved wealth transfers from depositors and bank assets to debtors (Damill *et al.*, 2012).

In December 2001, the administration defaulted on its national debt until 2005, concluding with a debt swap (mainly from dollar-denominated to indexed peso-denominated). A haircut was applied on the stock, and a contingent with a gross domestic product growth coupon was introduced). After the crisis, the character of a dual-currency system was limited to a great extent. It is currently an almost completely peso-denominated system with fractional reserve requirements. As a sterilization instrument in the post-crisis monetization process, central bank bills and notes were created (as the Treasury had defaulted on its public debt, traditional open market operations could not be conducted). Interest rates were freed but were negative in real terms. Banking deposits and loans are currently concentrated in the short term. The economy grew at high rates until 2007, with little credit in subsequent years. Bank investments are concentrated in government securities issued by the Treasury and the central bank. Loans primarily focus on personal, overdraft and discount documents, all in the short term and are peso-denominated. During the previous stage (1991-2001), the most dynamic segment was dollar-denominated mortgages.

In sum, the sector underwent financial repression, financial liberalization, domestic and external crises and now has a limited reach. In the past, mergers took place to resolve critical macroeconomic episodes and more recently for microeconomic reasons. Between 2002 and 2011, 24 mergers took place. Of those, nine took place between 2002 and 2003 and were motivated by urgent measures of the Central Bank to avoid the extension of the systemic crisis. Instead, those mergers which take place after 2003 were intended to improve performance, in a economy that started to grow again. Some mergers were driven by international banks' decisions of leaving the country, or by a natural concentration process. Of the 15 mergers between 2004 and 2011, we choose 5 as examples to develop our argument that efficiency assessment prior merger authorization is recommended.

2.2 Conceptual issues in the discussion of bank mergers

A merger is a combination of corporations in which only one of them continues and the others are absorbed and cease to exist. In a merger, the acquiring company assumes the

assets and liabilities of the merged entities. A merger or acquisition enables the combined company to achieve efficiency gains through cost reductions (or cost synergies), increased revenues (or revenue synergies), the exchange of best practices and/or risk diversification (Ayadi and Pujals, 2005; Vander Vennet, 2002).

The gains from mergers are derived from both improvements in efficiency or market power, which have direct implications for antitrust policies. If greater market power leads to higher profits, antitrust policies are likely to increase social welfare, moving prices towards competitive levels and allocating resources more efficiently (Berger and Humphrey, 1997). If value creation is derived from increased market power, the transaction is, on the one hand, redistributive in favour of the shareholders, as consumer surplus is transferred to producers. On the other hand, the exercise of increased market power likely implies reduction in output and an overall loss in economic welfare. The deadweight loss (also known as excess burden or allocative inefficiency) is the sum of the consumer surplus reduction from the output decreasing plus the producer surplus reduction of the same origin. The net effect on welfare, then, depends on the relative prevalence of efficiency effects or market power increase due to the merger (Ayadi and Pujals, 2005).

The restructuring of operations allows efficiency gains through the reorganization of teams (managers and employees) and/or the spread of best practice, known as X-efficiency, i.e. the ability of management to decide on inputs and outputs so as to maximize profits or minimize costs. The X-efficiency can be improved following a merger or acquisition if the acquiring institution is more efficient ex ante and brings efficiency to the acquirer at its own level to disseminate senior leadership, skills and procedures. The merger or acquisition itself can also increase efficiency by alerting management to the need to implement substantial improvements or restructuring. Alternatively, efficiency can be worsened by merger costs (legal fees, consulting and severance payments) or disruptions due to changes in scale, the difficulties of integrating organizational cultures, etc. (Ayadi and Pujals, 2005).

The conventional wisdom among banking consultants and the non-specialist media is that mergers are and have historically been successful at improving cost and efficiency levels, at least for a considerable number of firms. However, academic studies find no such improvement, on average. There is a consistent finding of the literature on mergers in unregulated markets that they do not enhance firm value. Although in many instances, shareholders of acquired firms benefit, the value of the acquiring firm or the integrated firm does not increase. There are a substantial number of studies showing that mergers have instead eroded the firm value. This is reflexed in short- and long-term analysis, across industries and countries and in different types of mergers (Haleblian *et al.*, 2009).

A large part of the possible explanation for mergers go beyond technical issues. Mergers serve strategical purposes. The incentives and constraints of the involved stakeholders appear in many cases more relevant than the possible synergies. The general finding that mergers (on average) did not yield improved performance (efficiency, or even profits or shareholder's wealth) drew the attention of researchers to various managerial reasons for mergers ("hubris hypothesis"), including maximizing the compensation of chief executive officers, choosing a "quiet life", defensive entrenchment of management and maximization of the size of assets as alternative explanations. (Molyneux, 2009).

"Quiet life" hypothesis was stated by John R. Hicks (Hicks, 1935). It establishes that firms in monopolistic markets will be more risk-averse than firms in competitive markets. Because of management's subjective cost of reaching optimal profits, firms use their market power to allow inefficient allocation of resources. Increasing competitive pressure is therefore likely to force management to work harder to reach optimal benefits. As Hicks pointed out:

> [. . .] it seems not at all unlikely that people in monopolistic positions will often be people with sharply rising subjective costs; if this is so, they are likely to exploit their advantage much more by not bothering to get very near the position of maximum profit, than by straining themselves to get very close to it. The best of all monopoly profits is a quiet life.

