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Structure and Performance: Some Evidence from California Banking

Randall J. Pozdena*

The "Structure-Performance Hypothesis" has been the subject of controversy for 35 years. One aspect of this controversy is the difficulty of measuring the economic performance of firms. In this paper, data on the rate of bank entry in California banking markets is used in a new, indirect test of the hypothesis. The results are consistent with the idea that increased concentration is associated with increasingly high profits.

Anti-trust policy toward the banking industry rests partly upon the premise that increased concentration of market share causes a deterioration in the performance of banking firms. As concentration increases in a market, according to the premise, so too does stable, anti-competitive conduct (such as overt or tacit collusion). Known in the industrial organization literature as the structure-performance hypothesis, this premise has been debated hotly for over thirty years on both theoretical and empirical grounds.

This paper re-examines empirically the link between structure and performance by indirectly using data from California banking markets. In particular, we study the relationship between the structure of California banking markets and the rate of bank entry. Although entry is not *per se* a performance measure, its study provides some insight into the relationship between structure and performance without many of the conceptual and measurement problems encountered in using direct performance measures such as profits and prices.

Our results are consistent with the contention that increased concentration is associated with

increasingly high profits. In addition, we find that at any given level of concentration, entry rates are higher in markets with a large number of suppliers. This latter finding is consistent with the notion that entry-limiting pricing discipline is difficult to sustain when the number of producers becomes large. These findings, thus, reinforce the arguments that support anti-trust policy. As we discuss below, however, such evidence of a structure-performance link is only one step in the logic that supports a policy of active manipulation of market structure to improve market efficiency.

The remainder of the paper is organized as follows. First, we discuss the origins of the formal structure-performance hypothesis and the various theoretical and empirical criticisms of its study and use in anti-trust policy. Second, we discuss the rationale of structure-entry tests as an alternative to conventional structure-performance studies. After discussing the data and empirical findings, the paper concludes with a summary of the findings and their policy implications.

I. The Structure-Performance Relationship

The notion that market structure influences performance originates from observations about the

theory of the firm. In a world characterized by pure and perfect competition, for example, theory argues that firms in the marketplace will perform in a socially desirable fashion, producing where price

* Senior Economist, Federal Reserve Bank of San Francisco.

equals marginal cost and enjoying only “normal” profits. One of the attributes of the perfect competition model is that production is performed by many firms, each too small to influence market prices. Thus, in the classic model of competition, low concentration of market share is associated with socially desirable performance.

In contrast, under circumstances of pure monopoly — where there is, by definition, only one producer and, thus, complete concentration of market share — socially undesirable performance results. Under such performance, price exceeds marginal cost and leads to sub-optimal production and “excess” profits. In this case, concentration of market share is associated with undesirable performance.

Understandably, the implications of these two special models of the firm — perfect competition and pure monopoly — spawned the notion that markets displaying an intermediate level of concentration might, therefore, perform in a manner between these extremes. Since most markets are not characterized by the features of the simple perfect competition or monopoly models, such a notion is of practical interest. Economic theory, however, does not articulate clearly the association between concentration of market share and performance in imperfectly competitive models.

The notion that a monotonic relationship might exist between market share concentration and performance is thus a purely empirical one. It was first advanced by the economist Joe S. Bain in the late 1940s.² He hypothesized that the ability of firms to engage in overt or covert collusive behavior increases as the concentration of market share increases. In the process, the likelihood that the firms would display anti-competitive or quasi-monopolistic performance also rises. Bain first tested this hypothesis in 1951 using reported profits of the firm as a measure of performance.³ He found that increased concentration, indeed, was associated with higher profit rates and this result started the structure-performance controversy.

Criticisms of Structure-Performance Studies

Structure-performance studies are controversial for a number of reasons. First, discovering an asso-

ciation between market concentration and performance does not establish market concentration as the *cause* of the observed performance and, thus, does not by itself provide a rational basis for a policy of manipulating market structure to improve performance.

