Merger-Related Cost Savings in the Production of Bank Services*

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Abstract:

This paper utilizes a new flow measure of the true output of bank services to analyze the impact of mergers on the cost and productivity of Bank Holding Companies (BHCs) over the period 1987–1999. It shows that there are conceptual problems in the output measures used in previous studies, which may be the reason for their paradoxical findings: Bank mergers are estimated to lead to significant increases in profit, without cost savings or increases in market power. This paper also points out the problematic understanding of diversification in previous studies. To remedy these problems, this paper uses a new measure that accounts coherently for risk in measuring bank service output and recognizes that the funds banks borrow and lend are a special intermediate input. Once one accounts for the better diversification resulting naturally from mergers, the commonly used, book-value-based output measure shows little improvement in cost productivity. In contrast, the new flow measure of bank output shows more improvement, although it is still insignificant—partly because the sample size is relatively small. The gap widens further when one corrects for possible bias in the new output estimate. Thus, the new measure of bank output has the potential to resolve the paradox found in the existing literature, by showing that mergers do lead to cost savings.

JEL Codes: G21, D24, G34, O47

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I. Introduction

We have witnessed a sweeping wave of consolidations in the commercial banking industry that began in the early 1980s, gathered momentum till the late 1990s, and, after a brief hiatus, has resumed. The proportion of industry assets involved in mergers and acquisitions every year increased from less than 10% before 1983, to nearly 40% in the latter half of the 1990s. The rapid pace and massive scale of that merger frenzy have changed the structure of the banking industry considerably. First, cross-state ownership has become prevalent, especially after the Riegle-Neal Act that eliminated all regulatory limits on inter-state branching since 1997. Over the 1990s, the average size of banking organizations increased more than 35%, epitomized by the emergence of a score of banks with assets exceeding $50 billion. Parallel to this aggressive expansion in scale was the broadening in scope. The non-bank subsidiaries of bank holding companies (BHCs) now sell insurance, underwrite corporate debt, and provide brokerage services. After a temporary lull during the latest recession, merger activities are heating up again. Further consolidations, especially across different branches of the financial services industry, are anticipated because of the Gramm-Leach-Bliley Act, passed in November 1999, which repealed the depression-era law separating commercial banking from other financial intermediaries (FIs).

The rising concentration in (especially geographical) markets caused by bank mergers is a significant regulatory concern.[1] The Antitrust Division of the Justice Department endeavors to eliminate each merger's anti-competitive effects in the affected markets, largely by limiting the increase and the level of the Herfindahl-Hirschman Index (HHI).[2] At the same time, it recognizes the productive efficiency gains through mergers and approves mergers that can concretely demonstrate such potential. The possible trade-off between allocative inefficiency (resulting

[1] Berger and Hannan (1989) and Hannan (1991) find connections between static market concentration and interest rates on deposits and commercial loans, respectively. Bank regulators also examine how a merger affects the access to credit of local communities and small businesses, which rely heavily on banks for funding.

[2] The Justice Department generally tries to articulate the legal standards with sufficient clarity so that most proposed bank mergers do not pose significant risks to competition. The necessary condition for a merger to be deemed a threat to competition is that it would raise the HHI by more than 200 points to over 1800. For those that do, the Department remedies the harmful portion of mergers, mostly by using divestitures (e.g., Fleet and Shawmut agreed to divest 64 offices in their merger in 1995), and then approves the mergers. For an exposition of the principles of antitrust policy toward bank mergers, see the address by Anne Bingaman (Assistant Attorney General, Antitrust Division) before the Comptroller of the Currency's Conference on November 16, 1995.

from diminished competition) and productive efficiency has also spurred a large volume of academic studies. The findings hitherto are inconsistent. On the one hand, contrary to bank managers' promises of substantial savings, previous studies detect little improvement in cost efficiency and typically obtain estimates of roughly constant returns to scale from the cost function.[3] On the other hand, improvement in profitability appears statistically significant, but there is little evidence that mergers actually increase market power, except for some intra-market combinations that have raised concentration substantially.[4] These previous studies attribute the contradictory findings to the increase in revenue captured by the profit function but not by the cost function: Merged banks supply the same *quantity* of services that now contain better quality and thus incur higher cost; hence the discrepancy between the cost and the profit efficiencies.[5]

In principle, however, such a discrepancy should not exist: Barring measurement errors, better quality should be accounted for as a greater quantity of quality-adjusted output, which will then offset the increased cost and reveal the correct change in efficiency in the cost function. But the output measure used in virtually all previous micro studies of banks uses the book value (BV) of financial assets as output quantity, and thus it cannot account for cross-bank differences in either the risk of loan portfolios or the quality of bank services, as shown in Wang (2003a). This may be a major cause of the contradictory findings in previous studies. Wang (2003a) makes it clear that loan book values generally bear no definitive relation to the value added of the underlying services, let alone to the change in the value of services after mergers. It achieves this clarification by presenting a unified model of bank operation that accounts coherently for the relationship between risk and the quantity of bank output of

[3] See Berger and Humphrey (1992a), DeYong (1996), and Rhoades (1993). Given their estimate of constant returns to scale, the finding of wide dispersion of relative efficiencies offers the only potential for cost savings. Some other studies (e.g., Rhoades, 1990 and Pilloff, 1996) find little improvement in simple cost ratios following mergers.

[4] Akhavein *et al*. (1997) detect negligible rise in loan rates following mergers, and surmise that one reason may be the large fraction of market extension mergers (usually across state borders), which cause little rise in market concentration. Besides, banks have to face increasing competition from non-bank FIs, such as thrifts and mutual funds. See also Berger (1998), and Berger *et al*. (1999) offers the latest survey of the literature.

[5] In particular, merged banks hold a higher proportion of loans in their asset portfolios. Loans offer a higher rate of return than securities, but also demand more servicing and thus incur higher labor cost.

services. The model implies a new measure of bank output that is a direct *flow* measure of bank services and is, in principle, able to account for quality differentials in bank services.

In accordance with the BV-based measure, previous studies interpret the fact that loan interest rates have risen only slightly following mergers as evidence of only slight loss of competition. But the banking model in Wang (2003a) shows that this interpretation is not necessarily valid. Furthermore, using the new output measure to estimate banks' value-added cost function, Wang (2003c) finds some evidence of modest scale economies, in contrast to the constant returns to scale estimated using the BV-based output measure. The new output measure also generates estimates of greater productivity dispersion across banks than does the BV-based measure. Both results point to greater potential for merger-related cost savings from economies of scale or productivity improvement. Last, the standard profit function used in the previous studies is not well defined under imperfect competition, which characterizes most of the markets for bank services. In summary, the impact of mergers should be re-examined, since the existing evaluation was largely driven by the problematic BV-based output measure.

By examining the post-merger change in bank operating cost, this paper explores whether bank mergers enable cost savings that would otherwise be infeasible. It uses the new measure of bank output to estimate the production and the cost functions in order to identify the respective contributions of productivity improvement vs. degree of returns to scale to the post-merger cost change.[6] To avoid relying solely on a parametric estimate of the productivity effect that is potentially biased by measurement errors, this paper also looks at the post-merger change in *average* cost, which captures the joint influence of the productivity fixed effects and the degree of returns to scale (given input prices). Last, it compares the results computed using three different measures of bank output (i.e., the new and the BV-based measures and the measure used in the National Income Accounts) to assess whether and, if so, how the existing output measures bias the estimate of post-merger cost savings.

[6] This paper concentrates on the cost function, instead of the supposedly more general profit function, primarily because the former is free of the influence of various, mostly unobserved, factors in the output markets (e.g., market structure, concentration, etc.) that affect the latter.

To better reveal a merger's overall impact on the merging banking organizations, I analyze Bank Holding Companies, since I expect important merger-related decisions (e.g., post-merger organizational and operational changes) to be made by holding companies, instead of by the subsidiary banks. In contrast, almost all previous studies look at merger-related efficiency effects on banks. The only potential caveat is that BHC data may obscure the precise timing of certain merger-induced changes, such as the actual integration of facilities and implementation of restructuring programs within each bank.

The paper is organized as follows. Section II describes the three output measures to be compared and discusses their implications for evaluating the effect of bank mergers on cost as well as on the production and cost function parameters. Section III explains the methodology for comparing pre- and post-merger average costs and for estimating the production and cost functions. Section IV then describes the data, constructs the panel, and presents the empirical results. Finally, section V concludes.

II. Output Measurement and Theories of Bank Mergers

2.1 The New Measure of Bank Output and the Two Existing Ones

The definition and measurement of bank output is a difficult issue that has seen much debate and little consensus in the empirical banking literature. The role of deposits is a particularly hard question: Is it an input of funds for making loans or an output of depositor services? The usual measure of output in national income accounting, which deflates firms' nominal revenues to derive their real output, cannot be readily applied to banks. This is because banks receive little explicit revenue that is not labeled interest income, while interest is treated in national income accounts not as compensation for real products but merely as a transfer of property income. Given the minute size of fees relative to total bank income, banks would appear to produce hardly any output. This is clearly counterintuitive. So, to date, virtually all empirical micro studies of banks use the book value (BV) of financial assets of one type or another as a measure of output. However, no model has formally justified the use of book value in a way that is consistent with economic theories relevant for the various aspects of bank operations, which, broadly speaking, comprise both allocations of *financial*

instruments based on the risk-return tradeoff and the production of *real* services. Existing approaches to measuring bank output, especially, lack a coherent model of the relationship between financial risk and real service output, and this gap likely lies at the heart of the difficulty to date with measuring bank output.

