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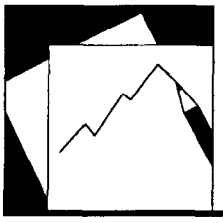

IMF Working Paper

Systemic Risk and Financial Consolidation: Are They Related?

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Systemic Risk and Financial Consolidation: Are They Related?

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Abstract

We argue that firm interdependencies, as measured by correlations of stock returns, provide an indicator of systemic risk potential. We find a positive trend in stock return correlations net of diversification effects for a sample of U.S. large and complex banking organizations over 1988–99. This finding suggests that the systemic risk potential in the financial sector may have increased. In addition, we find a positive consolidation elasticity of correlations. However, such elasticity exhibits substantial time variation and likely declined in the latter part of the decade. Thus, factors other than consolidation have also been responsible for the upward trend in return correlations.

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I. INTRODUCTION

The on-going consolidation of financial systems in developed countries is one of the most notable features of the contemporary financial landscape. The resulting creation of a number of very large and in some cases increasingly complex financial institutions has raised concerns that the degree of systemic risk in these financial systems may have increased. For example, although consolidation may have increased the extent of diversification at individual institutions, and thus lowered individual firm's risk, consolidated firms may have become more similar, and thus raised the vulnerability of the aggregated financial system. In addition, greater concentration of certain activities, such as inter-bank loans and large dollar payment activities, may have augmented systemic risks.[2] However, as noted in the recent survey by DeBandt and Hartmann (2000), research aimed at specifying empirical models of systemic risk is quite limited. In addition, no previous work has examined the relationship between systemic risk and financial consolidation. This paper attempts to contribute toward filling both gaps.

Guided by a general definition of systemic risk, we argue that firm interdependencies provide an indicator of systemic risk potential, and measure interdependencies with correlations of stock returns. Our analysis proceeds in two steps. First, we analyze the dynamics of such correlations during the 1988–99 period for a sample of U.S. large and complex banking organizations (LCBOs). With the exception of Campbell et al. (2000), no prior study has focused on the dynamics of interdependencies at the firm level. Second, we relate firms' return correlations to their consolidation activity by estimating measures of the consolidation elasticity of correlation both cross-sectionally and through time. This is a novel contribution that builds on our previous efforts.[3]

We find that there was a significant positive trend in stock return correlations among the sample LCBOs during the 1990s. This finding is consistent with the view that the potential for economic shocks to become agents of systemic risk in the financial sector appears to have increased over the last decade. In addition, consolidation at the sample LCBOs appears to have contributed to LCBO interdependencies during the sample period. However, consolidation elasticities of correlation exhibit substantial time variation, and likely declined in the latter part of the decade. Thus, factors other than consolidation have also been responsible for the upward trend in return correlations.

The paper proceeds as follows. Section I defines systemic risk, focusing on the critical need for interdependencies between firms and the central role of the largest and most complex banking organizations. Section II presents our measure of total interdependency, and

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[2] See Group of Ten (2001), chapter IV.

[3] Group of Ten (2001), chapter IV.

describes and interprets trends in this measure over the 1990s. Section III describes our measure of consolidation. Section IV presents estimates of the consolidation elasticity of correlation, and the final section concludes.

II. Defining Systemic Risk

Systemic financial risk is the risk that an event (shock) will trigger a loss of economic value or confidence in, and attendant increases in uncertainty about, a substantial portion of the financial system that is large enough to, in all probability, have significant adverse effects on the real economy.[4] Two critical and related features underlie this definition. First, economic shocks may become systemic because of the existence of negative externalities associated with severe disruptions in the financial system. In a decentralized banking and financial system such as that in the United States, this normally implies the need for contagion effects running from one firm to other firms. In highly concentrated financial systems, such as those in the Netherlands and Switzerland, the failure of a single major firm could be a systemic event. The potential existence of negative externalities between financial institutions is the aspect of systemic risk that drives the analysis in this paper. However a second feature, not addressed further here, is also central to a broader consideration of systemic risk. Namely, in our view truly systemic financial events must be highly likely to induce undesirable real effects, such as substantial reductions in output and employment.[5]

We use the implications of the need for externalities between financial firms to obtain measures of the potential for systemic risk in the financial sector. Specifically, we argue that for externalities to exist, firms must be interdependent in some way. Interdependencies can either be direct or indirect, and the size of a financial institution's total interdependencies (direct plus indirect) with other financial institutions, and the quantitative strength of these interdependencies across many firms will be key determinants of whether a shock to one (or a small number of) financial institutions has the potential to become systemic.

Direct interdependencies arise from inter-firm on- and off-balance sheet exposures. A straightforward example is exposures arising from inter-bank loans through the federal funds market. Another would be direct interdependencies through counterparty credit exposures on derivatives and repurchase agreements. More subtle examples include direct interdependencies arising from payment and settlement relationships, such as the credit,

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[4] This is the definition used in the Group of Ten (2001). Excellent discussions of systemic risk, including thoughtful reviews of the literature may be found in De Bandt and Hartmann (2000) and in Dow (2000).

[5] This definition is consistent with most definitions of systemic risk proposed in the literature. However, it is stricter than some because it explicitly requires that (i) the negative externalities of a systemic event extend both to agents in the financial system and to the real economy, and (ii) these externalities are highly likely to occur.

account, and other direct connections between settlement banks and other banks, broker dealers, and so-called "market utilities" such as the Depository Trust Company.

Indirect interdependencies arise from exposures to the same or similar assets, and possibly from other sources. Important examples are potential losses caused to several institutions through the loan participation market, loan concentrations to the same industry, or otherwise highly correlated portfolios. Indirect interdependencies are the mechanism through which it is possible, as was noted in the Introduction, for *individual firms* to have become more diversified, but for the *banking system* to have become more vulnerable to a systemic shock.

In the United States, systemic risk concerns have focused traditionally on the implications of bank deposit runs for the payments system, the money supply and financial intermediation. However, the advent of deposit insurance, an understanding of the need to maintain an adequate supply of money and money market liquidity, and the development of prudential supervision and regulation have essentially eliminated the threat of deposit runs by retail customers (primarily households and small businesses) of insured depositories.[6]

Indeed, systemic deposit runs and flights to currency have not occurred in the United States since World War II. As a result, discussion of systemic risk has shifted more to consideration of issues raised at the wholesale level.[7] In practice, this means concentrating attention on the largest and most complex financial institutions. This refocusing has been reinforced by the forces of technological change, deregulation, globalization and the increasing use of financial markets that have been driving the rapid evolution of the U.S. and global financial systems. For all of these reasons, this paper is limited to attempting to clarify the relationship between systemic risk, the largest and most complex banking organizations, and consolidation activity at such institutions.

In order to conduct empirical work, the set of financial institutions that has the potential to impose systemic risk must be defined. One approach would be merely to use some arbitrarily defined group of the very largest institutions. However, recent developments in banking supervision allow us to adopt a more refined procedure. The sample of banking organizations used here includes firms that have been identified by Federal Reserve supervisors as large and complex banking organizations, or LCBOs.[8] In general, LCBOs (i) have significant on-

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[6] Estimates from the Federal Reserve Board's 1998 Survey of Consumer Finances indicate that only 2 percent of U.S. households that hold deposits have uninsured deposits in U.S. depository institutions. Uninsured deposits are estimated to represent about 14 percent of total household deposits. For more on the 1998 Survey of Consumer Finances see Kennickell et al. (2000).