A corollary is the existence of "organizational slack", according to which resources are not being completely utilized, employees are being overpaid, etc. Monopoly power permits firms with organizational slack to survive. Mergers increasing significantly power market would decrease efficient resource allocation due to promoting "quiet life".

Roll (1986) formulated the "Hubris hypothesis". He asked:

> If there were no value at all in takeovers, why would firms make bids in the first place? They should realize that any bid above the market price represents an error [. . .] Even if gains do exist for some corporate combinations, at least part of the average observed takeover premium could still be caused by valuation error and hubris.

Thus, manager's overconfidence about expected synergies from mergers results in overpayment for the target company.

The empire-building hypothesis is simpler than hubris or quiet life explanation: managers after the mergers will have larger companies to manage and hence, more power and prestige. Thus, managers will involve in merger and acquisition operations to maximize their individual utility instead of the shareholders'. The utility of managers could be related to the growth in their salaries or other benefits (pride, prestige and "quiet life") which are correlated with the firm size (Haleblian *et al.*, 2009).

2.3 Review of the empirical literature

Molyneux (2009) explores how mergers improve banks' productivity and performance. The evidence from European banks shows that poorly performing banks (measured by low cost efficiency or meagre profits) are purchased. There is no evidence of capitalization differences between acquirers and acquired in Europe, while the banks purchased in the USA tend to be more capitalized. The consensus view of the studies of mergers from the 1980s until the mid-1990s is that the cost and benefit efficiencies that were achieved through the mergers were not important (Peristiani, 1997). In general, the more recent literature from 2000 onwards supports the view that bank mergers in North America are or may be efficiency-enhancing, although in the past, the "event-studies" show a mixed picture. Some evidence holds that mergers in Europe have resulted in efficiency gains and increased shareholder value.

In comparative efficiency literature, a frontier is defined by productive units with higher production (least costs), which are deemed as efficient, and a score of 1 is assigned to them. Inefficient units are defined as those whose production is a fraction of the efficient ones or their costs are a multiple of the units in the frontier. Thus, their scores are lower than 1 and higher than 0. That the average cost efficiency shows little improvement following the mergers does not necessarily imply a lack of improvement in profits. Efficiency benefits incorporate both cost and revenue efficiency. Cost efficiency is defined as the ratio of minimum costs to current costs, while revenue efficiency is defined as the ratio of maximum revenue to current revenue. Revenue efficiency can be improved simply by increasing prices to the extent that market power permits; market power expands through mergers. Alternatively, revenues can be increased because the merged institution changes its asset mix (Molyneux, 2009).

Gjirja (2003) seeks to determine the effects on the efficiency of bank mergers in Sweden by using an unbalanced panel of savings banks for the period of 1984-2002. A cost frontier function with a stochastic inefficiency term was estimated to find

improvements in efficiency from bank mergers. The results advance strong evidence for the hypothesis that inefficient banks were acquired by more efficient ones. Moreover, post-merger analysis does not show significant improvements in technical efficiency after consolidations.

In the 1990s, both the Italian and German financial systems experienced a wave of mergers and consolidations. Both countries had very fragmented systems at the beginning of the decade. Fiorentino *et al.* (2009) analyze productivity changes after mergers between 1994 and 2004 in both countries. In Italy, both privatization and the subsequent mergers resulted in significant changes in productivity from comparatively low levels; mergers in Germany also increased productivity.

Di Salvo *et al.* (2002) test the hypothesis that Italy's wave of mergers and acquisitions in ten years prior to their paper raised the efficiency level of cooperative credit banks in terms of overall performance and production efficiency. Cost efficiency improved very marginally from mergers (1.7 per cent on average).

Lopez *et al.* (2002) use both parametric and non-parametric techniques to analyze efficiency in a panel of 450 observations of Italian mutual banks for the period of 1995-99. They are small institutions organized as cooperatives. The authors find that there is scope to improve efficiency, as other empirical studies show.

Harada (2005) assesses the implications of the technical efficiency of mergers among Japanese banks before and after consolidation in the period of 1999-2003. Mergers and acquisitions in this period had to do with the liquidation or bankruptcy of failed or weak banks. Using DEA, he finds that technical efficiency tended to decline in the period, as the consolidation of healthy banks with other unhealthy ones did not improve the latter's condition.

Lang and Welzel (1999) use a translogarithmic cost frontier to analyze the cost efficiency of nearly 300 cooperative bank mergers that took place in Bavaria from 1989 to 1997. The post-merger period shows no evidence of efficiency gains attributable to mergers, but initial differences in efficiency were levelled.

Košak *et al.* (2009) focus on efficiency changes motivated by eastern European countries' access to the European Union and the opportunity to close the gap with the Western members. The mergers were carried out at high fixed costs because of technological change and the need to apportion a greater turnover. They apply stochastic frontier analysis to estimate the initial efficiency gap and its dynamics in 1996-2003. They find that the East-West gap narrowed, helped by the consolidation process.