Wang (2003a) develops a unified model of bank operations that endogenizes a bank's optimal output of services along with its asset allocation, based on the risk-adjusted return. The model achieves coherent treatment of the financial and real aspects by integrating theories of asset pricing, financial intermediation, and production. Consistent with the theories, the model recognizes that the financial good—loanable funds—that banks borrow and lend is merely a special intermediate input in the production of real services, just as purchased merchandise is to retailers. Hence, the return accrued to the funds as compensation for bearing the risk–i.e, the risk premium–should not be included in the nominal value of bank service output. In turn, total interest receipts net of this purely risk-based return should be implicit compensation for a bank's real services. Portfolio risk and bank services are related in that they both affect the market value of a bank: Risk determines the discount rate used to value future profits, while bank services generate part of the profits. But the *quantity* of service output is affected by risk only to the extent that portfolios of different degrees of risk require different amounts of processing to resolve asymmetric information problems.

Specifically, the model classifies the myriad functions of a typical bank most parsimoniously into three qualitatively distinct groups: (1) In the lending process, banks mitigate asymmetric information problems (adverse selection and moral hazard) associated with uncertain investment returns; (2) Once loan applicants are screened and approved, banks finance the loans by channeling funds from bank debtholders and shareholders to the borrowers, and then they channel returns on the funds in the opposite direction; (3) Banks provide a wide array of transaction and payment services, mostly to depositors. Functions (1) and (3) both consume real resources such as labor and physical capital, and they create real services—the value added of a bank. In contrast, in function (2), banks merely act as a conduit, transferring financial properties and the income generated—"pure interest"—between ultimate users and suppliers of funds; so in performing this function banks create no

value beyond the risk-related return that depositors and shareholders would demand according to asset pricing theories. Pure interest is not bank value added, but it should still be considered part of (nominal) *gross* output. The residual of gross interest receipts net of pure interest is the implicit revenue of bank services. The implicit income plus explicit fees then equal nominal bank value added. It is shown that this imputation of value added remains valid even when banks cannot fully resolve borrowers' private information, or when banks have market power in supplying the services. Last, the model formulates the production functions of two categories of bank service value added and establishes separability between them and loanable funds.

Wang (2003b) then imputes the two types of bank value added (i.e., (1) and (3) above) using BHC data and estimates the production and cost functions of aggregate value added. This paper adopts the same empirical imputation of bank output and estimation of the functions. Total nominal value added of each function equals the implicit value plus explicit service charges. The nominal value of the implicitly priced part of (1) is gross receipt of loan interest net of the risk-adjusted return on the funds lent. The value of the implicit part of (3) is the gap between the risk-adjusted return on deposit funds and the actual deposit interest payment. Total nominal value added yields the real output when divided by a proper deflator. Aggregate value added of a bank then equals the sum of the real value of (1) and (3), and it is the new measure of output used in this study.

In contrast, neither of the two existing measures of bank output has a theoretical foundation that can account for risk. Furthermore, the BV-based measure of bank output mentioned above essentially uses the *stock* value of *financial* variables as a proxy for the *flow* of *real* services. Clearly, the financial stock has at best an indefinite relationship with real services, since they are linked only to the extent that some services are generated to determine a bank's asset portfolio. There are three variants of the BV measure—the asset, user cost, and value-added approaches—that differ only in whether deposits are considered an output or an input.[7] (See Berger and Humphrey (1992b) for detailed descriptions, Berger and Mester (1997)

[7] Deposits are treated as an output in the asset approach but as an input in the value-added approach, and their status is endogenously determined by data in the user cost approach.

for an empirical comparison, and Triplett (1992, 1998) for discussions of the conceptual issues.) Among the three variants, only the user cost approach is based on an underlying micro theory (Hancock, 1985) that tries to consider risk implicitly in identifying which *financial* products should be considered output. Ultimately, however, the three approaches[8] all use BVs of financial instruments as quantities of bank output, so, it is not surprising that they generate similar results (see Berger and Humphrey 1997). So, I follow Wang (2003c) and examine only the asset approach in this study, because its categorization of output best matches the definition of function (2) in the new model of bank output.

The other existing output measure is defined in the 1993 System of National Accounts (thus referred to as the SNA93 measure) and used in the National Income Accounts. Following the intuition that bank services are implicitly compensated through the spread between interest receipts and payments, it computes nominal aggregate output as the sum of net interest income and explicit fees. Moulton and Seskin (2003) discuss the latest revision, which uses the risk-free rate as the reference rate to divide total net interest income into two parts: nominal values of implicit services to borrowers and depositors, respectively. However, Wang (2003a) has shown that part of the net interest income is still risk-related returns on funds and *not* bank value added, and the latest revision leaves that part in the nominal value of implicit borrower services.

2.2 Implications of the Output Measures for the Evaluation of Bank Mergers

Assuming banks maximize the market value of their equity, the ultimate motivation for any merger should be to enhance the market value, or, equivalently, profits, of the merged

[8] The first, the asset approach, views deposits as an intermediate input in generating bank credit and sees only the financial *assets* as banks' final outputs. It thus ignores the production of depositor services, and the fees charged on deposit accounts are not counted as revenues, but are used to offset the costs of labor and physical capital. The second, the value-added approach, treats all bank activities that incur labor or capital cost as outputs. So, all retail deposits besides the financial assets are viewed as outputs. In a sense, this method evades the question of identifying bank outputs by looking at the factor-income side of the equation instead of the product side. It also ignores the role of deposit funds as an intermediate input. The third, the user cost approach, is developed in Hancock (1985). It determines the input-output status of a financial product endogenously on the basis of its net contribution to bank revenue. By definition, products contributing positively to revenue are outputs, and they have negative user costs; the opposite applies to inputs. The user cost of a financial product is defined as the difference between an opportunity cost and the holding revenue of an asset or holding cost of a liability.

entity beyond the sum of the two banks' separate value. That is, one plus one should be greater than two.[9] There are two ways to boost profit: (i) save on the cost of producing the same product mix, and (ii) introduce new products and enhance revenues in a manner that more than offsets any increase in cost. Costs can be saved through economies of scope and scale in supplying banking services (e.g., eliminating redundant fixed costs such as back-office operations and branches). But an undesirable channel for saving costs also arises from the moral hazard problem created by deposit insurance: Some banks attempt to become "too big to fail" (TBTF) and thus pay lower interest rates on borrowed funds than would be required by the risk of their asset portfolio. Revenues can be enhanced through charging a higher markup. But since regulators would block mergers that might increase market power, merging banks always claim that revenues are enhanced by expanding the scope and raising the "quality" of the product mix (e.g., "one-stop shopping" and moving "up market"). Here, the premise is that either there is complementarity between the demand for different banking products[10] or the larger bank formed by a merger can overcome the constraints on either party's product offerings prior to the merger. In addition, both lower costs and higher revenues can be achieved through improvements in managerial efficiency when better-managed acquirers reorganize less-efficient targets.

Since the quantity index of each bank's bundle of products is quality-adjusted (with relative prices as quality weights), quality improvement after a merger is equivalent to an increase in quality-adjusted output quantity. That is, a merger that enhances revenues can be equivalently expressed as a merger that cuts costs—lowering average costs. However, no bank-specific quality-adjusted output index is available. In fact, only industry-level price indices are available for deriving the quantity index of a bank's output bundle. This means that available deflators cannot account accurately for price changes after a specific merger. Instead, post-merger increases in output prices will be reflected as increases in measured quantities of output. That is, this study can be viewed as treating all post-merger price

[9] Otherwise, with agency problems between managers and shareholders, there can be undesirable motives for mergers in general, such as "empire building" by managers (e.g., Jensen's notion of "free cash," 1986), or sheer managerial hubris—overly optimistic projections of merger-related gains.

[10] Clearly, the essence is still to raise markup, but through utilizing properties of the utility function.

increases as quality improvements. It therefore almost surely overstates post-merger increases in output.

In light of the equivalence discussed above, this study analyzes the impact of mergers from the cost side and considers only one element of the cost effects: whether mergers reduce the operating cost of supplying bank services, and the degree to which any such saving can be attributed to economies of scale vs. better efficiency.[11] The main task here is to evaluate how different measures of output affect the estimate of the post-merger change in average cost and long-term productivity. Ideally, the comparison should be done for identical products or for the quantity index of a quality-adjusted bundle of products before and after a merger. But the above analysis makes it clear that post-merger cost reductions may be overestimated. This upward bias will have only minor influence on the study's conclusions to the extent that all the output measures examined in the paper are similarly affected.

The measure of output also affects what post-merger changes to estimate and how to interpret the changes. One prominent example is how to interpret the finding of negligible increases in loan interest rates after mergers. Previous studies view this finding as evidence of only slight loss in competition, since there is little increase in prices—corresponding to the quantity of the book value of loans. As explained above, observed loan interest rates are typically a "bundle" that contains both the risk-adjusted return on the funds lent and the implicit charges for services to borrowers. Markups on these services are but one of the factors that can change following a merger: They will rise if a merged bank enjoys greater market power. Some other factors, often unobserved, are likely to move in the opposite direction and offset increases in the markups. One such factor is that merged banks tend to lend to bigger borrowers (Berger, 1998), leading to a lower service charge per dollar of loan balance, *ceteris paribus*. If a merger also better diversifies the bank's loan portfolio (e.g., leads to a lower geographical concentration), then the observed interest rate will decline further. In

[11] This paper aims to account for the actual changes occurring in merged banks but does not attempt to infer the likely motives from those observed changes. The reason is that the multitude of factors influencing a merged bank's optimal decision often lead to ambiguous predictions of the net post-merger change of the financial and operating structures, making it difficult to infer definitively a bank's motivation for merging.

short, observing little increase in loan interest rates following a merger does not rule out an increase in market power.