[7] Wholesale financial services include the provision of intermediation, investment banking, securities trading, asset management and payments services to corporations and other institutions. Excellent discussions of the changing nature of systemic risk are found in Bank for International Settlements (September 1998) and Chapter IV of International Monetary Fund (1999).

[8] LCBOs are discussed in DeFerrari and Palmer (2001) and Group of Ten (2001), pp. 132–135. The Federal Reserve does not publish a list of the names of LCBOs, and for that reason we do not identify the names of the

(continued)

and off-balance sheet activities; (ii) offer a broad range of products and services at the domestic and international levels; (iii) participate extensively in large-value payment and settlement systems; and (iv) are of substantial size.

It is important to understand that the set of LCBOs is not homogeneous, and even simple comparisons reveal clear variations in business mix. Indeed, market participants report that, for purposes of analysis, they typically divide large banking institutions into so-called "peer" groups.[9] For these reasons, we divide the sample LCBOs into five peer groups that have been identified by bank supervisors. These groups correspond roughly to a declining degree of complexity. "Active Trading" firms are distinguished in terms of their trading and derivatives activities, as well as in other dimensions such as global and custodial activities. The characteristics of "Second Tier" companies resemble some aspects of the Active Trading firms, but with somewhat less intensity. A group of "Trust and Custody" organizations have substantial fiduciary businesses and a range of complex trading or other activities that support those businesses. A "Cusp" set of banking organizations with predominantly traditional activities have commenced specialty businesses and expanded in ways that make them look somewhat like the Second Tier firms. Lastly, a group of relatively more "Traditional Intermediaries" continues primarily to fund themselves with deposits and to make loans.

For supervisory purposes, the set of LCBOs is fluid, and can change due to developments at either the individual firm or in the overall industry. DeFerrari and Palmer (2001) report that since the program's formal establishment in 1999, the number of LCBOs has been in the range of 25 to 30 institutions.

III. Trends in Total Interdependencies

This section first defines our measure of total interdependency, and describes our LCBO sample in more detail. It then describes and interprets the evolution of our measure of interdependency over the sample period.

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banking organizations included in this study. Suffice to say that the largest banking organizations are included in our sample. In addition, a list of the 50 largest U.S. bank holding companies as of December 31, 1998 and which ones were considered LCBOs are reported in Study Group on Subordinated Notes and Debentures (1999), p. 29.

[9] See, for example, Study Group on Subordinated Notes and Debentures (1999).

A. Definition of Interdependency

Total interdependencies are measured by the correlations of percentage changes in LCBO stock prices (hereafter also called returns).[10] Stock prices seem ideally suited to this purpose, because they reflect market participants' collective evaluation of the future prospects of the firm, including the total impact of its interactions with other institutions. Thus, a fundamental assumption of our analysis is that an observed increase in correlations among LCBO stock returns (due, as discussed above, to increased direct or indirect interdependencies) may signal an increase in the potential for a shock to become systemic. Conversely, discovery of no change or a decrease in correlations would be consistent with the view that systemic risks had not increased or even declined.

For each year from 1988 through 1999, weekly percentage changes in stock prices are computed for each of the sample LCBOs. Following convention, cross-correlations of returns between pairs of firms are computed using a 52-week rolling window.[11] As reported below, these correlations are evaluated in a variety of ways.

Because the focus of this study is on U.S. firms, a sample of U.S.-chartered and -owned LCBOs is used.[12] Sample selection and data construction proceeded in two steps. First, the 18 U.S.-chartered and -owned LCBOs in existence on December 31, 1999 were identified. Second, inspection of the sample led to the addition of four more LCBOs that did not exist at the end of 1999, because they had been acquired by another firm. However, because the acquisition of these four firms occurred not earlier than year-end 1997, and because supervisors had informally classified each as an LCBO in 1998, we decided to, where possible, include all four firms in the sample. Thus, for the vast majority of the sample period the number of sample firms is constant at 22 LCBOs.

It is noteworthy that the importance of the sample LCBOs has risen substantially in recent years. For example (and as described in more detail in Section III), their share of the total assets of U.S. bank holding companies and independent banks grew steadily from 34 percent in 1988 to 69 percent in 1999. In addition, because the LCBO program was only formally established in 1999, it is not possible to "officially" identify LCBOs going back into our sample period. Thus, we examine the same 22 firms over the entire sample period.

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[10] Stock prices of LCBOs are end-of-Friday quotes taken from Bloomberg. Stock prices are adjusted for stock splits and other factors except changes in dividends. However, for our sample changes in dividends in weekly data are not an important concern.

[11] See Engle (2000) and Campbell, et al (2000). Also following convention, as noted where appropriate below, the rolling window methodology is sometimes not used.

[12] Foreign banking organizations account for about one-third of the LCBOs. See DeFerrari and Palmer (2001).

B. Trends in Interdependency

Figures 1 and 2 present our first descriptions of how LCBO interdependencies evolved during the 1990s. Figure 1 plots the mean and median 52-week rolling-window correlations between the 231 LCBO pairs from 1990 through 1999. Although there is considerable variability in the series, a substantial jump in both the mean and median correlations is evident beginning in 1996 and continuing through the rest of the decade.

The conjecture of an increase in return correlations is supported by the data summarized in Figure 2, which shows average R-squared statistics for two sets of "market model" regressions estimated for each individual firm for each week using a rolling-window set of observations. The solid line gives the mean R-square for a two-index market model estimated for the LCBOs for each week in the sample. The two indexes include the S&P 500 market index, a measure of overall market returns, and an LCBO index computed by the authors of equally weighted LCBO returns that is constructed to be orthogonal to the S&P index.[13] The dashed line summarizes results using only the S&P 500 index as an independent variable.

Both models show a marked increase in mean and median R-square beginning in 1996, suggesting that the ability of overall market conditions, including common conditions at LCBOs, to "explain" returns at individual LCBOs increased in the latter part of the 1990s. Put differently, the models suggest that returns at LCBOs became more vulnerable to overall market conditions in the last half of the decade.

The inference that the increase in return correlations is driven, at least in part, by increases in exposures to common factors is supported further by the data summarized in Figures 3 and 4. Figure 3 shows increasing median beta coefficients for the single factor market model regression. Figure 4 exhibits the median beta coefficients associated with the market and the (orthogonalized) LCBO index of the second market model. Interestingly, when both indexes are included, it is only the beta associated with the LCBO index that increases through time. This suggests that increases in interdependencies among the LCBOs were an important driving force of the upward trend in correlations.

[13] The component of the equally weighted LCBO index orthogonal to the S&P index is the series of residuals of a regression of the LCBO index on the S&P index.