While there were 2,153 mergers and acquisitions in the European Union involving at least two national banks in the period of 1995-2000, only 346 involved cross-border mergers during the same period, mainly because of geographical risk diversification. Vander Vennet (2002) tests the hypothesis of cross-border mergers motivated by efficiency gains against the alternative explanation for the achievement of management objectives.

Allen and Bosbol-Batchelor (2005) study pre- and post-merger technical efficiency in the Malaysia's financial system during the period of 1996-2002. The Southeast Asian financial crisis affected the local financial system. After the 1997-98 crisis, and to avoid systemic risk, the government forced the 54 banks in the industry to consolidate into ten banking groups ("anchor banks"), hence eliminating many redundancies. By 2001, the country had completed the process. The authors use DEA and decompose pure technical efficiency and scale efficiency. They find that acquiring banks were technically more efficient, and the absorbed banks were less scale-efficient. Sufian (2004) used the DEA approach to analyze the technical and scale efficiency of commercial banks in Malaysia during the period of

mergers, comparing the same results before and after the process. They find that during the merger period, efficiency deteriorated on average compared to previous levels but improved in the post-merger years. Alias *et al.* (2009) study mergers and their impact on efficiency and productivity in Malaysia for the period of 1993-2004, which includes pre- and post-merger years. They make a non-parametric analysis with DEA and the Malmquist index. The authors find productivity changes, most of which stem from technical change rather than efficiency improvement.

Efficiency studies have conflicting results because of the techniques used; they also differ greatly between countries. In that sense, Bikker and Bos (2008) provide a comprehensive banking performance survey expressed in terms of competition, concentration, efficiency, productivity and profitability analysis. Their empirical results cover banks in 46 countries for the period of 1996-2005 (Table I).

The empirical literature summarized in this sub-section is not conclusive about efficiency gains from mergers. DEA seems to be more common than stochastic frontier analysis in this field.

Author	Method	Place	Results
Alias *et al.* (2009)	Studies efficiency with DEA and productivity changes using Malmquist indexes	Malaysia	Finds productivity enhancement but no efficiency gains from mergers
Allen and Boobal-Batchelor	Analyzes technical efficiency with DEA after a merger wave	Malaysia	They find declines in efficiency in the initial years of mergers and ambiguous results in subsequent years
Bikker and Bos (2008)	Performs a comprehensive cross country econometric study to assess efficiency gains from mergers	46 countries	Mixed results concerning efficiency gains
Di Salvo *et al.* (2002)	Tests efficiency gains in cooperative banks after a wave of mergers using DEA	Italy	Cost efficiency improved very marginally from mergers, nevertheless, economies of scale were achieved
Fiorentino *et al.* (2009)	Analyzes productivity changes before and after merger wave	Germany and Italy	Mergers increase productivity
Gjirja (2003)	Econometric study of efficiency frontiers to assess efficiency gains from mergers	Sweden	Inefficient banks were acquired by more efficient ones
Harada (2005)	Analyzes technical efficiency gains from mergers using DEA	Japan	Finds a decline in technical efficiency after mergers
Košak *et al.* (2009)	Estimates efficiency gains from mergers after accession to EU of Eastern European countries	Eastern Europe	Finds a narrow gap between Eastern and Western European banks after mergers
Lopez *et al.* (2002)	Parametric and non-parametric efficiency analysis for mutual banks	Italy	There is room for gains in economies of scale and efficiency gains from mergers
Molyneux (2009)	Survey of empirical literature	Europe	Poorly performing banks are purchased. Mixed evidence on efficiency gains from mergers
Vander Vennet (2002)	Econometric analysis of cross border mergers	European Union	Finds partial profit efficiency enhancement, but not any tangible gains in terms of cost efficiency

Table I.
Synthesis of reviewed studies

3. Banking mergers in Argentina (2005-11)

3.1 Applicable regulations

Argentina's Competition Law 25,156 from 1999 (modified by Decree 396/01) regulates competition and prohibits and punishes acts or conducts that would constitute abuse of dominant positions. It defines concepts such as dominance, concentration and mergers; it also lists various liable restrictive sanction behaviours and defines the entities that must comply with the standards. Law 25,156 indicates that acts of merger, acquisition and others of certain minimum dimension must be approved by the National Competition Authority, which authorizes or denies the operation or may sanction it when certain conditions are satisfied (Nochteff and Soltz, 2003)[1].

3.2 Case studies

We will focus on five case studies featured in the following tabulation as they offer interesting properties for this study. They are all mergers with microeconomic motivations that occurred after the 2001-02 macroeconomic crisis. The mergers were approved without an efficiency frontier analysis, and no significant market concentration was foreseen (the competition authorities concluded that the HHI was low pre-merger and grew only slightly in each case)[2]. These cases were chosen for three reasons:

(1) occurrence after the resolution of the local financial crisis (2001-2002);

(2) data availability; and

(3) diversity of the results (i.e. mergers which increased efficiency and those which did not show any improvement) useful for the conceptual point we are trying to make (Table II).