Another major conceptual problem inherent in the BV-based measure is its implication that diversification is a benefit of bank mergers (referred to as the "diversification hypothesis" hereafter). For example, Akhavein *et al.* (1997) and Berger (1998) argue that geographical and industry expansion affords a merged bank a better-diversified asset portfolio, enabling it to pay lower interest rates on borrowed funds. Under the BV-based output measure, this leads to a higher profit and thus is considered a benefit of mergers. However, finance theories have established that diversification *per se*, effected through a merger, does not enhance the market value of a firm, but simply transfers value from shareholders to bondholders through the "co-insurance" effect first noted by Lewellen (1971).[12] This is because the increase in profits exactly compensates for the increase in shareholders' required rate of return, while the firm's overall cost of capital remains the same.[13] This inconsistency will not arise under the new measure of output, because borrowed funds do not contribute to the creation of bank value added. Hence, they are not used in computing the output quantity under the new measure, and their cost does not enter the operating cost incurred in producing the value added. In contrast, the SNA93 measure will be inflated by the diversification effect, since cheaper borrowed funds will boost net interest income, *ceteris paribus*.

The BV-based measure of output is also susceptible to distortions by other merger-induced changes, leading to biased estimates even absent measurement errors. First, merged banks have been found to raise the loan-to-securities ratio, probably because the lower total return variance of their loan portfolios affords them optimal liquidity with a smaller portfolio of market securities than was the case for each pre-merger bank, and because loans of the

[12] Mergers reduce the price a bank pays on its debt, but increase proportionally the implicit rate of return on equity. This is because shareholders of the merging banks, now having to co-insure each other's debt, demand a higher return. So, mergers raise the value of existing debts, but lower the value of equity (i.e., shareholders' implicit put option) by exactly the same amount (see, e.g., Brealey and Meyer 1991, p. 826-28). Hence, investors do not reward mergers that offer *merely* diversification. In fact, some researchers, such as Berger and Ofek (1995), have found that diversification through scope expansion destroys value.

[13] For diversification to achieve real gains, there must be savings on the costs associated with the asymmetric information between a bank and outside investors (see Froot and Stein 1998, for an exposition of such costs), or savings on bankruptcy costs or the costs of risk management (e.g., holding a smaller securities portfolio and making more loans).

merged banks command higher markups.[14] Furthermore, merged banks typically increase the share of commercial and industrial (C&I) loans in the loan portfolio. Both adjustments raise the non-interest cost per unit of funds, since loans require information processing—especially C&I loans, which are generally riskier and subject to greater information asymmetry. The BV-based measure understates the increase in bank output by treating both securities and loans as output, since the decline in the BV of securities partially offsets the increase in loans. This will lead to an underestimate of the productivity improvement in the cost function. But the BV-based measure may also overstate the true increase in bank service output and thus overestimate the productivity improvement, since merged banks have also been found to raise the average size of loans. Similarly, the SNA93 measure is also prone to overstating the output increase after mergers, because it includes the risk-related return (one component of the net interest income) in bank output, and merged banks seem to heighten their portfolio risk through asset reallocations like those discussed above. Merged banks' interest spreads are also boosted by the lower post-merger interest rates on borrowed funds, owing to better diversification.

In contrast, the new output measure is subject to none of the conceptual problems above, since BVs of neither assets nor liabilities enter the cost function, and the flow measure of bank services based on risk-adjusted revenues should take account of the post-merger change in risk and thus capture the true additional output of loan processing. In reality, however, merger-induced changes introduce additional measurement errors into the new output measure and most likely overstate the increase in output. First, broad-based price indices are unlikely to capture the rise in the markup of services after mergers. Second, observed market interest rates used as proxies for the expected return on loanable funds typically cannot fully account for the likely increase in portfolio risk following a merger, thus

[14] The implicit assumption is that either bank-specific risk matters (for reasons such as proposed in Froot and Stein 1998) or the two parties could not fully diversify before, and banks hold securities (outside the trading accounts) mostly to manage liquidity risk, according to the rationale discussed in Holmstrom and Tirole (1998). (The merged entity may also choose to hold a relatively larger trading portfolio to profit from price movements.) The degree of managerial risk tolerance can matter as well, if the interests of managers and shareholders are not fully aligned because of the principal-agent problem.

biasing upward the post-merger increase in the implicit output imputed from gross interest receipts.

In light of these potential problems with the existing measures of bank output, this paper focuses on evaluating the extent to which the new model-based measure alters the previous common finding of little post-merger productivity improvement. It first calculates the non-parametric change in average cost after mergers, which is less affected by measurement errors that potentially bias the parametric estimates of the cost function, and compares the results from the three different output measures. To be comparable with previous studies, this paper then estimates the cost function, the associated productivity improvement, the degree of returns to scale, and the implications for cost savings.

III. Estimation Methodology

3.1 Impact of Mergers on Bank Average Cost

The natural post-merger entity is the combined BHC, while the comparable pre-merger entity is "synthetic" and formed by aggregating the *quantities* of output and cost of the acquirer and the target. Then, the merging pair's pre-merger average cost (AC) is computed as:

$$AC_{it} = (C_{it}^{a} + C_{it}^{b})/(Y_{it}^{a} + Y_{it}^{b}), \quad i = 1,\ldots, N, \ \tau_i - T_i^{-} \le t \le \tau_i - 1, \tag{1}$$

where C_{it}^{a} (C_{it}^{b}) is the pre-merger cost of the acquirer (target) in merger i, which occurred at τ_i, and T_i^{-} is the length of their pre-merger time series.[15] Y_{it}^{a} (Y_{it}^{b}) is the pre-merger aggregate service output of the acquirer (target) bank. Nominal aggregate output under the new measure is imputed as outlined in section 2.1, while that under the SNA93 measure equals the sum of net interest income and explicit fees. Price deflators are the same for both output measures, and this study examines two: the price index for "services furnished without payment by financial intermediaries" published by BEA, and the GDP deflator. The variable cost corresponding to both output measures is just the labor expense.[16] The asset approach of

[15] Data for the merger quarter (τ_i) are excluded to avoid accounting anomalies.

[16] Expenses on physical capital will also be included if they are considered a variable input, so is the opportunity cost of cash reserves when the reserves are treated as an inventory contributing to depositor services.

the BV-based output measure has no formal definition of aggregate output, and it treats each category of financial assets as a distinct element in the output vector of a multi-product bank. Nonetheless, in order to compile an AC series comparable to those based on the other two output measures, I compute the aggregate output as the total real BV of four groups of financial assets: market securities, and C&I, consumer, and real estate (RE) loans. It is produced with five inputs: labor, physical capital, deposits, other borrowings, and equity. The first four inputs are variable, and so are their costs. (See Wang 2003b for details of the computation of all the relevant output and cost variables.) The pre-merger AC is calculated for all three output measures. This synthetic time series is then appended to the actual time series of the post-merger survivor to form the unit of observation for the entire analysis.

The simplest measure of the post-merger change in cost is the mean percentage change of AC after the mergers ($\overline{Vac}$):

$$\overline{Vac} = (1/N)\sum_{i=1}^{N}(\ln \overline{AC_i^+} - \ln \overline{AC_i^-}). \qquad (2)$$

$\overline{AC_i^+} = (1/T_i^+)\sum_{t=s_i+1}^{s_i+T_i^+} AC_{it}$ denotes the average AC of the BHC formed after merger *i*, where s_i is the time of merger *i*, and T_i^+ is the length of the post-merger time series. $\overline{AC_i^-}$ is the counterpart for the synthesized pre-merger bank pair *i*. A negative value for $\overline{Vac}$ is the average percentage reduction in average cost after mergers. It can overestimate post-merger cost improvement if post-merger output growth is overstated under the new measure, since no bank-specific risk-adjusted rates of return or service price deflators are available to capture the likely increase in the portfolio risk and markup of merged BHCs. To see the change of AC over time following mergers, I also plot the time path of

$$\overline{Vac}_\tau = (1/N)\sum_{i=1}^{N}(\ln AC_{s_i+\tau} - \ln AC_{s_i-1}), \qquad \tau = 1,\ldots, \bar{T}, \qquad (3)$$

where $AC_{s_i+\tau}$ is the AC of the merged bank in the τ^{th} period after the merger *i*, and AC_{s_i-1} is the corresponding bank pair's AC in the period immediately prior to the merger. To reduce the influence of possible outliers in AC_{s_i-1}, $\overline{AC_i^-}$ can be used as a substitute. The $\overline{Vac}_\tau$ series shows how long it takes for savings on operating costs to materialize, and how different output measures affect the evolution of average costs.

The ultimate goal is to measure the net effect of mergers, i.e., the post-merger change *over and above* what would have happened had the two merging banks remained separate (the baseline case). So, the net post-merger change should ideally be calculated relative to the counterfactual, i.e., the actual output of a merged bank vs. the sum of outputs of the two parties had they stayed independent. This conceptual distinction is important because changes (e.g., output growth) take place over time in all the banks, including those not merging. The simple statistics of $\overline{Vac}$ and $\overline{Vac}_{\tau}$ above clearly measure the gross but not the net change. To approximate the pure merger-induced change in output and the other variables, I estimate the residual change net of the common trend and net of factors influencing all the banks:

$$\ln AC_{it} = \alpha_i + \beta D_{it} + \gamma_t + \eta_{it},$$

$$D_{it} = \begin{cases} 0, & \tau_i - T_i^- \le t \le \tau_i - 1 \\ 1, & \tau_i + 1 \le t \le \tau_i + T_i^+ \end{cases}, \qquad i = 1,\ldots, N,\ t = 1,\ldots, T. \tag{4}$$

AC_{it} is the AC of bank i at time t, and the pre-merger AC_{it} ($t < \tau_i$) for a merging pair is computed as in (1). α_i is a bank-specific intercept to account for any idiosyncratic level effects. γ_t represents the common factors in period t (such as the enactment of new banking legislation or a fall in the market interest rate), and it is estimated as one coefficient of a total of T–1 time dummies. D_{it} is the merger dummy variable, equal to 1 for the post-merger observations.[17] β thus equals the *average* proportional change in AC after mergers and should provide a better measurement of the net effect of mergers. β (and later β^Y and β^C), however, cannot uncover the idiosyncratic change induced by a specific merger, to the extent it deviates from the change common to all the merging banks. But merger-specific β_i's cannot be reliably estimated with short time series, which characterize most mergers in the samples of this study. Last, as discussed above, post-merger increases in output are likely overstated in this study, so β will likely overstate the merger-related AC improvement.