Figure 1. Mean and Median of LCBO Return Correlations

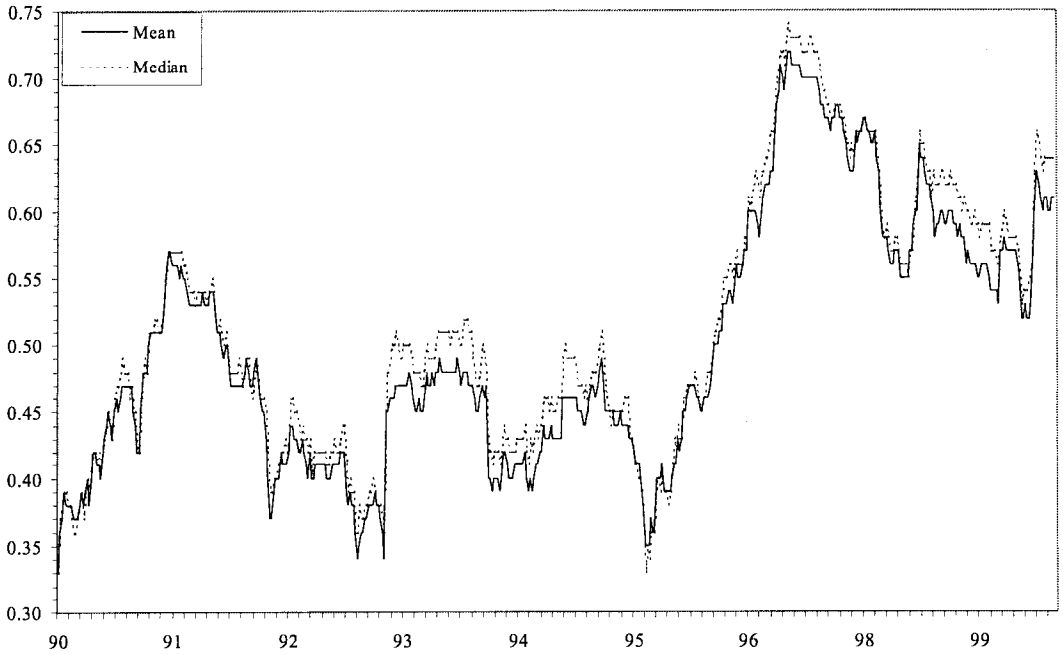


Figure 2. Two-Index and Market Model Average R^2 Statistics

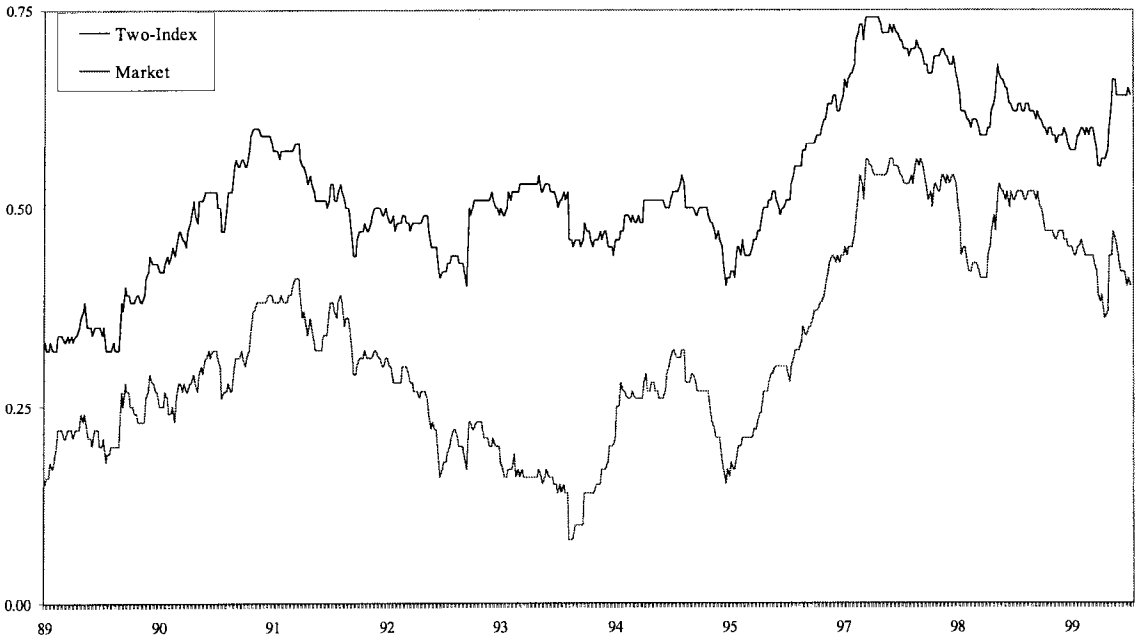
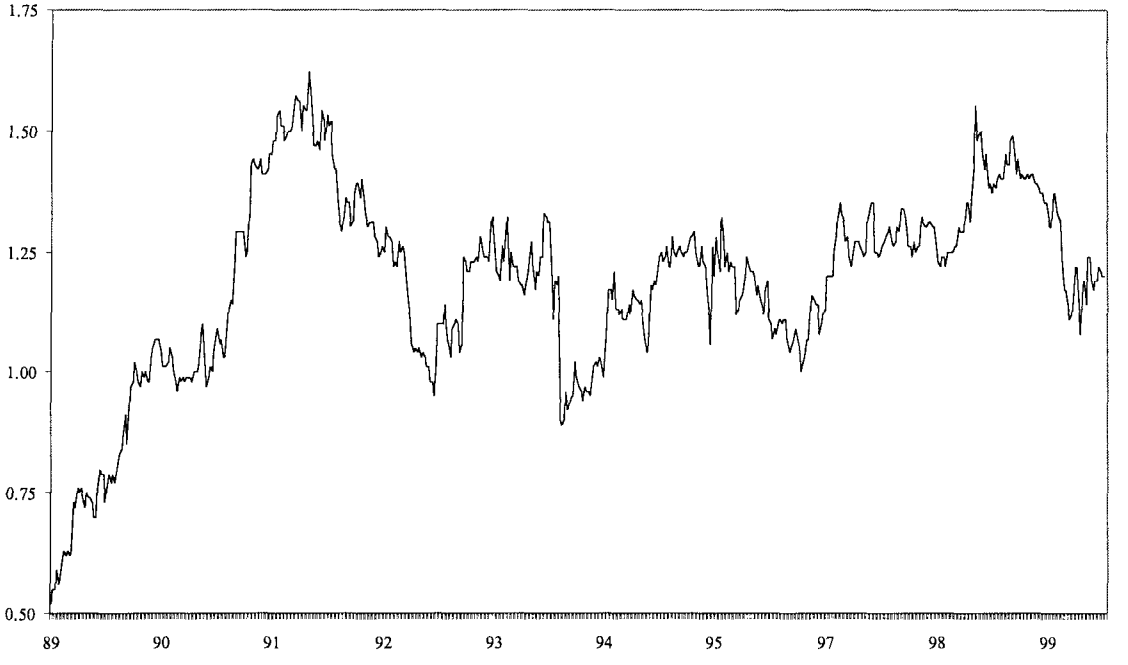