Competition authorities concluded that there would be no significant increase in market power, as Herfindahl–Hirshman index (HHI) of market concentration grew only slightly in every case. The dimension analyzed (considering that the acquirers are all commercial and retail banks) were loans, deposits, assets and net worth (Table III). All four variables are strongly correlated among them, with small differences. Only one merger exceeds – in just one dimension – the HHI value of 1,000. In the case of Macro + Privado de Inversiones, the latter was a small investment bank, for a selected public and with presence only in the capital city. Then, in this case, the branches dimension was considered. Nevertheless, the impact on HHI was negligible in this aspect (Table III).

Table II.
Recent bank mergers in Argentina: selected cases

Acquirer	Acquired	Starting date of CNDC process	Ending date of CNDC process	New name
Macro	Nuevo Banco Suquía	2004	2007	Macro
HSBC	Hexagon*	2006	2006	HSBC
Macro	Nuevo Bisel	2006	2009	Macro
Supervielle	Regional de Cuyo	2008	2010	Supervielle
Macro	Privado de Inversiones	2010	2011	Macro

Note: (*) Formerly Banca Nazionale del Lavoro
Source: Own elaboration

Merger	Loans before	Loans after	Deposits before	Deposits after	Assets before	Assets after	Net worth before	Net worth after
Macro + Suquía	774.43	781.35	1,041.22	1,049.00	867.39	873.58	543.96	551.18
HSBC + Hexagon	709.18	721.96	903.61	914.29	NA	NA	NA	NA
Macro + Bisel	663.61	672.33	904.47	913.74	839.48	847.63	651.41	657.05
Supervielle + Regional de Cuyo	576.97	578.07	667.73	668.70	892.17	892.57	689.56	689.45
Macro + Privado de Inversiones	*	*	*	*	*	*	*	*

Notes: *Negligible differences (less than 1% in HHI in the four components). Values not informed. There is only an effect in branches in the capital city, where activities of the Privado de Inversiones were concentrated, for which HHI before merger was 696.61 and after that, it was 698.19
Source: Awards of the CNDC

Table III.
HHI before and after the merger

4. Methodology and data

4.1 Methodology

The studies which aim to measure the efficiency gains by comparing the pre- and post-merger performance can apply frontier techniques or simple accounting ratios. Another strand of the literature uses the "event-studies" to assess the stock market reaction to announcements of mergers and acquisitions.

The most widely used method of mathematical programming is DEA, which provides a non-parametric alternative to econometric models. DEA does not impose any functional form on the data and seeks to determine which firms form an efficient frontier or envelopment surface with respect to the data sample. Firms that are on the frontier are considered efficient, while firms that fall below the frontier are considered inefficient. The inefficiency measure (known as Debreu–Farrell) is given by the distance between each company and the frontier. As each measurement is the reciprocal of a distance function, they meet certain desirable properties, making it possible to evaluate multi-product and multi-input situations.

We allow for constant returns to scale (CRS), as well as variable returns to scale (VRS). Thus, the frontier will depend on the returns to scale assumption. DEA models of technical efficiency can be input-oriented, output-oriented or non-oriented. In the first case, output is maintained constant and the model determines which potential proportional reduction in inputs is needed to achieve the frontier (or efficient peer[3] to which the unit is being compared) result. For example, if one firm uses ten units of labour and ten units of capital to produce one unit of output, and its efficient peer on the frontier uses eight units of capital and eight units of labour, the 20 per cent proportional reduction in input usage of the inefficient unit is equivalent to the possible efficiency gain. In the second case, inputs are maintained constant, and the model shows which potential increase in output is needed to achieve the frontier (or efficient peer to which the unit is being compared) result. For example, if two firms use ten units of labour and ten units of capital, and one firm produces 1 unit of output and the other one yields two units, it is said that the efficiency gap is 50 per cent: the inefficient firm is 50 per cent as efficient as the second one and can enhance its output by one unit to fill the gap. In the third case, inputs and outputs could be adjusted to fill the efficiency gap (in which case the input reduction and output increase are calculated together).

The minimum cost for the case of CRS (Charnes *et al.*, 1978) is obtained by solving the following linear programming problem for each bank:

$$\text{Min } C^* = \sum_{i=1}^{n} w_i^0 x_i \tag{1}$$

Subject to:

$$\sum_{i=1}^{n} \lambda_i x_{ij} \leq x_i \tag{2}$$

$$\sum_{i=1}^{n} \lambda_i y_{rj} \geq y_{r0} \tag{3}$$

Here, C denotes costs, x denotes input prices, y denotes outputs and λ denotes an intensity parameter. DEA uses linear programming methods to build a piece-wise frontier around the observations in the sample by assigning weights λ to the peer units (see below).