[17] For non-merging banks, $D_{it} = 0$, $t = 1,\ldots, T_i$.

3.2 Impact of Mergers on the Productivity Fixed Effects

If a merger succeeds in achieving cost savings, this will, by definition, be reflected in lower average costs post-merger versus the baseline case. Assuming perfect competition in factor markets (given little evidence suggesting monopsony power in the labor market), there are two ways to reduce AC: (a) raise output via increasing-returns-to-scale technology; (b) improve productivity, which acts as a cost shifter that lowers the entire cost schedule. One way to decompose the total change into the two elements is to estimate the following production function:[18]

$$\ln Y_{it} = \alpha_i^Y + \beta^Y D_{it} + \gamma_t + \ln \mathbf{x}_{it}^{'}\mathbf{B} + \varepsilon_{it}^Y . \qquad (5)$$

Y_{it} is bank i's aggregate output, $\boldsymbol{x}_{it}$ is a $k\times 1$ vector of inputs, and the pre-merger Y_{it} and $\boldsymbol{x}_{it}$ ($t < \tau_i$) for a merging pair are again constructed as in (1). $\mathbf{B}$ is the $k\times 1$ coefficient vector. α_i^Y is the productivity level specific to each BHC unit, and, for merging BHCs, it constitutes the entire pre- and post-merger time series. γ_t is the same time effect as in (4). D_{it} is the same merger dummy, and its coefficient (β^Y) measures the average proportional change in output following a merger, after controlling for changes in inputs.[19] A significantly positive β^Y is taken to mean that mergers on average improve productivity, i.e., (b) above is present. By comparison, an estimate of returns to scale γ^Y (= $\sum_{j=1}^{k} \partial \ln Y / \partial \ln x_j$) greater than 1 suggests that (a) above is present. Like β, β^Y (and later β^C) is likely to overstate the merger-related improvement because of the upward bias in the measured post-merger output.

The more direct way to identify the means by which mergers cut costs is to estimate the following cost function, for all three output measures:

$$\ln C_{it} = \alpha_i^C + \beta^C D_{it} + \gamma_t + \ln \mathbf{z}_{it}^{'}\mathbf{B}^C + \varepsilon_{it}^C . \qquad (6)$$

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[18] (5) is only estimated for the new and the SNA93 measure of output, since aggregate output is not defined according to the asset approach

[19] With i.i.d. errors, this is equivalent to the estimation method commonly used in previous studies: treating the "synthetic" pre-merger entity and the post-merger survivor as separate units with respective fixed effects in the cost function. The difference between the two BHC-specific intercepts measures the merger's impact on productivity, *ceteris paribus*. But the equivalence breaks down with non-spherical error structures. In particular, the latter will likely over-estimate the variance of the productivity change, given possible positive serial correlations within a unit before and after a merger.

C_{it} is the corresponding cost, $\mathbf{z}_{it}$ is the vector of input prices and outputs. $\mathbf{B}^C$ are $k \times 1$ coefficients. α_i^C is the cost-function counterpart to α_i^Y. D_{it} is the same merger dummy, and β^C measures the average impact of mergers on cost after controlling for changes in the output level and input prices. A significantly negative β^C is interpreted as evidence of savings through better productivity. The difference between β^C and β (in (4)) tells how much of the change in cost should be ascribed to changes in the relevant factors. (6) also offers comparability with the existing studies, but its estimation is more susceptible to the bias caused by measurement errors. In particular, errors in the new output measure bias the coefficient on output downward and, in turn, the estimate of returns to scale upward. (See Wang 2003b for discussion of potential errors in the new measure of output.) This means that when output increases after a merger, too much of the post-merger reduction in cost will be attributed to economies of scale (i.e., to (a) above) and the contribution from productivity improvement will be underestimated (i.e., there will be an upward bias in β^C). So, one way to mitigate this bias is to estimate (6) with a constraint of constant returns to scale (CRS). The bias in β^C will also be exacerbated if post-merger growth of the new output is overstated due to merger-induced higher markups that cannot be accounted for. Given these biases, it is better to regard this study's estimate of β^C under the new output measure as a lower bound for post-merger productivity gains and its estimate of β as an upper bound for potential cost improvement.

The specification of (5) and (6) essentially constrains all the slope coefficients to remain the same after mergers. Given a Cobb-Douglas (C-D) functional form, this means that mergers are assumed not to change the degree of returns to scale. With the more flexible Translog function, however, returns to scale can vary if inputs and output change after a merger. To evaluate mergers' impact on returns to scale, the change in inputs and output again should be only the part resulting solely from the mergers. Such changes can be estimated as in (4).

IV. Data and Estimation Results

4.1 The Data and the Sample

All the BHC financial data on a consolidated basis come from quarterly FR Y-9C reports organized by the Federal Reserve Bank of Chicago, which also supplies all the records of mergers between BHCs since 1976. The secondary-market interest rates used in estimating the cost function are in the Federal Reserve Economic Database (FRED) at the Federal Reserve Bank of St. Louis.

Simple differences between pre- and post-merger ACs (i.e., $\overline{Vac}$ and $\overline{Vac}_{\tau}$) are calculated for the maximal number of mergers possible (referred to as the full sample hereafter), i.e., for all the mergers with a minimum of one quarter of data before for both the acquirer and the target, and one quarter of data after for the acquirer. 76 mergers with 1314 observations meet the requirement, and their average total assets, interest income, and service output are summarized in Table 1, Panel A.

Longer time series are needed for estimating the production function (5) and the cost function (6). So, a subsample of mergers with at least four quarters of data both before and after (henceforth referred to as the subsample) is used in the estimations. The estimates of β^{Y} and β^{C} are best interpreted as reflecting mostly the short-term change in productivity from mergers, and four quarters may be too short to estimate the full change. But this selection criterion is chosen in order to achieve a sample of reasonable size, because two conditions severely restrict the number of mergers with adequate pre- and post-merger data.[20] First, many targets are small BHCs (i.e., having less than $150 million of consolidated assets), which report the parent-only but not the consolidated data, and those mergers thus must be excluded from the sample. Second, many mergers between large BHCs are excluded because the acquirers engaged in mergers too frequently to have sufficiently long time series either before or after the merger. 49 mergers with a total number of 989 observations remain. Their summary statistics are reported in Panel B of Table 1.

Comparison of panels A and B in Table 1 indicates that BHCs in the subsample of

[20] Only 22 mergers remain if the lower limit is raised to eight quarters.

mergers used to estimate the production and the cost functions are somewhat smaller than those excluded, but the difference is not statistically significant. Note that the size distributions (in terms of total financial assets) of both acquirers and targets are highly skewed by large BHCs. As for relative sizes, the targets are on average close to half the size of the acquirers, but the distribution is again asymmetric, with a median of 0.28 and a long upper tail. If changes after mergers of (near) "equals" differ substantially from those after mergers with much larger acquirers, then the wide dispersion of relative sizes points to the possibility of large discrepancies between the estimates of β, β^{Y} and β^{C}—average effects of mergers—and the true impact of either type of merger in any specific case.

The panel for estimating (5) and (6) also contains a reference group of non-merging BHCs, which should identify the industry-wide changes not directly related to mergers, allowing estimation of the merging BHCs to isolate the effects of mergers from these industry-wide changes. The reference group includes all the BHCs that have never merged and excludes any BHC that is considered in the merger panels above. The remaining BHCs, which were involved in mergers at some point but do not meet the four-quarter criterion above, have certain non-merging quarters included in the reference panel. A quarter qualifies if the BHC had not participated in any mergers in the past year, and did not in the next year. Excluding the eight quarters around every merger involving these BHCs is done to lessen the influence of merger-related activity on the production decisions of the reference group.[21] Each reference BHC is required to have at least eight quarters of data. In all, the reference panel contains 2211 BHCs totaling 38471 observations, and the summary statistics are listed in Table 1, Panel C. Note that the mean and median asset sizes of reference BHCs are about the same as those of the targets, but they are 4-5 times smaller than the acquirers. This is because most active acquirers are large banks, and buying other banks further enables them to grow much faster than the average BHC over time.

[21] Excluding more quarters (e.g., 16 quarters) hardly changes the estimation results.

4.2 Post-Merger Changes of Average Cost

To provide a background of the changes taking place in merged BHCs, I first describe briefly how they adjust their portfolios and pricing methods; these adjustments are represented by a set of ratios whose changes are explored in previous studies. Table 2 reports their pre- and post-merger means and changes in the means ($\overline{X^-}$, $\overline{X^+}$ and $\overline{\mathrm{V}x}$, respectively).[22] β in the last column measures the proportional *net* change in each ratio after mergers: A regression identical to (4) is defined for every ratio as the dependent variable, and β is the coefficient on the merger dummy D_{it}. The βs are estimated using the within estimator for the fixed effects model. Robust standard errors are computed using the most general covariance matrix estimator proposed in Arellano (1987).[23] The βs almost all bear the signs predicted by the "diversification hypothesis," and so do most $\overline{\mathrm{V}x}$'s, although many are insignificant.[24] As explained earlier, β should be a better indicator of the average *net* effect of mergers than $\overline{\mathrm{V}x}$, since it controls for the common factors affecting both merging and non-merging banks. According to the β estimates, the ratio of securities to loans and the proportion of RE loans both fall, suggesting an increase in total credit risk after mergers. Merged banks also borrow relatively more non-deposit funds, and the interest rate on long-term debt is (insignificantly) lower, presumably both owing to the better diversification resulting from mergers.