It has been argued, for example, that the higher profits observed to be enjoyed by large firms in concentrated markets are the result of economies of scale and the consequent superior efficiency of large firms. This claim seems particularly relevant in the context of the early structure-performance studies, which examined a cross-section of industries displaying different market share concentration levels. The firms in such a sample undoubtedly faced different technological and demand conditions that had the potential of systematically affecting a performance measure such as profit, as well as a structural characteristic such as market share concentration.⁴

For studies *within* an industry, such as the numerous structure-performance studies of the banking industry, this particular criticism is less likely to be relevant. The possibility remains, however, that a third factor positively related to both concentration and price or profit performance measures statistically links concentration and performance, giving the appearance of a direct, casual link when none exists.⁵

A second major criticism of structure-performance studies is that the structure-performance notion hypothesizes a relationship between structure and inefficient firm behavior but most studies have used performance measures that may not unambiguously detect such inefficiency. The use of published data on profits to proxy true economic profits, for example, is notoriously flawed. In an industry such as banking, where accounting relies heavily on book valuation of assets and liabilities, reported net income flows, rates of return on assets, and net worth are of dubious empirical usefulness. Moreover, expense-preference theory suggests that firms enjoying market power may express inefficiency by indulging in objectives other than maximizing shareholder profit. Such behavior would argue against finding a consistent relationship between structure and measured profits.⁶

Similar criticisms have been leveled against the

use of price as a performance variable. In most industries, including banking, the products offered by firms are not homogeneous, but rather vary in quality, attendant service characteristics and other attributes. In banking, for example, the proximity of branching facilities, availability of automated teller machine services, and many other service attributes are relative dimensions of the "price" of deposit or loan services (indeed, prior to the elimination of deposit rate regulation, this was the *only* dimension of competition for certain types of bank liabilities.) If the non-price attributes of bank products vary systematically with concentration because of their mutual association with a third factor, spurious relationships between concentration and price performance may appear when none exist, or no relationship may be observed when one, in fact, does exist.

Finally, structure-performance studies have been criticized because of the difficulty in properly defining the relevant variables and controlling for other possible influences.⁷ Defining an appropriate "market" and identifying its constituent producers, for example, certainly involves some arbitrariness. Similarly, alternative measures of concentration exist⁸ with little theory to guide choosing among them. These criticisms strike this author as somewhat nihilistic and properly could be directed at virtually all empirical work.

Entry and Market Structure

Almost all of the more than 200 structure-performance studies of the banking industry have employed profit or price measures of performance.⁸ Because of the potential problems of systematic bias pointed out above, it is worth considering alternative means of identifying inefficient performance. In this paper, we examine the relationship between rates of new entry and market share concentration. Although the logic of this relationship is itself not unassailable, entry can be measured more accurately than other factors required of direct structure-performance studies.

We thus will be focusing on the relationship between entry activity and concentration. The logic of the test is fairly straightforward. If market share concentration allows incumbent firms to enjoy abnormally high profits, new entry into the affected

marketplace would be expected. Indeed, at least in simple formulations of industry behavior, it is entry that is expected to bring discipline to the marketplace and to ensure that production is expanded to the point where price equals marginal cost. For this concept to be useful in examining the notion of a link between structure and performance, however, certain other assumptions and qualifications must be made.

First, it must be assumed that new entrants cannot be mobilized instantaneously. If this were the case, market structure could be altered instantaneously and one would not observe variations in market structure of any importance in markets that were otherwise identical. Thus, no relationship between market structure and entry rates would be observable.⁹ Finding a positive relationship between market concentration and entry does not, however, identify for us the process that permits high levels of concentration to be maintained. We can, however, structure the model to test for the simple possibility that concentration persists because of lagged adjustment. In particular, we define

$$E^*(t) = E^*(X(t)),$$

where $E^*(t)$ is the desired rate of entry if such entry could be effected immediately in period t , and $X(t)$ is a vector of variables influencing that rate.