From the solution of this problem, the optimal bundle of inputs $x^* = \left(x_1^*, x_2^*, \ldots, x_n^*\right)$ and the objective function show the minimum cost C* given the input prices $\left(w_i^0\right)$ that the bank under study faces. The constraints delimit the feasible output set, where x_{ij} represents the level of input i used by the bank j; y_{rj} is the level of production of the output r corresponding to bank j; y_{r0} is the output of the bank under analysis (which is fixed because the cost minimization requires the adjustment of the input demand – level and mix – for a given output level); and λ_i is a vector of intensity parameters that generates the convex combination of observed inputs and products (to build an envelopment surface). A firm is efficient if and only if the observed cost is equal to the minimum cost ($C^0 = C^*$). The cost efficiency of each firm is $E_{costs} = \frac{C^*}{C^0} \leq 1$.

To calculate the allocative efficiency, it is also necessary to estimate the technical efficiency with the following linear program:

$$\text{Min } \theta \tag{4}$$

Subject to:

$$\sum_{i=1}^{n} \lambda_i x_{ij} \leq \theta x_{i0} \tag{5}$$

$$\sum_{i=1}^{n} \lambda_i x_{rj} \geq y_{r0} \tag{6}$$

The solution to the problem is the proportion (θ) in which inputs observed in the bank under analysis can be reduced if it is projected to the frontier. If the radial contraction of inputs is possible ($\theta^* < 1$), the bank is inefficient and [$(1 - \theta^*) \times 100$] measures the percentage reduction that can be applied to costs and inputs. The above problems must be solved N times, once for each bank in the sample. In addition, estimates are made for each year of the period considered.

Once the technical efficiency has been obtained, the basket of technically efficient inputs ($x_i^{te} = \theta x_{i0}$, for all i), which is the radial projection of the input basket, is determined given an output level (y_{r0}, for all r). The cost of the technically efficient input basket is:

$$C^{te} = \theta \sum_{i=1}^{n} w_i^0 x_i = \theta C^0 \tag{7}$$

The total cost efficiency, CE, is defined as CE = TE × AE, where TE is technical efficiency and AE is allocative efficiency. In turn, CE can be decomposed as follows:

$$\text{CE} = \text{C*/Co} \tag{8}$$

and:

$$\frac{C^*}{C^0} = \frac{C^{te}}{C^0} \times \frac{C^*}{C^{te}} = \theta \times \alpha \tag{9}$$

Allocative efficiency (α) represents the factor by which costs can be further reduced by choosing the most appropriate input mix, consistent with the prices thereof.

The estimation of a model of VRS (Banker *et al.*, 1984) of any orientation only requires an additional constraint on the prior specifications:

$$\sum_{i=1}^{n} \lambda_i = 1 \tag{10}$$

This ensures that an inefficient single unit is only compared to similarly sized banks. The model of VRS does not limit the potential returns to scale, but in some cases, small and unproductive banks appear to be fully efficient given the simple lack of comparators within the sample.

The efficiency measurement can be used to estimate the gains that can be achieved by restructuring. Let us suppose that two firms, A and B, technically efficient at time $t = 0$ decide to merge. If each decision-making unit $i = 1,2$ is used to produce y^i with input x^i, integration would result in a decision-making unit by using inputs $x^1 + x^2$ to produce $y^1 + y^2$. In the absence of new synergies, the new firm is inefficient. Its alternatives to increase efficiency are possible if output remains constant, eliminating input redundancies – input-oriented – or increasing output with existing inputs – output-oriented[4].

The potential gains of a merger E can be decomposed into the product of three factors (Botegoft, 2012): the "learning effect" (LE), the "harmony effect" (HA) and the "scale improvements" (SI).

Formally:

$$E = LE \times HA \times SI \tag{11}$$

If E < 1, the merger saves costs; instead, if E > 1, the merger increases costs.

The LE represents the adjustment to best practices or technical efficiency potential gains from *individual* inefficiencies. The HA or "scope effect" refers to synergies and represents the potential efficiency gains from a reallocation in the mixture of inputs and outputs, with

reallocation becoming possible in a merged firm. Finally, the third component is the SI or size effect. If there are increasing returns at scale, larger firms can produce more output for a given amount of inputs.

As LE is linked to the efficiency gains of individual firms, the pure efficiency effect of the merger is:

$$E^{*} = HA \times SI \tag{12}$$

Hence:

$$E = LE \times HA \times SI = LE\,x\,E^{*} \tag{13}$$

or:

$$LE = E/E^{*} \tag{14}$$

The efficiency or LE is calculated from a new virtual bank which captures the potential efficiency gains of individual ones. To calculate LE, (x^1, y^1) is first projected to (E^1x^1, y^1) and (x^2, y^2) to (E^2x^2, y^2), where E^1 and E^2 are the standard efficiency measures for individual firms. The projected firms then merge, $(E^1x^1 + E^2x^2, y^1 + y^2)$. The efficiency of this imaginary or virtual firm is:

$$E^{*} = \text{MIN}E : E(E^1x^1 + E^2x^2) \text{ to produce } \left(y^1 + y^2\right) \tag{15}$$

Here, LE = E/E^{*} is the efficiency effect and E represents the total output of merging firms in the new virtual firm emerging from the addition of both individual firms, without adjusting for individual efficiency.