Figure 3. Market Model Median Beta

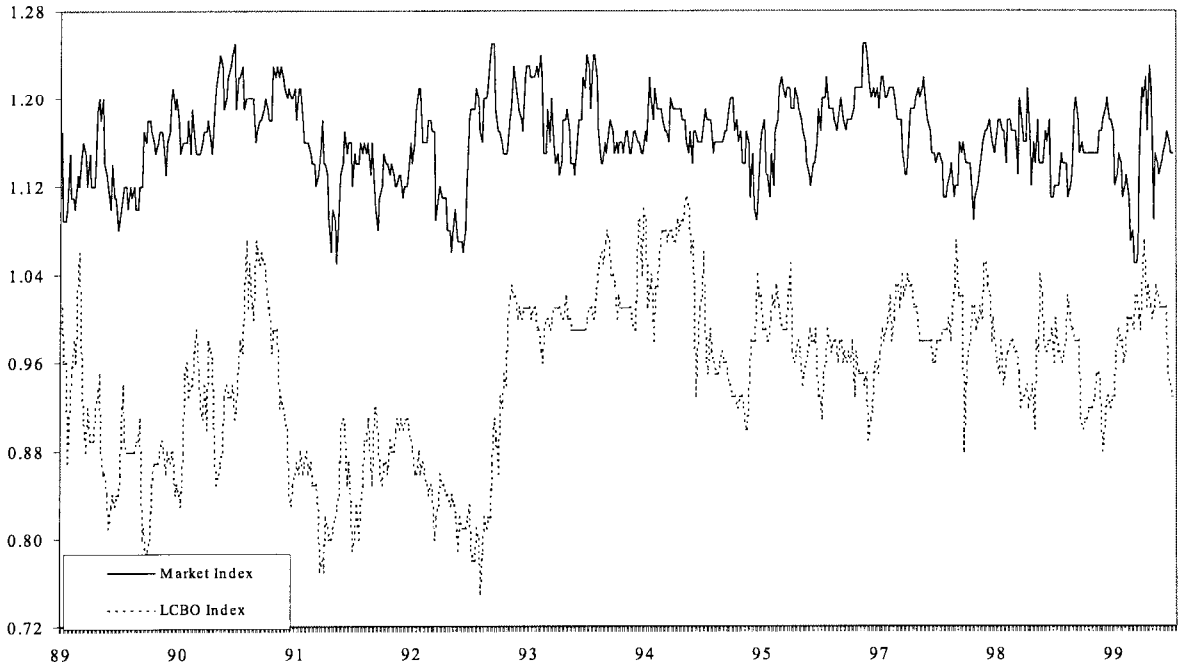


These results also indicate that the evolution of interdependencies was quite different at our sample LCBOs than among the vast majority of other publicly traded firms. In their mammoth study of stock returns, Campbell et al. (2000) "document the evolution of correlations among individual stocks by calculating all pair-wise correlations among stocks traded on the NYSE, AMEX, and Nasdaq" from 1962 through 1997, using both daily and monthly data.[14] Calculations with daily data use a one-year rolling window, and calculations with monthly data use a five-year rolling window. Their results show "a clear tendency for correlations among individual stock returns to *decline* (emphasis added) over time," and market model regressions comparable to the single index model used here display a declining trend in mean R-squares.[15]

[14] Campbell et al. (2000), p. 20. The number of stocks in their sample ranges from 1000 to 4500, and the number of pair-wise correlations from 500,000 to just over 10 million. Campbell et al. are primarily concerned with stock return volatility. Unfortunately, they do not report pair-wise correlation results for the banking industry or for relatively large firms in any industry. Thus it is possible that (at least some) large firms in (at least some) other industries could exhibit increases in return correlations similar to those we find for LCBOs. Even if true, however, such a finding would not obviate our interpretation of the LCBO results for systemic risk potential in the financial sector.

[15] Idem.

Figure 4. Two-Index Model Median Betas



Panels A and B of Table 1 provide a more disaggregated analysis of the time trends in LCBO stock return correlations over the sample period. In both panels, statistics are presented for the full sample of LCBOs, each of the five peer groups described earlier, and the ten possible combinations of the peer groups.

Panel A presents the mean raw correlations between pairs of individual firms aggregated, as suggested by chart 1, over the 1989–95 (column 2) and 1996–99 (column 3) periods. Looking first at the full LCBO sample, the mean correlation between firm pairs increased by some 37 percent, from 0.41 to 0.56 between the two sample periods. However, when the pair-wise correlations are divided into peer groups, more complex patterns emerge. Particularly large increases in group means are observed at the relatively less complex firms (Trust and Custody, Cusp, and Traditional), while changes are small or nonexistent at the groups containing the more complex institutions (Active Trading and Second Tier). When means are computed across peer group combinations, substantial increases in mean correlations are observed from the earlier to the later period in all ten possible combinations. However, the largest increases are concentrated at combinations of the less complex groups (2-3, 3-4, 3-5, and 4-5).

The relationships presented in panel A are only suggestive of a potential trend in correlations. As first pointed out by Ronn (1995), and later stressed by Boyer, Gibson and Loretan (1999), Forbes and Rigobon (1999) and English and Loretan (2000), observed increases in

Table 1. Time Trends in Stock Return Correlations

Mean Correlations	(1)	(2)	(3)
Group	Number of Correlations	1989–95	1996–99
ALL LCBOs	231	0.41	0.56
Active Trading (1)	10	0.47	0.55
Second Tier (2)	3	0.49	0.48
Trust & Custody (3)	6	0.34	0.62
Cusp (4)	6	0.44	0.61
Traditional (5)	15	0.41	0.67
1–2	15	0.44	0.55
1–3	20	0.37	0.52
1–4	20	0.43	0.51
1–5	30	0.41	0.49
2–3	12	0.39	0.54
2–4	12	0.43	0.55
2–5	18	0.45	0.56
3–4	16	0.37	0.56
3–5	24	0.37	0.62
4–5	24	0.43	0.59

Summary of Time Trend Coefficients

	(1)	(2)	(3)	(4)
Group	Number of Coefficients	Number of Coefficients >0 at 5 Percent Confidence Level	Percent of Coefficients >0 at 5 Percent Confidence Level	Percent of Coefficients <0 at 5 Percent Confidence Level
ALL LCBOS	231	109	47%	3%
Active Trading (1)	10	3	30	20
Second Tier (2)	3	2	67	0
Trust & Custody (3)	6	4	67	0
Cusp (4)	6	4	67	0
Traditional (5)	15	14	93	0
1–2	15	8	53	0
1–3	20	8	40	5
1–4	20	4	20	10
1–5	30	7	23	3
2–3	12	3	25	0
2–4	12	7	58	0
2–5	18	6	33	0
3–4	16	9	56	0
3–5	24	17	71	0
4–5	24	13	54	0

correlations computed on data of different time periods do not necessarily indicate increases in interdependencies. For example, under the assumption of bivariate normal returns, correlations measured in periods of high stock return volatility can be higher than those measured in periods of low stock return volatility even though the underlying correlation is constant.

In light of these findings, to detect time variation in correlations, we followed Longin and Solnik (1995) by estimating for each pair of LCBOs in the sample the GARCH constant conditional correlation model introduced by Bollerslev (1990) augmented with time trends in conditional variances, and tested the significance of a time trend included in the correlation equation. Specifically, for each of the 231 pairs of firms, denoted with indexes i and j, we estimated the following bi-variate GARCH model:

$$R(i,t) = a(i) + e(i,t) \quad (1)$$

$$R(j,t) = a(j) + e(j,t) \quad (2)$$

$$h(i,t) = b(i) + c(i)e(i,t-1)e(i,t-1) + d(i)h(i,t-1) + \lambda(i)\, t \quad (3)$$

$$h(j,t) = b(j) + c(j)e(j,t-1)e(j,t-1) + d(j)h(j,t-1) + \lambda(j)\, t \quad (4)$$

$$h(ij,t) = (\rho(i,j) + \Lambda(i,j)\, t)\ \sqrt{h(i,t)}\ \sqrt{h(j,t)} \quad (5)$$

Equations (1) and (2) are the return equations: R(i,t) (R(j,t)) denotes firm i (j) returns, a(i) (a(j)) denotes the unconditional mean of firm i (j) return, and e(i) (e(j)) is the innovation, or the unexpected return, of firm i (j). Innovations are assumed to be normal with mean 0 and 2x2 covariance matrix H(t). The diagonal elements of H(t) are the variances of firm i and j returns, denoted by h(i,t) and h(j,t) respectively. The off-diagonal elements of H(t), denoted by h(ij,t), are the covariances of firm i and j returns. Equations (3) and (4) are the variance equations, where we have added a trend term to control for time variation in conditional variances stemming from the volatility dynamics of the common factors driving returns. Importantly, the time trend also controls for decreases in variance due to diversification effects arising from consolidation.[16] Equation (5) is the correlation equation, which is also augmented with a time trend. Under the null hypothesis that the correlation between stock returns of firms i and j is constant, the coefficient associated with the time trend in the correlation equation, denoted with $\Lambda(i,j)$, should not be significantly different from zero.[17]

Panel B summarizes the results of this test by giving the total number of correlation time trend coefficients that are estimated to be statistically positive at the 5 percent level (column 2), the percent of all coefficients in a given group that are significantly positive (column 3), and the percent of coefficients in a given group that are statistically significant

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[16] Thus, our ability to detect increases in correlation caused by greater indirect interdependencies is somewhat reduced.