The response of actual entry $E(t)$ to $X(t)$ is likely to be influenced by the regulatory time lags and general adjustment costs that confront a new entrant. Thus the actual rate of entry in any given period is likely to depend upon the past pattern of entry in addition to variables influencing the "desired" or target rate of entry, $E^*(t)$. The actual entry relationship therefore might be written as

$$E(t) = E(X(t), E(t-1), E(t-2), E(t-3) \dots).$$

Because of data limitations, we are unable to examine such a generalized model for the adjustment of $E(t)$ to conditions in previous periods. Our studies employ only $E(t-1)$ to model the influence of previous economic states on current entry. Inclusion of a lagged dependent variable in a regression equation also may serve to proxy for the influence of variables omitted from the arguments of the equation.

Second, although finding a positive relationship between concentration and entry in such a model would be consistent with the notion that concentra-

tion is associated with excess profits, a converse finding offers no information. The absence of a relationship between concentration and entry could arise because the incumbent firms in a concentrated market, although they enjoy excessive profits, are able to erect impenetrable barriers to entry. Alternatively, the firms that constitute the concentrated market may be especially efficient and, although they enjoy excess profits, able to maintain price at or below the level needed to support an entrant of average efficiency.¹⁰ Unfortunately, therefore, the absence of an observed relationship between concentration and entry does not necessarily disprove the existence of a relationship between concentration and profits.

Finally, it should be emphasized that finding a positive relationship between market share concentration and entry need not imply that active intervention to deconcentrate market structure will improve efficiency. Improving efficiency would require an ability to define optimal entry from the standpoint of economic efficiency — something that cannot be done by this, or probably any, structure-performance study. Whether entry is sub- or supra-optimal has been argued to depend upon specific demand and cost characteristics.¹¹

In summary, excess profits should induce net entry into a banking market. To the extent that market structural factors are related to profit rates, therefore, entry and market structure may be associated. No association will be observed, however, if the market is in entry equilibrium at all times, that is, when excess profits are extinguished immediately by the influence of actual or threatened entry.

The Determinants of Entry

The simple theory of the firm provides the argument that excess profits observed within an industry may induce the net entry of new firms into a marketplace.¹² However, the presence or absence of excess profits may not be the only factor influencing entry. We turn here to a discussion of two possibly moderating influences on entry: growth in demand (that is, the “scale” of the market) and entry barriers.

Growth in demand or in the scale of a marketplace may or may not result in net new entry. If cost conditions are such that the optimal size of a firm in the marketplace is indeterminate (such as under

conditions of constant returns to scale) or favors large-scale firms (in an environment of increasing returns to scale), then current firms may meet the amplified demand for industry output by expanding their scale of production. If, on the other hand, increased firm scale is associated with decreased returns, growth in demand may be associated positively with the rate of net new entry. In the studies of entry rates reported below, various demographic and economic scalars are employed to isolate this effect.

A second factor influencing entry behavior is itself a market structure characteristic, namely, entry conditions. The ease or cost of entry can be influenced by numerous factors, including bank charter regulations and land use procedures affecting the location of commercial activity. To the extent such factors dominate the entry decision process, they will also obscure any observation of the hypothesized link between concentration and profits and entry.

Similarly, market share concentration may be associated not only with the enjoyment of abnormal profits, but also with efforts by incumbent firms to accumulate power for the purpose of retarding new entry. A common proposition along these lines is that the existence of economies of scale not only predisposes a market to display a concentrated structure, but also confers on incumbent firms the ability to retard entry.¹³ It is not necessary to replay the debate here, but it is worth noting that if entry conditions do deteriorate as concentration increases, this condition also would tend to bias studies toward the finding that concentration has no effect on profits and entry.

One of the inherent propositions in the structure-performance hypothesis, however, is that non-atomistic market structures may permit covert or overt coordinated pricing behavior that has the effect of limiting entry. To the extent that entry limit pricing (or other conduct that retards entry) is facilitated by the lack of numerous rivals, entry rates at any given level of industry profit should be higher in markets with a greater number of existing rivals. Thus, in addition to anticipating a positive relationship between concentration and entry, a positive relationship between the number of institutions in a market and the rate of entry also should be anticipated.