If $E \leq E^{*}$, then LE ≤ 1. For example, LE = 0.8 suggests that 20 per cent of the potential savings from the merger could have been achieved by the pre-merger firms. To estimate HA, we use the same projections calculated for LE, and the average is taken for outputs and inputs for the merged firm. We assume that the firms share resources and output obligations equitably:

$$HA = \text{MIN}\,H : H[0.5(E^1x^1 + E^2x^2)] \quad \text{to} \quad \text{produce } 0.5\left(y^1 + y^2\right) \tag{16}$$

If the technology is convex, this measure produces the greatest possible savings. If HA < 1, there are potential gains from scope; instead, HA > 1 indicates that it is costly to "harmonize" inputs and outputs. To capture SI, we can build an imaginary firm using HA $(E^1x^1 + E^2x^2)$ to produce $0.5(y^1 + y^2)$ or, more simply, calculate $SI = E^{*}/HA$. The merger is advantageous when SI < 1 under economies of scale and costly when HA > 1 under diseconomies of scale.

4.2 Data

The data used were obtained from the Central Bank of Argentina and cover all banks in the system. Table IV shows the descriptive statistics of the main variables.

The analyzed banks are retail commercial ones. Given the scarce financial development of the country, due to a long history of macroeconomic instability, financial crisis, high inflation and sovereign default, the business of the banking system is relatively simple. They take deposits, from firms and individuals, and use fixed assets and employee services

to produce three main outputs: loans (mainly personal and short term in the period of analysis), financial investments (almost exclusively public and central bank debt, the latter issued after the crisis when sovereign debt was defaulted and also used to sterilized later trade balance surplus) and net revenues for services (given banking role in the payment system). Therefore, Table IV presents the descriptive statistics of the data on outputs (loans, investments and net revenues for services) and inputs (deposits, employees and fixed assets).

Table V shows the change in each merged bank's share in deposits, credits and assets. We can see a clearly increasing trend in the shares of the acquiring banks (HSBC, Supervielle and Macro) over the entire period.

5. Results

The DEA models that we ran consider inputs as the employees, fixed assets and deposits and outputs as loans, investments and net revenues from services. Table VI shows the results obtained using DEA. The average efficiency levels for DEA-CRS model is 0.61, while the DEA-VRS model presents an average level of 0.73.

The standard deviations are 0.33 and 0.30, depending on the model. The distribution of frequencies in the CRS model is concentrated between 0.6 and 0.7 values, while the mode in the VRS model is situated in the 0.8 to 0.9 interval. The difference between maximum and minimum efficiency values indicates the presence of banks with different characteristics, and it does not strictly represent differences related only to management. This is related with the business each type of bank develops: national private and public banks are mostly retailers with presence in the whole country, provincial banks are local and are the financial agents of local governments and foreign banks are either retailers or wholesale investment banks in the capital city. Table VII presents the efficiency estimates for each year.

As the results suggest, considering VRS in DEA increases average efficiency levels. Therefore, it is important to have a criterion when choosing the relevant model.

Banker and Natarajan (2004) develop a test of returns to scale using efficiency levels estimated under the assumptions of CRS (EC^C) and VRS (EC^V). By definition, $E^V \geq E^C$. If we do not assume a probability distribution for E^V, we can use the non-parametric Kolmogorov–Smirnov test, given by the maximum vertical distance between $F^V[\ln(E^V)]$ and $F^C[\ln(E^C)]$. The Kolmogorov–Smirnov test tries to determine whether two samples differ significantly or whether they are obtained from the same distribution, without making assumptions about the distribution itself. The Kolmogorov–Smirnov test uses the maximum

Variable	Observations	Mean	Standard deviation	Dispersion	Minimum	Maximum
Loans	374	513,971	801,706	1.56	0	4,435,186
Investments	374	844,283	2,305,038	2.73	0	19,400,000
Net revenues for services	374	60,453	93,097	1.54	2	445,571
Fixed assets	374	182,509	366,978	2.01	311	3,338,337
Deposits	374	769,710	1,320,271	1.72	0	6,867,168
Employees	374	1,716	2,866	1.67	15	16,500

Notes: Variables in levels, thousands of 2001 pesos for all variables, except for staff, branches and ATMs, which are measured in units; decimals have been simplified for ease of viewing
Source: Own elaboration

Table IV. Descriptive statistics of the variables used to estimate efficiency after mergers