[17] As is standard, the model was estimated using the maximum of the conditional log-likelihood using the BHHH algorithm.

and negative (column 4). Looking at the row for all LCBOs, it is clear that positive coefficients are very common, with 47 percent estimated to be statistically positive, and only three percent (6 out of 231) negative. Dividing the coefficients by peer groups, the dominance of the positive time trend is evident for all but the Active Trading firms, where only 30 percent of the coefficients are estimated to be positive. Among the largest group, the Traditional Intermediaries, 93 percent of the time trend coefficients are significantly positive. Over 50 percent of the estimated time trends at inter-group combinations are significantly positive at half of the ten combinations of groups. As in panel A, the positive time trends are concentrated at the relatively less complex inter-group combinations, but not exclusively so. In addition, significantly negative time trends are quite rare, ranging from three to ten percent of coefficients at only three of the ten combinations of groups.

Overall, the results in this section strongly suggest that there was a significant positive trend in stock return correlations among the sample LCBOs during the 1990s. In addition, this trend was especially evident within and between the groups of relatively less complex financial institutions. Thus, given our maintained assumption regarding the interpretation of stock return correlations, the evidence is consistent with the view that the potential for economic shocks to become agents of systemic risk in the financial sector appears to have increased over the last decade.

C. Trends in Consolidation

The first part of this section defines our measure of consolidation at the sample LCBOs. The second describes the evolution of this measure over the 1990s.

Variable definition

We measure consolidation as the change in an institution's, or pair of institution's, market share. Market share is defined, in turn, by the ratio of an institution's (or pair of institution's) total assets to total assets in the U.S. banking system. Total assets in the U.S. banking system are computed as the sum of total consolidated assets at bank holding companies plus total assets at independent banks.[18] This straightforward measure has considerable intuitive appeal, although it ignores off-balance sheet activities. However, because the primary goal is to create a variable that captures important consolidation events within the sample LCBOs, this deficiency is not a serious concern. Indeed, inspection of the data for the 22 sample LCBOs indicates that any completed major acquisition recorded by the federal banking agencies is matched by a jump at the same date in an acquirer's market share.

[18] Total assets data were acquired from holding company "Y9" and bank "call" reports submitted to the federal banking agencies.

Trends in consolidation

Figures 5 and 6 present two ways of describing consolidation activity at the sample LCBOs from 1988 through 1999. Figure 5 gives the (quarterly) evolution of market shares aggregated at the 22 LCBOs' level, and aggregated within each of the five peer groups. In each of the peer group figures, the aggregated LCBO market shares are also provided by a dashed line with their scale given on the right hand side of the figure. In each figure, group shares are calculated by weighting each individual institution's share by its total assets. Figure 6 provides the percentage changes in the market shares shown in Figure 5. As in Figure 5, aggregated LCBO figures are given by dashed lines and may be read on the right hand scale.

Figure 5 shows that the aggregate market share of the sample LCBOs increased steadily and substantially over the sample period, rising from 34 percent in 1988: Q1 to 69 percent at the end of 1999, after peaking at 73 percent in 1998: Q4 and 1999: Q1. Active Trading, Cusp, and Traditional Intermediaries determined the overall trend. Consolidation activities at Second Tier firms were muted until 1998, and Trust and Custody institutions experienced a burst of activity early in the period that moderated thereafter. Consolidation activity at the aggregate LCBO and the peer group levels fell off in 1999 as merger and acquisition activity waned. On balance, however, these data indicate that a substantial amount of consolidation activity occurred among the sample LCBOs during the decade of the 1990s.

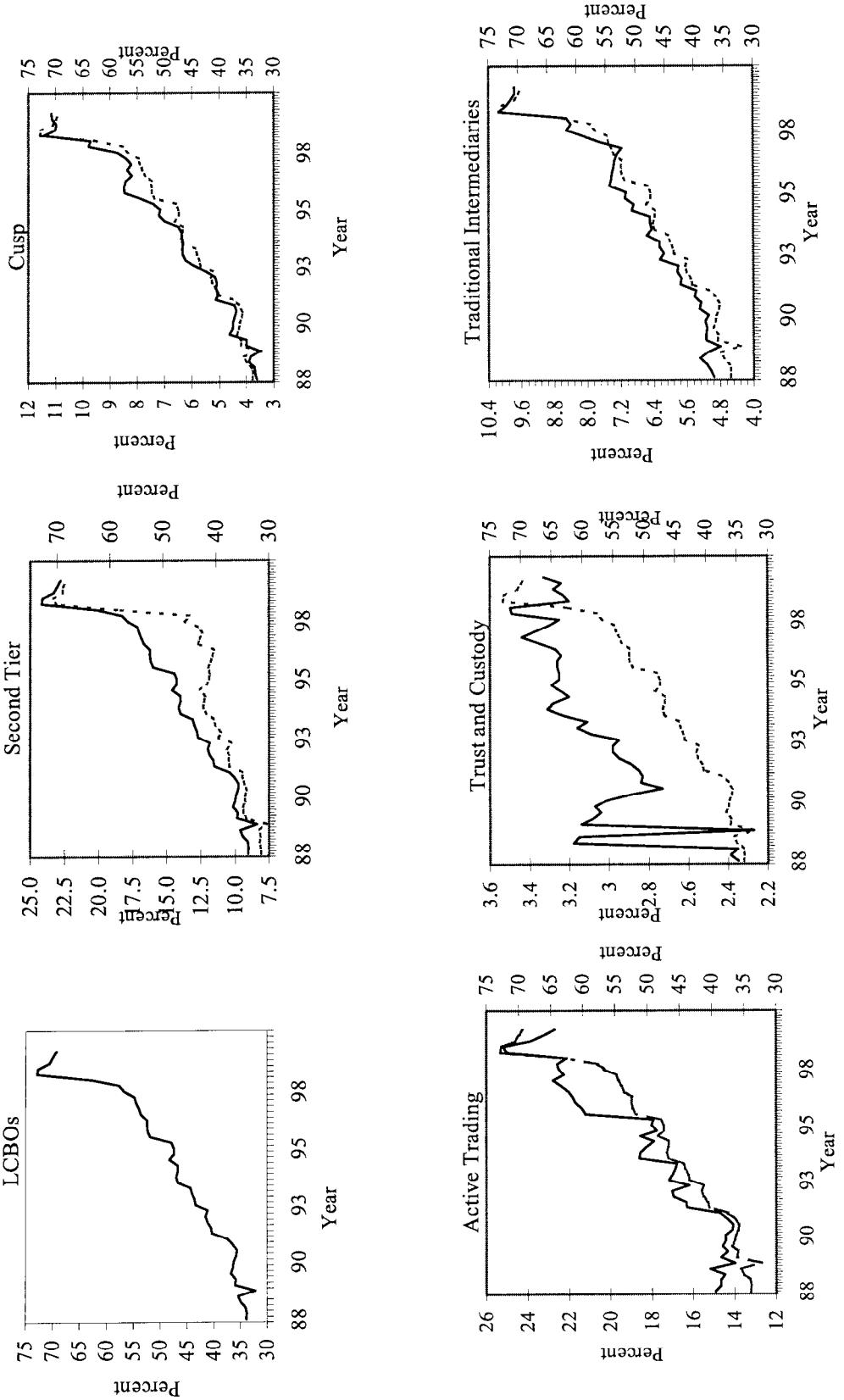
This overall view is supported by the data displayed in Figure 6. As measured by quarterly percentage changes in market share, substantial activity occurred throughout the period at the aggregate LCBO level and at the Active Trading, Second Tier, Cusp, and Traditional Intermediaries. Again, Trust and Custody firms had a spurt of activity early in the period, and then essentially maintained their market share for the rest of the 1990s.