Finally, structure-performance studies using *price* as the performance measure often are criticized (probably fairly) for ignoring differences in the qualitative aspects of the products offered by different-sized firms and firms in different markets. The advantage of studying the effect of structure on entry rather than prices is that we need worry less

about variation in service quality as long as all firms in the market *potentially* can offer the same product or service quality. Thus, for testing the hypothesis that high market share concentration may result in abnormal profits that attract entry, it makes little difference if the actual mix of products or quality of service varies within the sample.

II. California Banking Markets

The basic unit of observation in our study is a banking market. We focused on activity in California banking and constructed measures of the rate of entry of banking institutions and variables describing the structural and demographic characteristics of the banking markets in the state.

Before proceeding to a more detailed description of the data employed, it is worthwhile to review the rationale for focusing on the California market and the issues that arise in defining the variables. California banking operates in an environment particularly conducive to exploring the concentration-entry hypothesis. First, as mentioned above, California has long had a policy of unlimited, intrastate branching, and state banking policy has permitted vigorous entry. In 1970, there were 203 commercial banks; by 1980, this number had increased to 311.¹⁴ California's economic geography also provides the variation in economic conditions and bank structure necessary to test the structure-entry hypothesis. Indeed, the study of California banking is, in terms of sheer scale of banking activity, analogous to studying the banking system of a medium-sized western country. (California is very similar to Canada, for example, in population and growth levels of economic activity.)

Finally, the thrift industry in California — which must at least be considered a potential rival to the commercial banking industry — is relatively homogeneous. It consists almost entirely of savings and loan associations, with no mutual savings banks and few thrift and loan companies.

California, although an extremely large economy, abuts rural, desert or mountain areas, ocean or the country of Mexico. Thus, we need worry less about border competition effects and interstate differences in regulatory policy on banking in California than in other important banking markets such as New York

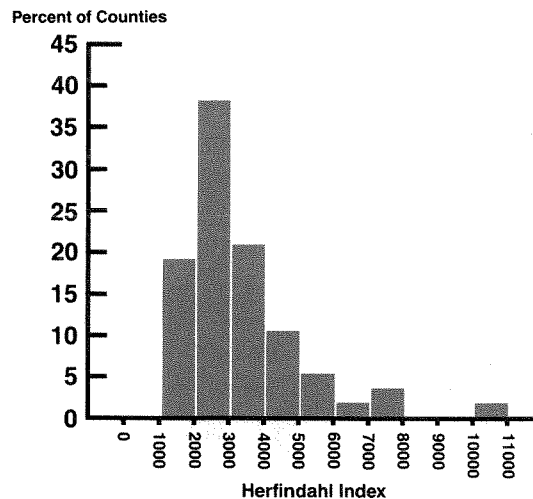
and Pennsylvania, which are adjacent to still other important banking markets.

The banking industry in California is considerably concentrated in all reasonable market geographies. In 1974, for example, the Herfindahl Index at the state level was over 2500 within commercial banking.¹⁵ The deposit market share of the four largest banks in California has hovered near 60 percent throughout the study period.

Banking also is concentrated at the local market level. The Herfindahl Index within California counties has exceeded 2,000 throughout the study period. The United States Department of Justice presently considers any Herfindahl Index in excess of 1,800 to signify a concentrated market.

Chart 1 presents additional detail concerning the distribution of concentration in commercial banking in California counties.

Chart 1
Market Concentration in California Counties, 1980



Defining Banking Markets

The preceding statistics on the geographic concentration of banking activity in California raise the important issue of how to define the appropriate market geography for this study. Such definition has been widely debated both among economists and among regulators and the judiciary.¹⁶ From a banking structure standpoint, the market geography should be defined in such a way that the aggregate of economic forces impinging upon the banks within that geography dominate the forces exerted upon them by institutions outside that geography. This, in turn, clearly depends upon the accessibility of various products to consumers, which, in turn, determines the extent to which the products offered by various institutions are close substitutes. Various investigators therefore have used market areas defined on the basis of commute patterns, shopping patterns, residential densities, and even proposed complex lexicographic schemes.¹⁷