I also examine how mergers affect the gap between the two flow measures of output—the new and the SNA93 measure. Wang (2003a) has established that the gap consists of the risk premium (over the risk-free asset) on securities, along with returns accredited to deposit insurance, and excess returns to equity over debt. Absent bank-specific, risk-adjusted rates of return, this gap is approximated using risk premia on the fixed income market securities

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[22] $\overline{X^-}$, $\overline{X^+}$ and $\overline{\mathrm{V}x}$ are computed according to the same formulae as for $\overline{AC^-}$, $\overline{AC^+}$, and $\overline{\mathrm{V}ac}$ in (2), respectively. Their values are about the same for the full merger sample and the subsample.

[23] This covariance estimator allows for unknown forms of heteroscedasticity and serial correlation within the time series of each individual unit, but the different units are assumed to be uncorrelated. The assumption of no cross-section correlation poses little problem for this study because only two mergers in the small sample involve the same acquirer.

[24] Given the definition of $\overline{\mathrm{V}x}$, it is possible to have $\overline{\mathrm{V}x} < 0$, while $\overline{X^+} > \overline{X^-}$. Some βs reverse the signs of the corresponding $\overline{\mathrm{V}x}$'s after controlling for industry-wide factors. One prominent case is the proportion of RE loans. Once the common rising trend is accounted for, merged banks are found to hold relatively smaller RE loan portfolios.

comparable to bank loans. This means that little change is expected in the estimated gap after mergers, given the stable premium over the sample period, even though the true gap is likely to widen as merged banks take on greater risk. Indeed, the relative gap is estimated to shrink an insignificant 3.7% after mergers. At the same time, as a first attempt to gauge the impact of mergers on how a bank prices its services, I find that the implicitly priced part of both lending services and depositor services rises relative to the respective explicit part (i.e., fees), but only the former rises significantly.[25] One plausible explanation is that the merged banks in the sample have either increased the credit risk of their loan portfolios but experienced a better than average default rate or have raised the markup on their implicit service charges, while general interest rates and price deflators are unable to account for such increases.

Post-merger changes in average cost estimated according to all three output measures are reported in Table 3.[26] The table shows both the gross AC change (i.e., $\overline{ac}$ in (2)) and the net AC change after controlling for common trends (i.e., β in (4)). Panels A and B report for the full merger sample and the subsample with at least eight quarters of data, respectively, and the two sets of results are rather similar.[27] Based on the estimate of β, the merged BHCs achieve a statistically significant 6% decline relative to their non-merging peers in the AC (with or without the opportunity cost of cash reserves) defined according to the new output measure. The AC computed according to the SNA93 measure falls only an insignificant 3.2%. The net change in the BV-based AC, however, is positive, although insignificant. $\overline{Vac}$, on the other hand, reverses the sign of β for all the measures except the new AC with the cost of cash reserves. The BV-based $\overline{Vac}$ falls more than the new-output-based $\overline{Vac}$, whereas the SNA93-based AC actually rises about 10%.[28] The contrast between β and $\overline{Vac}$ implies that the

[25] This seems contrary to anecdotal observations—taken to be evidence of mergers' anti-competitive effects—that merged banks charge higher explicit fees and for a wider array of services. Moreover, merged banks are found to rely more on non-interest income relative to interest income than non-merged banks, and they incur greater non-interest expenses accordingly. But this change can be more readily explained by a 4-5% fall in interest rates (represented by the Fed funds rate) over the sample period than by a shift toward more explicit pricing.

[26] Table 3 also lists the time-series means of average cost before ($\overline{AC^-}$) and after ($\overline{AC^+}$) a merger.

[27] β is estimated for the subsample of mergers only, so it is listed in Panel B, the last column.

[28] But all the $\overline{Vac}$s are insignificant, reflecting large cross-merger variation in the post-merger changes in AC.

BV-based AC decreases for all the banks during the sample period, not just the merged ones. The decrease is mainly due to falling interest rates and hence a lower cost of funds, which is part of the BV-based cost. This is consistent with the fact that the new-output AC with the cost of reserves falls more after mergers than the AC without. Once that common trend is controlled for, the merged BHCs show no extra cost savings according to the BV-based measure. As for the ACs associated with the other two output measures, they both rise over time for all the BHCs, but less so for the merged ones. All these illustrate the importance of controlling for common factors in evaluating the actual impact of mergers.

Next, time series of post-merger AC changes (i.e., $\overline{Vac}_\tau$ in (3), $\tau = 1,\ldots, \overline{T}$, and $\overline{T} \leq \max(T_i^+)$) are plotted for the two samples of mergers in Figures 1 and 2. $\overline{T}$ is chosen to be 12 because there are fewer than 20 mergers beyond 12 quarters, rendering the sample mean too variable. It seems reasonable to expect mergers to show cost-saving effects within three years. They again show similar patterns. First, the new-output AC series (with or without the cost of cash reserves) rises continually (and sharply in the 9th–11th quarters) after mergers, more than reversing the initial 5-10% fall after two years. The swing in the new AC in the last four quarters mirrors the sharp fall in output, whereas the AC's overall increase in the first two years reflects mostly faster growth in operating costs than in output. A possible explanation is that merged banks close branches and lay off staff shortly after mergers, but then add new services gradually. The new services may have greater value added and require more inputs, but are underestimated given the inadequate price index; or they may incur high fixed costs in the initial investing phase. Similarly, the AC calculated using the SNA93 measure rises steadily after mergers without any immediate declines following mergers, and this results in an 11% increase in the post-merger mean AC. The main cause is that the SNA93 measure of output barely grows in the merged BHCs, consistent with the finding that the gap between the new and the SNA93 outputs narrows by 3.7% after mergers. In contrast, the BV-based AC fluctuates slightly throughout the twelve quarters, but remains lower than the pre-merger level. This pattern implies that the cost rises less rapidly than the output, since the BV-based output grows continually after mergers.

4.3 Post-Merger Changes in Bank Productivity

The final set of analysis evaluates the impact of mergers on the productivity fixed effects of BHCs through both the production function (5) and the cost function (6). In the latter, the estimates control for input prices and output level, which affect a bank's cost but are not accounted for in the AC comparisons above. I follow the fixed effects estimation of the two functions as delineated in Wang (2003c). Both the Translog and the C-D functional forms are estimated, and a time dummy for every period is included in all the regressions. Robust standard errors are again computed according to the same Arellano (1987) estimator.

In the production function associated with the new output measure, the aggregate output of lending and depositor services is the dependent variable, and three inputs—labor, physical capital, and cash reserves—are the explanatory variables. In the corresponding cost function, physical capital and cash reserves are treated as quasi-fixed.[29] The estimation results are reported in the first columns of Tables 4 – 6 (and the third column of Table 6). Productivity β^Y (in (5)) rises about 5% after mergers—insignificantly. The C-D cost function estimate (β^C in (6)) finds a productivity improvement of 6.7% and significant improvement at the 10% level under the CRS constraint.[30] However, when the returns to scale are determined freely by data, the productivity improvement becomes less significant—as anticipated. This is because estimated increasing returns to scale combined with higher post-merger output (of about 2% over and above the non-merging peers) accounts for about 4% of the increase in productivity, or over 50% of the post-merger improvement. β^C may be further underestimated due to merger-induced measurement errors, since unobserved increases in BHC-specific markups or portfolio risk likely overstate the post-merger output increase. On the other hand, an unlikely offsetting effect can arise if mergers lower portfolio risk, which is unobserved. The productivity fixed effects β^C improve somewhat more significantly with the time dummies than without (the comparison not shown). The functional form matters slightly for the point

[29] This is the preferred specification chosen in Wang (2003c). I also examined alternative specifications where capital and cash reserves are treated as variable, and the estimates of β^Y and β^C remain basically unchanged.

[30] The constraint is imposed for the C-D specification only, for it is quite difficult to restrict the returns to scale in the Translog function, which depends not only on parameter estimates but also on data. In this section, all the tests of a coefficient's significance are double-sided asymptotic tests at the 5% significance level, unless otherwise specified.

estimates of β^C but not for their significance.[31]

The production and cost functions using the SNA93 measure are specified and estimated in the same manner as their counterparts for the new output measure. The results are listed in the second columns of Tables 4 – 6 (as well as the fourth column of Table 6). The cost-based productivity β^C improves 2-3% following mergers, but is insignificant. The CRS constraint has no effect, since approximately constant returns to scale are estimated from the cost function ($\gamma^C = 1.35$ with $\sigma = 0.08$, not shown). The estimated productivity increase is slightly lower from the production function–1.5%–and is again insignificant.

Only the cost function is estimated for the BV-based output measure, because the asset approach has no formal definition of aggregate bank output. The dependent variable—cost—equals the sum of expenses for labor and capital and the interest payment on borrowed funds, less explicit fees for depositor services. The explanatory variables include four outputs (market securities, and C&I, consumer, and RE loans), three input prices (deposit interest rate, wage rate, and the interest rate on other borrowings), and two quasi-fixed inputs (equity and physical capital). The Translog results, reported in Table 7, are most comparable with those in previous studies. Productivity barely changes following mergers (an estimated 1.5% improvement with a standard error of 1.5%), and the outcome is robust regardless of the functional form ($\beta^C = -0.019$ with $\sigma = 0.016$ from the C-D function, not shown) and the inclusion of quarter dummies.

In summary, the choice of output measure also matters for the assessment of mergers' impact on BHCs' productivity. In particular, the cost-based productivity associated with the new output measure exhibits the most post-merger improvement, while the BV-based cost shows the least improvement.[32] This exactly reverses the relationship for $\overline{Vac}$ across the three output measures. I now propose an explanation for this opposite ordering of $\overline{Vac}$ vs. β^C. The BV-based AC declines the most following mergers because the cost of loanable funds falls the

[31] The productivity fixed effects β^C improve about 1% more (4.1% vs. 3.2%, respectively) in the C-D specification than in the Translog one, but neither is significant.