IV. Relating Interdependencies and Consolidation

We examine the relationship between LCBOs' stock return correlations (interdependencies) and consolidation by estimating the elasticity of return correlations with respect to LCBO market shares. We call this measure the consolidation elasticity of correlation. We begin by considering a pooled time series cross-section model estimated at annual frequency. However, due to the clear time variability of our results and the availability of higher frequency data, we also evaluate cross-section regressions estimated at weekly frequency.

Our observation unit in all models is a firm-pair. In the pooled time series cross-section model, for each year in our sample we compute the correlation of returns associated with a different pair of firms. Since our sample includes at most 22 firms in each year, we compute

Figure 5. Evolution of LCBO Market Shares



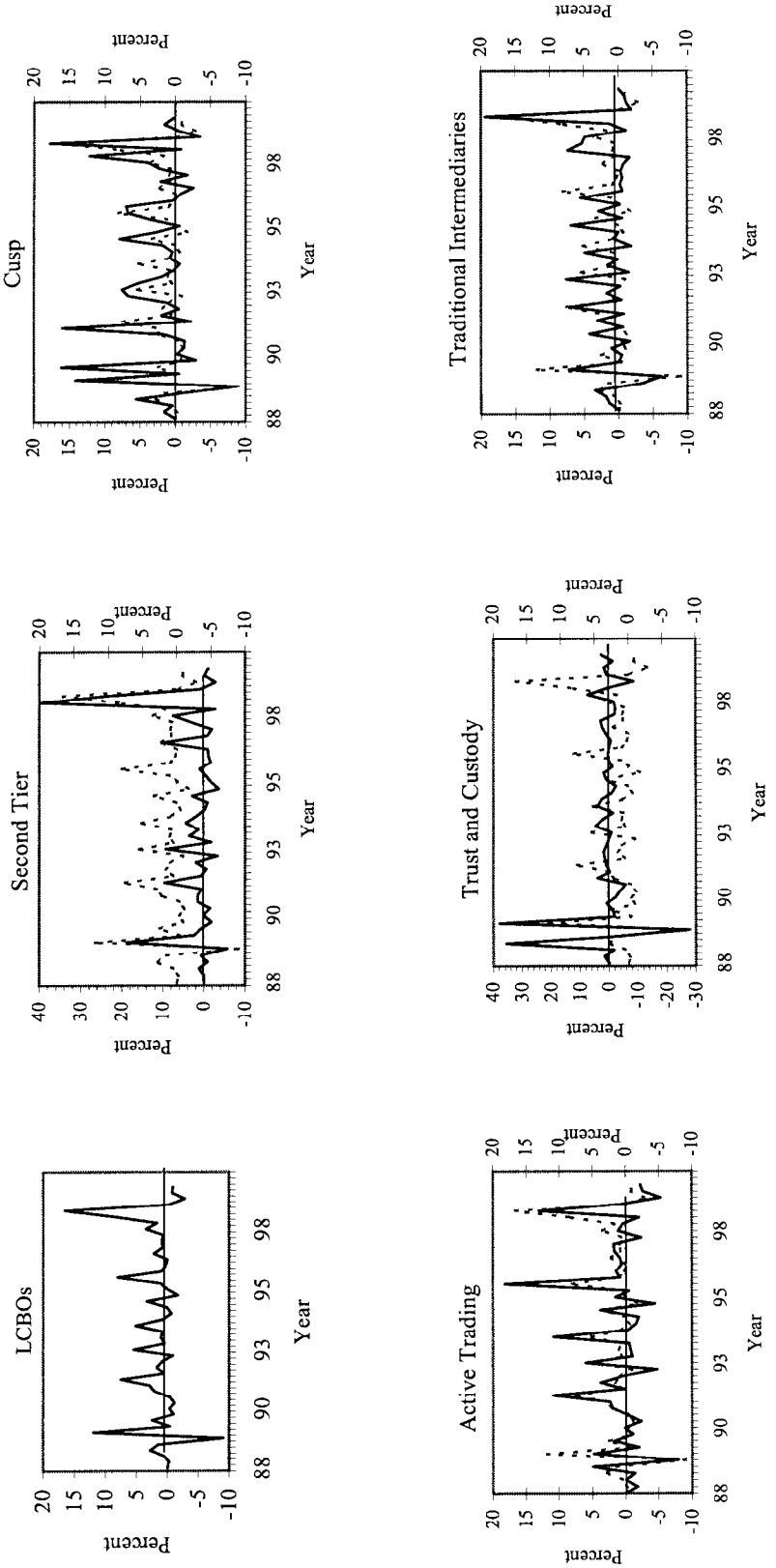


Figure 6. Percentage Change in LCBO Market Shares

at most 231 correlations associated with a different pair of firms in each year. The stock return correlation among a pair of firms in year t is computed using weekly stock return data of the 52 weeks preceding the last week of year t. The market share of a firm pair is the sum of the market shares of each firm in the pair at the end of year t.

Our "basic" equation estimated on non-overlapping yearly data is:

$$\text{Ln}(Z(k,t)) = \alpha'\alpha(t) + \beta\ \text{Ln}(X(k,t-1)) + \gamma\ \text{Ln}(Z(k,t-1)) + \varepsilon(k,t) \qquad (6)$$

The independent variable Z(k,t) is $\text{Ln}[(1+\rho(k,t))/(1-\rho(k,t))]$, a monotonic transformation of $\rho(k,t)$, where $\rho(k,t)$ denotes the correlation of any firm-pair k in year t. The variable X(k,t-1) is the sum of market shares of the two firms in firm-pair k in year (t-1). Time fixed-effects are indicated by the vector $\alpha(t)$, which includes time dummies assuming the value of unity for year t and zero otherwise, with α' denoting the transpose of the relevant coefficient vector. Time fixed-effects are introduced to control even at the annual level for the substantial time variation of correlations documented in section II. The lagged value of Z is included as an approximate control for other factors that may determine current correlation.

The coefficient β estimates the consolidation elasticity of correlation. Specifically, it estimates the percentage change in (a monotonic transformation) of stock return correlation associated with a lagged percentage change in the market share of a firm-pair. The specification of a lag for the consolidation variable is consistent with our assumption that consolidation may be a causal factor in the increased correlation of returns documented in section II.