Variable	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)	2011 (%)
Deposits							
HSBC	3.9	3.7	5.7				
Hexagon	2.8	2.3	0.3				
HSBC + Hexagon				6.1	5.5	5.6	6.0
Supervielle	1.3	1.2	1.3	1.5	1.5	1.5	
Regional de Cuyo	0.3	0.3	0.3	0.3	0.3	0.2	
Supervielle + Regional de Cuyo							1.8
Macro	3.4	3.2	4.3				
Suquía	1.9	2.1	1.5				
Macro + Suquía				6.1	6.4		
Bisel	1.1	1.2	1.3	1.2	0.7		
Macro + Suquía + Bisel						6.7	
Banco Privado de Inversiones	0.1	0.1	0.2	0.2	0.2	0.1	0.0
Macro + Suquía + Bisel + Privado de Inversiones							6.4
Credits							
HSBC	5.1	4.6	6.5				
Hexagon	3.1	2.6	0.3				
HSBC + Hexagon				6.2	6.2	6.6	6.2
Supervielle	1.6	1.7	1.8	1.7	1.8	2.2	
Regional de Cuyo	0.4	0.4	0.4	0.3	0.3	0.2	
Supervielle + Regional de Cuyo							2.4
Macro	3.1	3.6	4.9				
Suquía	1.9	1.9	1.3				
Macro + Suquía				6.7	6.8		
Bisel	1.2	1.2	1.4	1.5	0.8		
Macro + Suquía + Bisel						7.6	
Privado de Inversiones*	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Macro + Suquía + Bisel + Privado de Inversiones							8.3
Assets							
HSBC	3.1	2.8	4.0				
Hexagon	1.8	1.5	0.2				
HSBC + Hexagon				4.5	4.5	4.4	4.7
Supervielle	0.7	0.8	0.9	1.2	1.2	1.3	
Regional de Cuyo	0.2	0.2	0.2	0.2	0.2	0.2	
Supervielle + Regional de Cuyo							1.5
Macro	3.3	3.3	4.6				
Suquía	1.2	1.4	1.2				
Macro + Suquía				5.9	6.2		
Bisel	0.9	0.9	1.2	1.3	0.7		
Macro + Suquía + Bisel						6.4	
Banco Privado de Inversiones *	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Macro + Suquía + Bisel + Privado de Inversiones							6.1

Note: (*) Values are small but positive in all years
Source: Own elaboration from BCRA data

Table V.
Evolution on the share of total deposits, credits and assets

Descriptive statistic	CRS	VRS
Total banks	60	60
Average	0.61	0.73
Standard deviation	0.20	0.22
Dispersion	0.33	0.30
Maximum	1.00	1.00
Minimum	0.09	0.09
Range	Relative frequencies CRS (%)	Relative frequencies VRS (%)
0-0.1	1.7	1.8
0.1-0.2	1.7	1.8
0.2-0.3	5.1	5.5
0.3-0.4	10.2	3.6
0.4-0.5	13.5	5.5
0.5-0.6	10.2	5.5
0.6-0.7	27.1	16.4
0.7-0.8	15.3	20.0
0.8-0.9	10.1	25.4
0.9-1	5.1	14.5

Source: Own elaboration

Table VI.
Technical efficiency

Model	2005	2006	2007	2008	2009	2010	2011
CRS							
Average	0.637	0.635	0.581	0.593	0.635	0.589	0.594
Standard deviation	0.231	0.240	0.221	0.211	0.201	0.211	0.226
Dispersion	0.362	0.378	0.380	0.357	0.316	0.358	0.380
VRS							
Average	0.741	0.727	0.705	0.736	0.751	0.761	0.758
Standard deviation	0.246	0.237	0.237	0.242	0.213	0.242	0.258
Dispersion	0.332	0.326	0.336	0.328	0.283	0.318	0.340

Source: Own elaboration

Table VII.
Relative efficiency levels, 2005-2011

vertical distance between the two distributions, calling that distance *D*. The value of statistic *D* only considers the relative distribution of the data.

This test evaluates the null hypothesis that there is no scale efficiency (no VRS) or that, alternatively, the null hypothesis indicates the presence of CRS. The *D* statistic yields values in the range [0, 1]. A high value indicates the existence of significant scale efficiency in the sample. The results in this case suggest that we reject the null hypothesis at 1 per cent significance. So, the VRS model better represents the phenomenon under study. Table VIII shows pre-merger efficiency analysis for the whole financial system. The estimates of potential efficiency gains for each of the five mergers under analysis are presented in Columns 6 and 7 in Table VIII.

In all cases, except HSBC + Hexagon, the technical efficiency effect or LE is positive, which means that each individual bank is inefficient. Thus, this fact indicates that each bank can improve its level of efficiency independently. Also, in all cases, the "scope" effect is

positive, denoting the possibility of synergies. The interpretation of the scale coefficients, in turn, is different. A value <1 denotes diseconomies of scale, a value 1 denotes constant economies of scale and a value > denotes economies of scale.

Under the best model, VRS, the Supervielle + Regional de Cuyo merger exhibits the greater potential gain of the mergers (29.27 per cent; Column 7 of Table IX), followed by the Macro + Bisel (22.57 per cent, also in Column 7). The remaining concentrations show low (or nil) expected gains from the merger. In fact, the HSBC + Hexagon merger shows that no potential gains from the merger can be expected. The LE in this case is close to 1, indicating that none of the banks have much to gain individually; nevertheless, some of them would show increases in overall efficiency.

The estimates of actual efficiency changes (contrasting with expected or ex ante gains) are presented in Table IX. Consider the merger Macro + Suquía. The pre-merger estimated that efficiency level E is 0.825, and the post-merger estimated efficiency (called E+) yields 0.627. That is, the overall change in efficiency (after/before) is −24 per cent. The potential gain due to the merger (E*) is 9.88 per cent. The potential increase in efficiency was not achieved, on the contrary, more than 14 per cent points of efficiency were lost. HSBC + Hexagon shows a similar overall result, while there were no benefits expected from this merger. On the other hand, the remaining three cases show increases in overall efficiency, which overcomes the expected results of the mergers (Table IX).