[32] One thing to note is that when standard errors are not corrected according to Arellano (1987), the productivity improvement becomes significant at the 1% level under the new output measure, but remains insignificant under the other two measures.

most among all the cost components after mergers, presumably owing to better diversification as well as to a general decline in interest rates over the sample period. Once the lower price of loanable funds is accounted for, the net reduction in the BV-based AC becomes negligible, if not reversed. In contrast, labor and capital cost rises almost as fast as output following mergers, preventing the AC based on the new measure, as well as on the SNA93 output measure, from decreasing after mergers. But once one accounts for the change in input prices, more pronounced productivity improvements are detected—especially for the new output. In fact, the lack of significance in the β^C estimate may be due partly to the small sample size and short time series, especially if cost savings take more than one year to realize.

These results suggest that the BV-based output measure may have understated the post-merger improvement in productivity, and so may have the SNA93 measure to a lesser extent. The new output measure provides tentative evidence that mergers do reduce costs, and these results can potentially resolve the paradoxical findings in existing studies. In particular, more and better data in future analysis will enable us not only to estimate economies of scale more precisely but also to explore economies of scope. This should in turn enhance the accuracy of the estimate of post-merger productivity change. Until then, we cannot rule out either the possibility that intended cost savings fail to be achieved after mergers or the possibility that the main objective of mergers is not to save costs but to boost revenue. Finally, differences between bank and BHC data do not seem to be the factor driving the results in this paper based on the new output measure, since the estimates using the BV-based measure basically confirm the findings in existing studies. In short, further investigation is necessary.

V. Conclusions

This paper applies a new measure of the value added of bank services to evaluate the impact of mergers on bank costs and productivity. It shows that existing studies' use of the book value of financial assets as bank output is potentially responsible for their paradoxical findings: Bank mergers are estimated to bring about significant increases in profit, but no cost savings or increases in market power. In particular, it is shown that a negligible rise in loan

interest rates is not valid evidence of no increase in market power, as the BV-based output measure in existing studies would imply. The study also demonstrates that, contrary to what the BV-based measure would imply, mergers create no real savings merely through the better diversification that follows the combination of the two parties' assets. The new output measure is a flow measure that can coherently account for risk in computing the output of bank services from properly imputed and deflated revenue flow. It also recognizes that the funds banks lend are only an intermediate input, and so the risk premium on the funds should not be considered part of their value added. The new measure can account for the quality of bank services in principle. In short, it is free of any of the conceptual problems discussed above.

This study first documents how merged banks adjust their portfolios and shows that the adjustments are mostly consistent with the hypothesis that banks take advantage of the better diversification resulting naturally from mergers. It then reveals that, between the two flow measures of bank output, the SNA93 output measure is likely to be subject to more of the additional measurement errors that mergers may introduce than is the new measure. Next, the BV-based measure is shown to experience the largest decline in average cost after mergers, but this is mostly due to lower post-merger interest rates on loanable funds. Once these are accounted for, the new measure of bank output yields the most--yet insignificant--improvement in productivity fixed effects, and the BV-based measure the least. The gap widens further when one also controls for the potential bias due to measurement errors in the new output series.

The limitation introduced by short time series in the sample is a likely reason why the new-output-based productivity is not significantly higher after mergers, since merger-related savings in operating costs can take well over one year to realize. The small sample size may be another reason, since it means a high variance for the estimated coefficient of the merger dummy. Potential overstatement of the post-merger output increase, due to unobserved increases in markups, is yet another reason. Moreover, the sample contains few mergers between either two small or two large BHCs, mergers which are most likely to benefit from economies of scale and scope, respectively. So, caution must be exercised in generalizing the

results of this study, and further analysis aided by more detailed and accurate data is necessary. Nevertheless, the new output measure holds the potential of resolving the contradictory findings in previous studies by showing that mergers do realize cost savings.

This paper focuses mostly on analyzing the effects of mergers on bank costs, but cost savings are only one of the potential consequences of bank mergers. Loss of competition is another significant one. In future works, I intend to assess the impact of mergers on loan and deposit pricing as well, and to distinguish the effect on costs from the effect on competition. To that end, I will incorporate market information, such as market structure, concentration, and the growth of non-bank financial institutions, to obtain more precise estimates of post-merger changes in interest rates, fees, and markups, and in turn on real output and costs. These studies should also offer better clues as to the main motivation for mergers—to save on costs or to gain market power.

Table 1. Summary Statistics of the Merger Samples

Panel A. The sample of all the mergers (N = 76) with data for both acquirer and target

		Pre-Merger			Post-Merger
		Acquirer	Target	Total	
Total Finl. Assets[a]	Mean	4486.5	962.9	5449.5	5643.8
	S. E.	6564.0	1678.0	7706.2	7910.5
	Med.	2068.7	290.1	2701.8	2169.1
Tot. Int. [1, a, b]		84.5	18.8	103.3	106.1
		(125.3)	(31.8)	(147.9)	(156.6)
Tot. Services[2, a, b]		52.6	9.8	62.4	61.9
		(90.7)	(18.0)	(101.5)	(100.1)
Tgt. Rltv. Sz.[3, b] (%)			0.42		
			(0.51)		
T. S. Obsn.[4, b]				8.8	8.4
				(6.0)	(6.0)

Notes:

[a]. The unit is $1,000,000

[b]. The statistics reported are sample means, and the corresponding standard errors (S.E.) are in parenthesis, except for Total Financial Assets.

[1]: Total interest income

[2]: Total service output (i.e., the aggregate output according to the new measure) = lending services + depositor services

[3]: Relative size of the target, based on total financial assets

[4]: The number of observations in the time series of each merger unit

Table 1. (continued)

Panel B. The subsample consisting of mergers (N = 48) with at least four quarters of data for both acquirer and target

		Pre-Merger			Post-Merger
		Acquirer	Target	Total	
Total Finl. Assets[a]	Mean	4357.2	1101.3	5458.5	4563.9
	S. E.	6411.4	1799.2	7843.0	6955.2
	Med.	1783.9	282.2	2663.8	1511.3
Tot. Int. [1, a, b]		84.2	21.4	105.6	84.9
		(127.5)	(34.4)	(155.2)	(129.5)
Tot. Services[2, a, b]		52.2	11.3	63.6	48.3
		(88.6)	(19.9)	(102.7)	(84.1)
Tgt. Rltv. Sz.[3, b] (%)			0.45		
			(0.46)		
T. S. Obsn.[4, b]				10.3	10.4
				(5.0)	(7.0)

Notes:
The same as for Panel A

Panel C. The reference panel (2211 BHCs)

		Non-Merging BHCs
Total Financial Assets[a]	Mean	990.3
	S. E.	3348.6
	Med.	235.8
Total interest income[a, b]		20.0
		(73.8)
Total service output[a, b]		11.4
		(43.7)
Time Series Obsn[b]		17.4
		(11.8)

Notes:
[a]. The unit is $1,000,000.
[b]. The statistics reported are sample means, and the corresponding standard errors (S.E.) are shown in parenthesis, except for Total Financial Assets.

Table 2. Summary Statistics of Mean Post-Merger Change in Bank Financial and Operating Structural Variables

	Pre-Merger Mean ($\overline{X^-}$) [a]	Post-Merger Mean ($\overline{X^+}$) [a]	$\overline{Vx}$ (%) [b]	Net Change (β) [c]
New-SNA93 Gap[1]	0.300	0.261	-16.4	-0.037
	(0.140)	(0.126)	(41.9)	(0.040)
Cash Reserves [2]	0.064	0.061	-3.2	0.003
	(0.023)	(0.018)	(12.9)	(0.022)
Securities/Loans	0.429	0.409	-4.9	-0.102*
	(0.211)	(0.200)	(29.4)	(0.050)
LT Debt/Deposit	0.045	0.063	24.2	0.089
	(0.046)	(0.061)	(56.4)	(0.098)
Equity/Loans	0.131	0.141	6.7	0.014
	(0.028)	(0.030)	(14.5)	(0.027)
Liability/Equity	11.288	9.869	-12.2	-0.049*
	(2.539)	(1.667)	(12.8)	(0.021)
RE/(C&I + Consmr)[3]	1.337	1.521	11.7	-0.036
	(1.388)	(1.499)	(22.2)	(0.035)
Int./non-Int. Income[4]	7.348	6.551	-12.8	-0.014
	(3.237)	(3.124)	(22.0)	(0.029)
Int./non-Int. Expense[4]	1.122	0.985	-11.8	0.020
	(0.430)	(0.323)	(29.2)	(0.023)
Lendg. Imp./Exp.[5]	0.594	0.533	6.7	0.076*
	(0.248)	(0.514)	(23.3)	(0.033)
Dep. Svc. Imp./Exp.[6]	0.681	0.710	6.4	0.001
	(0.210)	(0.195)	(30.5)	(0.022)
Lendg./Dep. Service [7]	1.320	1.411	1.1	0.101
	(1.163)	(1.517)	(80.1)	(0.075)
LT Debt Int. Rate[8]	1.970	2.675	-1.7	-0.046
	(1.024)	(5.975)	(32.2)	(0.041)

Notes:

I. All the statistics are calculated for the full merger sample.

II. The figures in parentheses are the corresponding standard errors.

*: significantly different from zero at the 5% level

[a]: $\overline{X^-}$ and $\overline{X^+}$ are the actual pre- and post-merger means, respectively.

[b]: $\overline{Vx}$ is the pre- and post-merger differences, in percentages.

[c]: β's are the coefficient estimates of the merger dummy in an equation identical to (4).