Table 2 presents estimates of equation (6) in which all firm-pairs are pooled (panel A) and in which we allow for different consolidation elasticities within groups and between groups (panel B). To save space, time fixed-effects coefficients are not reported. Looking first at panel A, the estimated consolidation elasticity is 0.077 and is significantly different from zero. Thus, a 10 percent increase in firm-pair market shares implies a 0.8 percent increase in (a monotonic transformation of) correlation. Put differently, during the 1988–99 period an increase in consolidation is estimated to have contributed to an increase in LCBOs' interdependencies, as measured by the correlations of their stock returns.

Turning to panel B, both consolidation elasticities are significantly positive, and the fact that the estimated consolidation elasticity for between-group correlation is 0.083, whereas that estimated for within-group correlation is 0.069, suggests a difference in the effects of consolidation across the two groups. A standard dummy variable test of the statistical significance of this difference reveals that the difference is significantly different from zero at the 5-percent level. Thus, it appears that consolidation among relatively dissimilar firms has tended to have a larger positive impact on correlation (interdependency) among firms' returns than has consolidation among firms with more similar degrees of complexity. These results are consistent with the view that consolidation has tended to make at least some firms look more alike.

Table 2. Estimated Consolidation Elasticities
Pooled Time Series Cross-Section Regressions
Fixed-Time Effects

A. Equal within-group and between-group consolidation elasticity of correlation

$$\text{Ln}(Z(k,t)) = \alpha'\alpha(t) + 0.077\ \text{Ln}(X(k,t-1)) + 0.292\ \text{Ln}(Z(k,t-1)) + \varepsilon(k,t)$$

t-stat	(5.58)	(13.27)
p-value	(0.00)	(0.00)

Adjusted R2 = 0.44

D.W.=2.03

B. Different within-group and between-group consolidation elasticity of correlation

$$\text{Ln}(Z(k,t)) = \alpha'\alpha(t) + 0.069\text{Ln}(XW(k,t-1)) + 0.083\ \text{Ln}(XB(k,t-1)) + 0.287\ \text{Ln}(Z(k,t-1)) + \varepsilon(k,t)$$

	Within-group	*Between-group*	
t-stat	(5.01)	(5.84)	(13.12)
p-value	(0.00)	(0.00)	(0.00)

Adjusted R2 = 0.44

D.W.=2.03

On balance, the results presented in this section suggest several general conclusions. First, over the 1990s it appears that increases in consolidation at the sample LCBOs contributed to increases in LCBOs' interdependencies, increases that are both statistically and economically significant. Moreover, consolidation among relatively dissimilar firms has tended to have a larger positive impact on interdependency than has consolidation among firms with more similar degrees of complexity. However, the estimated consolidation elasticities clearly vary over time, and likely declined in the latter part of the decade.

As documented in section II, time variation in correlations has been pervasive during our sample period. In addition, and as documented in section III, consolidation activity at the sample LCBOs has been intense during the period, but has proceeded in waves of different intensity for different peer groups. Depending upon the peer group, consolidation has been intense at the beginning of the period, sustained during the period, and intense in the last year of the period. The time variations in both correlations and consolidation activity raise the question of whether the impact of consolidation on correlations is time varying.

To test for time variation in the consolidation elasticity, we estimate cross-section regressions of equation (6) using the highest frequency time series data available to us—weekly data for

correlations and quarterly data on market shares. For each of the 520 weeks running from 1990.1 to 1999.52, we estimate equation (6) using correlations computed with a 52-week rolling window, and market shares of firm pairs observed in the previous quarter (i.e. lagged 13 weeks). As in the annual regression, lagged correlation is controlled for with correlations lagged 52 weeks.

Figure 7 summarizes results for the basic (constant elasticity across all groups) cross-sectional specification of equation (6). The top panel displays the time-series of the estimated consolidation elasticity, which clearly shows substantial variation over time. It starts off relatively high at the beginning of the sample period, decreases between the end of the 1980s through the beginning of 1994, increases sharply during 1994–96, and then falls off quickly crossing 0 at the beginning of 1997, and becomes negative for most of the end of the sample period.

The middle panel of Figure 7 reports the time series of p-values of the t-statistic of the consolidation elasticity. The dotted line indicates the 10 percent value (0.10), so that all values below the line are significant at least at the 10 percent level. These tests confirm the time variability of the estimated elasticity. Consolidation is estimated to have significantly positive effects at the very beginning and in the middle of the sample period, but quite mixed effects are found in 1991–93 and towards the end of the sample period. These patterns are also reflected in the time series of the R-squares of the regressions, shown in the bottom panel of Figure 7, which are largest in the middle of the 1990s. Figure 8 reports elasticity estimates and relevant p-values for within-group and between-group regressions in the same format as Figure 7. Overall, the panels of the chart show that the time variation of within-group and between-group consolidation elasticities is very similar.