Table VIII. Components of the potential efficiency gains (ex ante)

Merger	Technical efficiency (LE)	Scope (HA)	Scale (SI)	E = LE × HA × SI	Total potential gain (1 – E)	Potential gain of the merger [1 – (HA × SI)]
Macro + Suquía	0.9160	0.7560	1.1920	0.8255	0.1745	0.0988
HSBC + Hexagon	1.0000	0.9064	1.1033	1.0000	0.0000	0.0000
Macro + Bisel	0.8810	0.6270	1.2350	0.6822	0.3178	0.2257
Supervielle + Regional de Cuyo	0.9990	0.6840	1.0340	0.7065	0.2935	0.2927
Macro + Privado de Inversiones	0.9930	0.9520	1.0030	0.9482	0.0518	0.0451

Source: Own elaboration

Table IX. Summary estimates of efficiency ex ante and ex post

Merger	Pre-merger estimated efficiency level E	Post-merger estimated efficiency level E+	Post-merger/ pre-merger efficiency level (E+/E) – 1 (%)	Potential gain of the merger [1 – (HA × SI)] (%)	Merger increased or reduced efficiency?
Macro + Suquía	0.825	0.627	−24.0	+9.88	Reduced
HSBC + Hexagon	1.000	0.841	−15.9	0.00	Reduced
Macro + Bisel	0.682	0.955	+40.1	+22.57	Increased
Supervielle + Regional de Cuyo	0.707	1.000	+41.6	+29.27	Increased
Macro + Privado de Inversión	0.948	1.000	+ 5.4	+4.51	Increased

Source: Own elaboration

From the comparison between ex post and ex ante efficiency levels, we observe dissimilar results for each operation, from negative results to an over 40 per cent improvement in overall efficiency in two cases, with 23 and 29 per cent gain attributable to the merger. Data are annual; thus, the ex post efficiency gains are calculated one year ahead of the merger. From the discussion above, we can conclude that two mergers were damaging from an efficiency point of view. Had this method been applied ex ante, one of them could be avoided as no efficiency gain was expected from the merger.

6. Conclusions

We present a way to compute the efficiency gains of mergers with a systematic method that can be added to the rest of the evidence (i.e. market shares, concentration indexes and mark ups) in each individual case.

Mergers are often justified from the point of view of efficiency gains and their (potential) transfer to consumers. Scholars and practitioners usually object to them for their effect on market concentration. We measure the potential and actual efficiency gains of bank mergers and conclude that some mergers that took place would not have been approved had an efficiency analysis been performed (because no room for efficiency gains existed). Others promised gains but efficiency actually decreased, while a third set shows that some mergers increased efficiency according to their potential and beyond.

We conclude that in all examined cases, the LE is positive as each bank individually is inefficient. However, the pure potential merger gain (regardless of the learning or pure technical efficiency effect) is important. Out of five approved mergers, we find two promising cases (with 29.3 per cent and 22.6 per cent gains). But, the remaining concentrations show much lower or even zero expected pure efficiency gains.

The method we suggest is useful for public policy to detect potentially damaging mergers from an efficiency point of view. The method would prevent foreseeable losses of efficiency. It cannot predict unexpected ex post gains or losses.

From the comparison between ex post and ex ante levels, we see dissimilar results for each of the operations, although there is some consistency in the best and worst results. These mixed results call for more research to determine why differences exist in the success of the mergers.

Notes

1. An anonymous referee asked if these interventions were made to prevent harm resulting from unilateral and coordinated effects, such is now the case in Europe and the USA. It is useful to point out that these mergers were contemporary to 2008 Financial Crisis, and it did not impact locally. The local legislation on Competition Policy dates from 1999. Currently, there are projects to reform the Competition Law (February 2017) but in issues not related with the financial system. We thank the observation.

2. A measure of economic concentration is the Herfindahl–Hirschman index (HHI), defined as the sum of the squared of the firms' market shares, measured at equilibrium quantities. Values of the HHI range from 0 in perfectly competitive markets to 10,000 in a monopoly. The CNDC calculates the HHI for various relevant variables (deposits, loans, assets, equity and branches) to study whether the acquisition operation generates important variations on the concentration levels, usually at national level and also at the local level, for example, in cities with overlapping branches. The criterion of the Department of Justice of the USA is that if a market HHI is less than 1,000, it is considered not concentrated, and if the variation in HHI by a merger between two or more firms is less than 100, the same has no adverse effects on competition (Horizontal Merger Guidelines).

3. In an econometric model, there is a frontier function to compare each observation; in DEA models, there is no such function. Instead, observations must be compared with the efficient "peers" (those on the envelope line) to determine its relative inefficiency.
4. Because before a restructuring can eliminate possible redundancies (cost duplications due, in turn, to input duplications), they are a source of inefficiency.

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