In this paper, our choice of market definition is a practical one compelled by the availability of economic and demographic data necessary to test for the effects of growth in market scale as discussed above. In particular, we must employ counties (or aggregates of counties). We do not deny the

arbitrariness of this definition, but hasten to point out that California — like many states — implements land use regulation through county general plans. There may be, therefore, fortuitous relationships between the county geography and the geography implied by employment, commute or residential land use patterns. Indeed, as arbitrary as the political subdivision may be in defining banking markets, it has survived structure-performance studies that compared it to alternatives.¹⁸

Our approach resulted in the definition of 58 markets in California, although our markets are large relative to the geographic market definitions employed by investigators in Eastern states. Minor variations on the county market definition were explored, such as employing SMSA definitions in metropolitan areas and eliminating extremely large counties such as San Bernardino County from the sample in alternative regressions. Since these variations did not yield important differences in the findings, the following discussion is based only on the use of county measures of market areas.

Trends in Entry and Concentration

As Chart 2 shows, there has been vigorous entry by new institutions in California county banking markets throughout the study period and, consistent with this, there has been a secular decline in concentration as well. In the third panel of Chart 2, the entry rate — defined as the net number of new institutions entering a county market over a two-year period divided by the number of institutions in the base year — is graphed. As the graph indicates, the rate of net new entry of institutions has fluctuated between slightly above 1 percent to over 7 percent on an annualized basis over the study period. Because of this significant variation, it was important to test the hypothesis using a series of cross-sections to ascertain the stability of the relationship, if any, between concentration and entry rates.

Chart 3 depicts the distribution of banking institutions among counties. Most of the counties (over 35) have 9 or fewer banking institutions. Conversely, only about a dozen counties have 20 or more institutions in them. To the extent that the number of institutions in a marketplace may affect

Chart 2
Measures of Selected Variables for California,
1974-1980

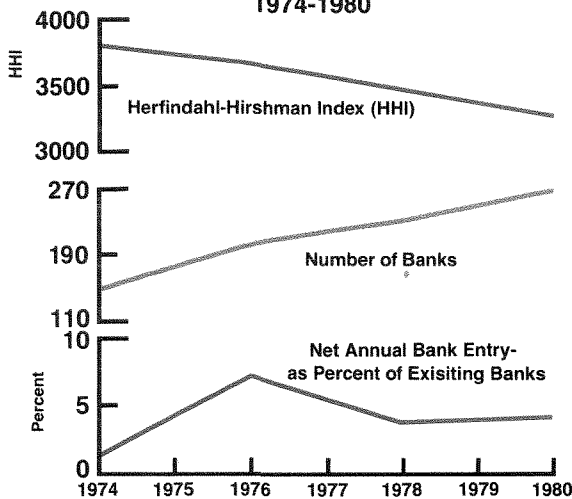
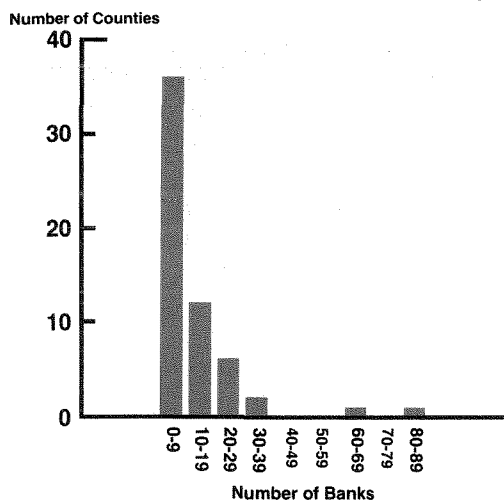


Chart 3

Distribution of Number of Banks in County, 1980



competition independent of the Herfindahl measure of concentration, it is important to note the wide disparity in bank populations by county. We address this issue in the empirical work below.