[1]: Gap between the new and the SNA93 output, as a fraction of the latter

[2]: Fraction of cash reserves in total financial assets

[3]: Ratio between RE loans and the sum of C&I and consumer loans

[4]: Interest vs. non-interest income and expenses, respectively

[5]: Ratio between implicit and explicit lending service output

[6]: Ratio between implicit and explicit depositor service output

[7]: Ratio between lending and depositor service outputs

[8]: Interest rate on long-term non-deposit borrowings, in basis points

Table 3. Pre- and Post-Merger Average Cost Comparison

Panel A. The sample of all the mergers (N = 76) with data for both acquirer and target

	Pre-Merger ($\overline{AC^-}$)			Post-Merger ($\overline{AC^+}$)	$\overline{Vac}$
	Acquirer	Target	Total		
New Output (w/o $)[1]	0.433	0.490	0.437	0.439	0.004
	(0.160)	(0.222)	(0.149)	(0.128)	(0.223)
New Output (w/ $)[2]	0.635	0.717	0.641	0.632	-0.012
	(0.202)	(0.282)	(0.184)	(0.160)	(0.167)
BV Output	0.0167	0.0173	0.0176	0.017	-0.018
	(0.0034)	(0.0032)	(0.0032)	(0.0027)	(0.125)
SNA93 Output	0.278	0.288	0.281	0.316	0.093
	(0.069)	(0.071)	(0.064)	(0.078)	(0.116)

Notes:

[1]: The average cost, based on the new output measure, not including the cost of cash reserves

[2]: The average cost, based on the new output measure, including the cost of cash reserves

Sample standard deviations are in parentheses.

Table 3. (continued)

Panel B. The subsample consisting of mergers (N = 48) with at least four quarters of data for both acquirer and target

	Pre-Merger ($\overline{AC^-}$)			Post-Merger ($\overline{AC^+}$)	$\overline{Vac}$	Net Change (β_{AC}) [3]
	Acquirer	Target	Total			
New Output (w/o $) [1]	0.420	0.465	0.418	0.444	0.019	-0.058*
	(0.159)	(0.202)	(0.146)	(0.135)	(0.255)	(0.027)
New Output (w/ $) [2]	0.620	0.679	0.616	0.636	-0.012	-0.063*
	(0.201)	(0.260)	(0.180)	(0.167)	(0.202)	(0.027)
BV Output	0.0170	0.0173	0.0178	0.0169	-0.015	0.007
	(0.0035)	(0.0032)	(0.0033)	(0.0026)	(0.123)	(0.012)
SNA93 Output	0.274	0.278	0.274	0.320	0.110	-0.032
	(0.073)	(0.069)	(0.067)	(0.080)	(0.130)	(0.024)

Notes:
[1]: The average cost, based on the new output measure, not including the cost of cash reserves
[2]: The average cost, based on the new output measure, including the cost of cash reserves
[3]: β_{AC} is the coefficient estimates of the merger dummy in equation (4) for average cost.
*: significantly different from zero at the 5% level
Sample standard deviations are in parentheses.

Table 4. Post-Merger Changes in Productivity based on Bank Production Function (Translog and C-D Functional Forms): According to the New and the SNA93 Output Measures

		Translog Production Function		C-D Production Function	
		New Output	SNA93	New Output	SNA93
Parameter Estimates	D_{merger}	0.0465	0.0155	0.0447	0.0150
		(0.0328)	(0.0165)	(0.0369)	(0.0216)
	L	0.5445	0.5563	0.4790	0.4897
		(0.0217)	(0.0206)	(0.0654)	(0.0672)
	K	-0.0091	-0.1452	0.1041	0.0901
		(0.0504)	(0.0373)	(0.0227)	(0.0228)
	Csh Res.	-0.0017	-0.1287	0.1811	0.1184
		(0.0512)	(0.0386)	(0.0178)	(0.0166)
	L^2	-0.1240	-0.1283		
		(0.0116)	(0.0124)		
	K^2	0.0397	0.0223		
		(0.0089)	(0.0060)		
	CR^2	0.0412	0.0219		
		(0.0077)	(0.0062)		
	L×K	0.0332	0.0491		
		(0.0205)	(0.0211)		
	L(CR)	0.0166	0.0016		
		(0.0286)	(0.0240)		
	K(CR)	-0.0256	0.0029		
		(0.0081)	(0.0059)		

Notes:
1. Csh. Res. (CR): cash reserves
2. Standard errors of the parameter estimates are in parentheses.
3. A blank parameter value means it is not used in the regression.

Table 5. Post-Merger Changes in Productivity based on Bank Cost Function (Translog Functional Form):
According to the New and the SNA93 Output Measures

		Translog Cost Function	
		New Output	SNA93
Parameter Estimates	D_{merger}	-0.0316	-0.0198
		(0.0268)	(0.0239)
	Y	0.1466	0.6230
		(0.0491)	(0.0923)
	wage (w)	1.0000	1.0000
	K	-0.2065	-0.1436
		(0.0953)	(0.0745)
	Csh Res.	0.3165	0.2909
		(0.0957)	(0.0887)
	$(Y)^2$	0.0419	-0.0068
		(0.0156)	(0.0368)
	w^2	0.0000	0.0000
	K^2	0.0662	0.0516
		(0.0098)	(0.0097)
	CR^2	0.0297	0.0112
		(0.0076)	(0.0068)
	wK	0.0731	0.0668
		(0.0524)	(0.0503)
	w(CR)	-0.1109	-0.1086
		(0.0532)	(0.0512)
	K(CR)	-0.0126	-0.0177
		(0.0084)	(0.0098)
	wY	0.0000	0.0000
	KY	-0.0158	-0.0103
		(0.0117)	(0.0193)
	(CR)Y	-0.0131	0.0088
		(0.0123)	(0.0155)

Notes:
1. Csh. Res. (CR): cash reserves
2. Standard errors of the parameter estimates are in parentheses, except for those constrained by the cost function (e.g., $\beta_L = 1$).

Table 6. Post-Merger Changes in Productivity based on Bank Cost Function (C-D Functional Form):
According to the New and the SNA93 Output Measures

		No CRS Constraint		CRS Constraint	
		New Output	SNA93	New Output	SNA93
Parameter Estimates	D_{merger}	-0.0407	-0.0337	-0.0629	-0.0327
		(0.0272)	(0.0247)	(0.0346)	(0.0248)
	Y	0.2132	0.5230	1.0000	1.0000
		(0.0105)	(0.0199)		
	wage (w)	1.0000	1.0000	1.0000	1.0000
	K	0.2630	0.1892	0.0614	0.0720
		(0.0124)	(0.0102)	(0.0081)	(0.0058)
	Csh Res.	0.1620	0.1043	-0.0647	-0.0043
		(0.0093)	(0.0068)	(0.0086)	(0.0060)

Notes:
1. Csh. Res. (CR): cash reserves
2. "No CRS Constraint": The constant-return-to-scale (CRS) constraint is not imposed on the C-D cost function.
3. Standard errors of the parameter estimates are in parentheses, except for those constrained by the cost function (e.g., $\beta_L = 1$) or the CRS constraint.

Table 7. Book-Value-Based Cost Function (Translog Functional Form)
(First-Order and Second-Order Terms)

		BV-Based Cost Function	
		Coefficient	Standard Error
Parameter Estimates	D_{merger}	-0.0152	0.0146
	Sec. (Y_1)	0.3179	0.0429
	L. Ind. (Y_2)	0.1385	0.0488
	C&I (Y_3)	0.2665	0.0572
	RE (Y_4)	0.3174	0.0729
	Eqt. (X_1)	-0.3615	0.0957
	Dep. R. (X_2)	0.7864	0.0579
	wage (X_3)	0.2231	0.0577
	K (X_4)	-0.0532	0.0587
	FF. R. (X_5)	-0.0095	0.0226
	Sec.^{2}	0.0674	0.0122
	L. Ind.^{2}	0.0212	0.0055
	C&I^2	0.0359	0.0089
	RE^2	0.0998	0.0168
	Eqt.^{2}	0.0115	0.0100
	Dep. R.^{2}	0.0847	0.0168
	wage^2	0.0532	0.0121
	K^2	0.0438	0.0099
	FF. R.^{2}	0.0079	0.0127

Notations:

Sec.: Investment securities
L. Ind.: consumer loans (loans to individuals)
C&I: commercial and industrial loans
RE: real estate loans
Eqt.: equity
Dep. R.: deposit interest rate
FF. R.: Federal funds rate

Table 7. (continued)

Translog Book-Value-Based Cost Function (Cross-Product Terms)