Figure 7. Evolution of Consolidation Elasticity

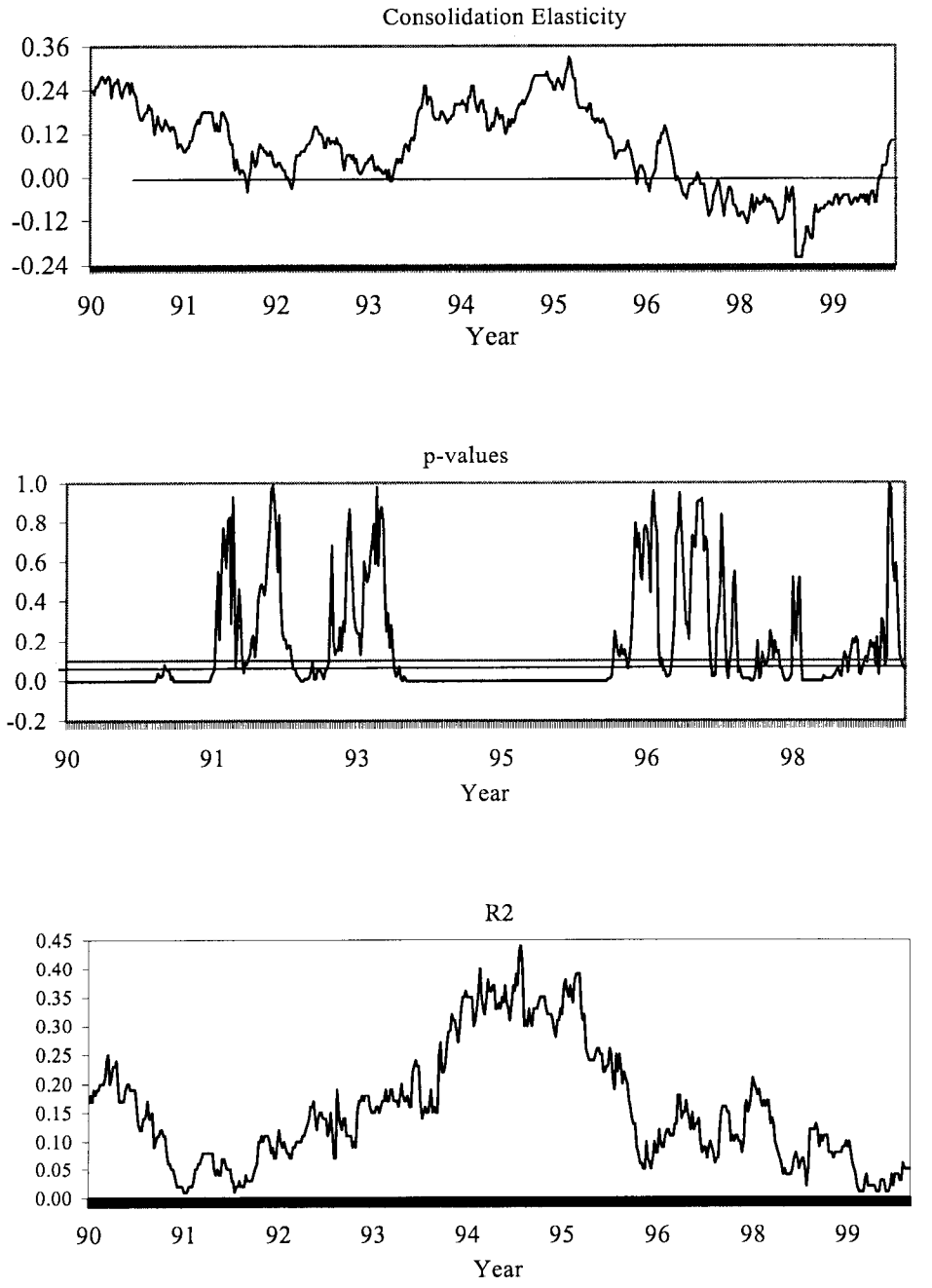
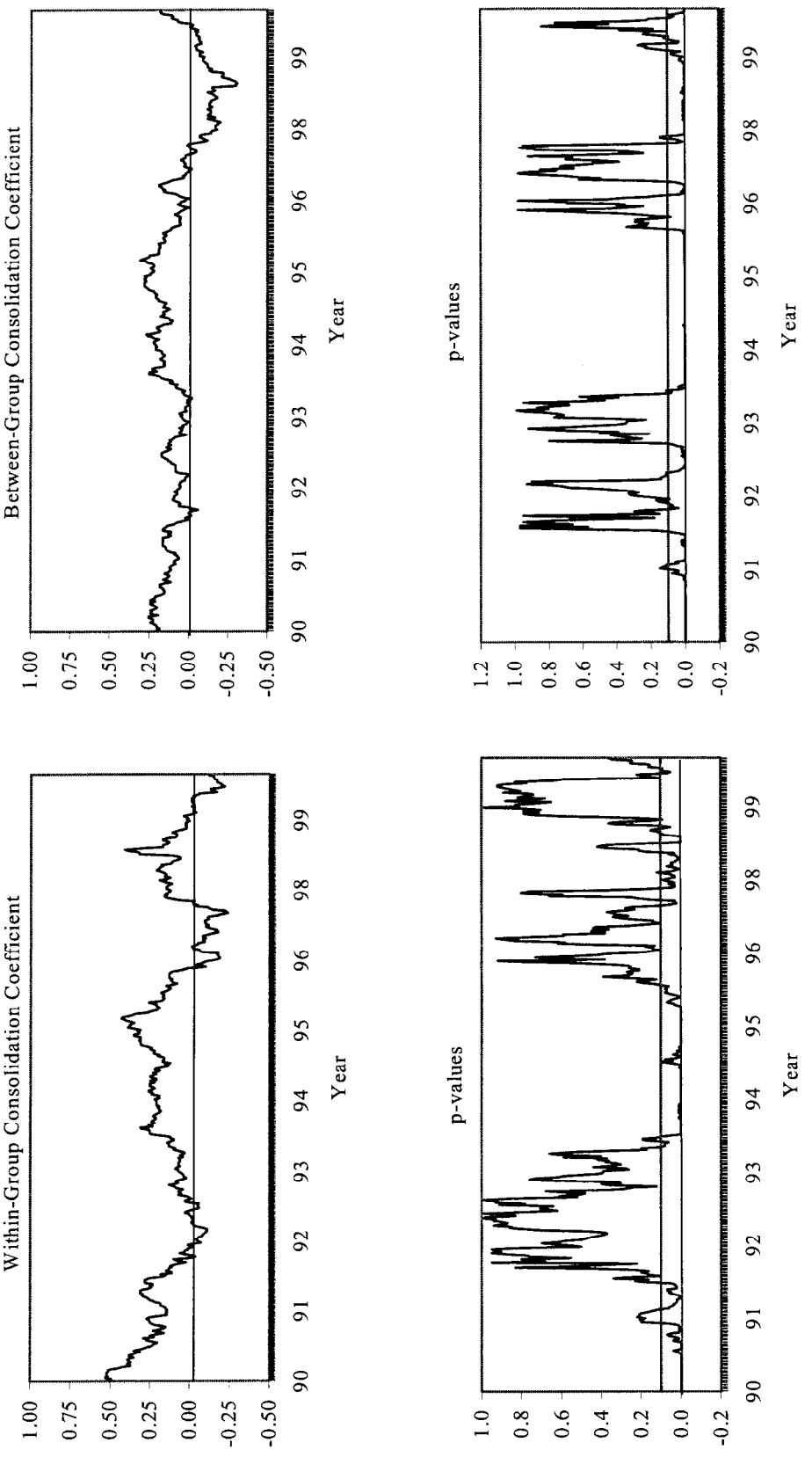


Figure 8. Evolution of Within-Group and Between-Group Consolidation Coefficients



V. Conclusion

This study has considered two basic questions. First, has the degree of interdependency, and by implication the degree of systemic risk potential in the banking system, among a sample of large and complex banking organizations changed over the 1990s? Second, has the degree of interdependency been associated with consolidation activity at the LCBOs?

With regard to the first question, the evidence is highly consistent with the view that there was a significant upward trend in the degree of interdependency, as measured by stock return correlations, among the sample LCBOs during the 1990s. This trend seems particularly evident within and between the groups of relatively less complex banking organizations. This suggests that the potential for economic shocks to become agents of systemic risk in the financial sector has likely increased over the last decade.

The answer to the second question is more complex. Statistical tests suggest that consolidation activity at the sample LCBOs indeed had a positive effect on the degree of interdependency. Moreover, the effect may have been stronger among relatively dissimilar firms. However, the strength of the positive effect varies considerably over time and appears to have waned in the latter part of the 1990s. In addition, the variables considered here, including consolidation and lagged correlation, generally "explain" well under half of the variation in stock return correlations. Thus, it seems clear that factors other than consolidation are also responsible for the upward trend in stock return interdependency. Identifying what these factors are seems a fruitful topic for future research.
Another interesting topic for future research is identification of the sources of increased interdependency among LCBOs and the role, if any, of consolidation in creating these sources. Research conducted by the authors as part of the recently completed G10 Report on Consolidation in the Financial Sector (2001) took some steps in this direction. As documented in that Report, it appears that LCBO direct interdependencies through short-term interbank lending and derivatives exposures increased substantially over the 1990s.
In addition, direct interdependencies appear positively related to consolidation through short-term interbank lending and derivatives activities. Medium- to longer-term interbank loans did not appear either to have been associated with raised interdependency among LCBOs or to have been affected by consolidation. These results, although suggestive, deserve further investigation. In addition, we know of no studies of indirect interdependency, such as any tendency for loan portfolios to be correlated across firms.

The results of this study reinforce the view that policymakers should pay close attention to the implications of the changing financial landscape for systemic risk. Some consolidation of the banking industry and the creation of large and complex financial institutions capable of competing on a global basis may have many benefits, but it appears that these developments, and others not examined here, also may create somewhat different, although not necessarily new, risks.

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