Trends in Bank Size

There also is wide variation in the rates of growth of individual banks within the state between 1972

and 1980. The average annual rates of growth for banks that were in the sample in 1972 and remained in the sample in 1980 was highly variable. Moreover, the growth rates bore no statistical relation to bank size (measured in this context by total deposits).²¹ This finding, interestingly, is consistent with Gibrat's stochastic model of market share concentration. Gibrat argued that if rates of growth of firms in a marketplace were distributed randomly (independent of firm size), this stochastic process alone would be sufficient to generate a non-uniform distribution of market share among firms much like the pattern observed in most marketplaces. Namely, most of the market would be served by a few large firms, but many small firms would coexist.²²

If Gibrat's hypothesis explains the market share concentration observed in California banking markets, the interpretation of our study of concentration and entry rates may be less ambiguous since Gibrat's hypothesis militates against the argument that economies of scale or permanent differences in the efficiency of individual firms explain the market share supremacy of certain firms over others. Thus, if we find a positive relationship between concentration and entry, it suggests that concentration *per se* affords incumbent firms some protection from profit-extinguishing competitive behavior.

III. Empirical Tests of the Relationship Between Entry and Concentration

We turn now to our empirical examination of the relationship between entry and market share concentration. Data from the period 1972 to 1980 were used to construct the variables employed in the studies reported here. The statistics on banking activity and market demography were available only for the years 1972, 1974, 1976, 1978 and 1980. (We chose not to expand the study into the 1980s to avoid the influence of the major changes in state and federal banking regulation that occurred at that time.) Because of the complexity involved in constructing some of the measures employed here, we digress momentarily to describe the construction of dependent and independent variables.

Constructing The Variables

We measured entry by observing flows of institutions, branches and other measures of capacity in and out of various geographic banking markets. The entry rates were measured using two-year measurement intervals. Thus, from 1972 to 1980, we obtained four two-year cross-sections of entry observations. Since the basic form of the estimated relationship is that presented in the preceding section, a lagged entry rate variable was one of the arguments of the regression leaving us with three cross-sections to study.

Our main interest is in the notion of *new entry*, that is, the entry of banking firms into banking

markets in which they were previously not represented. We are also interested, however, in the possibility that high levels of concentration may induce existing firms to expand their presence in the marketplace, net of any withdrawal from the marketplace that may occur. The *branch growth rate* was used to study this entry process. Finally, we wish to study the extent to which entry is a phenomenon of existing banks or new banks. We therefore examined the *de novo branch growth* and *de novo bank entry rate* as additional measures of entry activity.

In all cases, the entry rate was defined as the change in the entry measure occurring over a two-year period divided by the level of that measure at the beginning of the two-year period. Therefore, in some of the entry measures studied, we distinguished between a *gross* rate of entry, an *exit* rate and a *net* rate of entry. The gross rate was computed by counting all entry events over each two-year time frame as a percentage of the level in the base of the two-year period. The *exit rate* was a count of all exit events as a percentage of the level of the measure in the base of the two-year period, and the *net entry rate* was constructed as the net of entry events over exit events divided by the level's measure in the base of the period.

The independent variables in the regression, if they are level variables, are the measures relevant to the base year of the entry measure. Those independent variables that are *rate variables* (such as population and income growth) are the rates that occurred in the two-year period just prior to the base date of the entry measure. In this way, the independent variables may be viewed as measures that are truly not contemporaneous with the entry activity they are seeking to explain.

In addition to the lagged dependent variable, the independent variables consist of the Herfindahl index and the number of branches and/or institutions as measures of the structural characteristics of the banking market. The rate of growth of per capita income and the rate of growth of population were included as scalars of market demand.

Numerous variations on these three basic entry notions also may provide insight into the processes that stimulate entry into California banking markets. We examine, for example, the exit of existing

firms to see if the process of elimination of banking firms is in any way related to market share concentration or the other demographic or structural variables. Most exit in the banking industry occurs through merger, either voluntary or arranged, for failing banking firms by bank regulators. The exit concept that can be developed from available data, therefore, differs somewhat from the exit concept in the economic literature, which refers to the departure of productive capacity from the marketplace altogether.