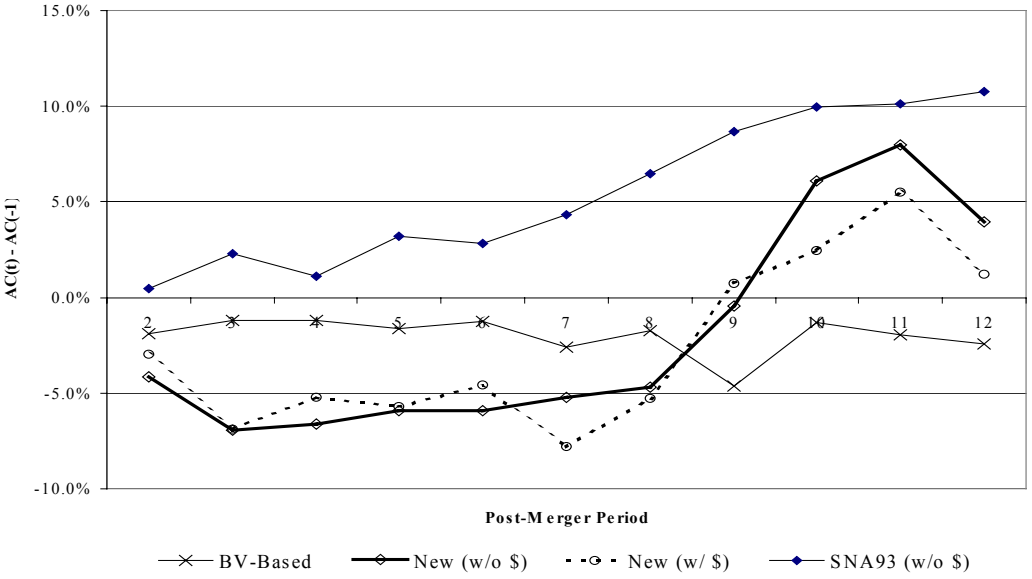
		BV-Based Cost Function	
		Coefficient	Standard Error
Parameter Estimates	$Y_1 Y_2$	-0.0040	0.0055
	$Y_1 Y_3$	-0.0258	0.0048
	$Y_1 Y_4$	-0.0537	0.0070
	$Y_2 Y_3$	-0.0053	0.0041
	$Y_2 Y_4$	-0.0044	0.0089
	$Y_3 Y_4$	-0.0444	0.0090
	$X_1 X_2$	-0.0042	0.0164
	$X_1 X_3$	-0.0437	0.0133
	$X_1 X_4$	-0.0096	0.0100
	$X_1 X_5$	0.0029	0.0031
	$X_2 X_3$	-0.0650	0.0125
	$X_2 X_4$	-0.0061	0.0137
	$X_2 X_5$	-0.0197	0.0112
	$X_3 X_4$	0.0245	0.0134
	$X_3 X_5$	0.0118	0.0055
	$X_4 X_5$	-0.0040	0.0021
	$Y_1 X_1$	0.0261	0.0098
	$Y_1 X_2$	0.0336	0.0082
	$Y_1 X_3$	-0.0292	0.0075
	$Y_1 X_4$	-0.0158	0.0082
	$Y_1 X_5$	-0.0044	0.0020
	$Y_2 X_1$	-0.0129	0.0086
	$Y_2 X_2$	0.0027	0.0062
	$Y_2 X_3$	-0.0043	0.0058
	$Y_2 X_4$	0.0034	0.0064
	$Y_2 X_5$	0.0015	0.0015
	$Y_3 X_1$	0.0213	0.0081
	$Y_3 X_2$	-0.0023	0.0060
	$Y_3 X_3$	0.0008	0.0056
	$Y_3 X_4$	0.0154	0.0090
	$Y_3 X_5$	0.0015	0.0019
	$Y_4 X_1$	0.0022	0.0123
	$Y_4 X_2$	-0.0380	0.0102
	$Y_4 X_3$	0.0368	0.0104
	$Y_4 X_4$	-0.0146	0.0068
	$Y_4 X_5$	0.0012	0.0027

Notes: Notations in this table match the ones in the table on the last page as follows:

Y_1: Sec. Y_2: L. Ind. Y_3: C&I

Y_4: RE X_1: Eqt. X_2: Dep. R.

X_3:wage X_4: r^K or K X_5: FF. R.



New (w/o $): AC based on the new output but without the cost of cash reserves
New (w/ $): AC based on the new output and with the cost of cash reserves

Figure 1a. Post-Merger Time Series of the Changes in Average Cost (All the Mergers)

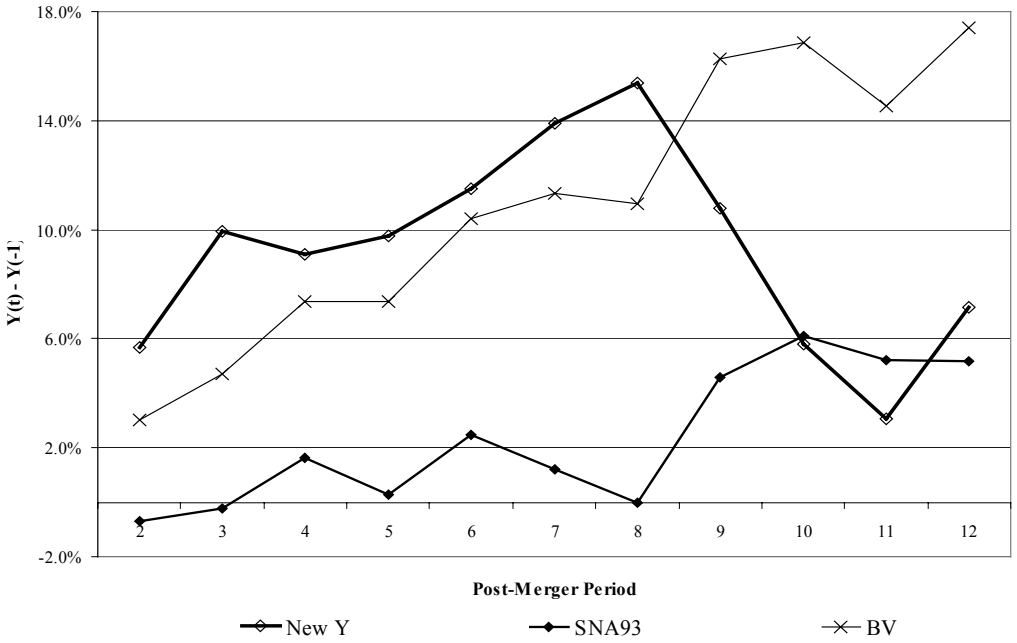


Figure 1b. Post-Merger Time Series of Output Changes (Three Different Output Measures, All the Mergers)

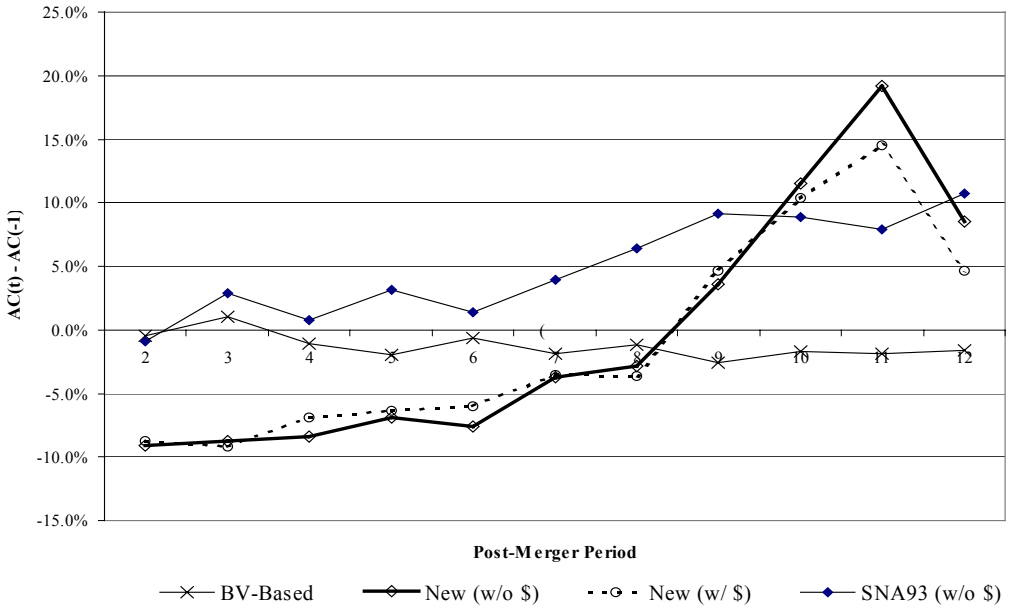


Figure 2a. Post-Merger Time Series of the Changes in Average Cost
(Subsample: Mergers Used in the Cost Function Estimation)

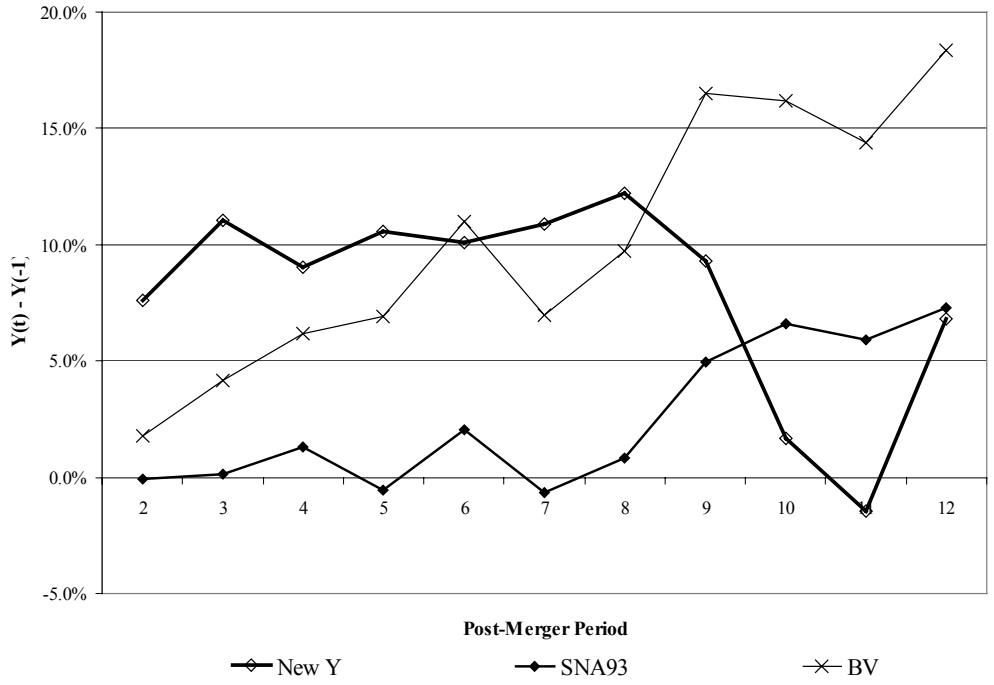


Figure 2b. Post-Merger Time Series of Output Changes
(Three Different Output Measures, Subsample of the Mergers)

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