New Bank Entry

Table 1 presents regression results from a pooled time series of cross-sections used to analyze the effects of concentration and the other independent variables on new entry.²³ Concentration and the rate of new entry appear to be positively related in the sample. The size of the coefficient indicates that an increase in the Herfindahl Index by 50 would result in an increase in the 2-year rate of entry of 2 percent. (This is an elasticity of approximately 0.6 at the sample means.)²⁴ New entry also is positively related to population and personal income growth in the county markets, although with marginal significance.²⁵

The number of institutions already in the market appears to have a significant, positive effect on entry. This finding is consistent with the notion that entry limit pricing discipline may be more difficult to maintain in a market in which there are many potential rivals. Alternatively, the positive association between the number of institutions and the rate of entry may be the result of differences in the minimum efficient scale in markets of different capacity. It may be easier, for example, for a bank to enter a market with the capacity to support a large number of banks than a market that can support only a few banking facilities of an efficient size. Attempts to verify this hypothesis, however, were unsuccessful.²⁶

Finally, it should be noted that the coefficient on the lagged value of entry variable is small and of marginal statistical significance. This does not necessarily imply that past entry rates do not influence current rates given the simplicity of the lagged structure permitted us by the data. The fairly consistent negative sign on this variable may indicate that

stochastically high or low rates of entry in a given time period may, respectively, discourage or encourage entry activity in the two years following. This could be the consequence of information lags, the reaction of incumbent firms or simply misspecification of the model. In addition, the lagged variable may be a proxy for some omitted, contemporaneous influence on entry.²⁷

Table 1 also presents the results of studies of the *exit rate* and the *net bank entry rate* using a regression model of the same structure containing the same variables. Analysis of our sample indicates that most banking firms “exited” the market through merger with surviving institutions. Most of the coefficients in the exit regression are not statistically significant. However, the significant, positive association of exit with population growth suggests that incumbent firms respond at least partly to the growth in the scale of the market by acquiring existing banking capacity. The *net bank entry rate* regression reinforces the notion, however, that new entry is responding not so much to growth to market scale as to the level of concentration in the market.

De Novo Entry and Concentration

In the preceding reported results, we studied the effects of a market’s concentration on the entry of

banking firms not previously serving that market. In Table 2, we focus our activity on true *de novo* bank entry by studying the effects of concentration on the rate at which new banking firms are created. It is important to make this distinction in the event that regulatory barriers to entry — which are presumably more important for *de novo* banks than for new branch facilities — are an important determinant of entry patterns.

As Table 2 indicates, however, the pattern of the relationship between *de novo* entry rates and concentration is similar to that observed between concentration and all forms of entry into the county market. In our sample, the entry of *de novo* banks explains about one-third of the total entry rate over our study period; most of the new entry into county markets was due to the geographic expansion of existing banks. Nevertheless, it appears that the market structure variables have an influence on *de novo* entry that is qualitatively similar in direction and magnitude to that observed for geographically expanding institutions.²⁸

Branch Entry and Concentration

By analyzing entry only in terms of entry of banking institutions, we may be under- or overstating the responsiveness of entry to changes in

TABLE 1
Studies of Bank Entry

	Rate of Bank Entry	Rate of Bank Exit	Net Rate of Bank Entry
Lagged dependent variable	-0.12 (1.4)	-0.13 (1.5)	-0.13 (1.7)
Herfindahl Index	1.8×10^{-5} (3.2)	3.3×10^{-6} (1.2)	1.5×10^{-5} (2.9)
Personal Income Growth	0.03 (1.6)	0.01 (0.92)	0.02 (1.2)
Population Growth	0.55 (1.8)	0.26 (1.8)	0.31 (1.1)
Number of Institutions	4.1×10^{-3} (3.7)	2.0×10^{-3} (4.0)	2.1×10^{-3} (2.2)
R ²	0.39	0.26	0.26
n	174	174	174

Note: Numbers in brackets are t-ratios.

concentration if the entering institutions are larger or smaller, respectively, than existing banking firms. In addition, we may be failing to measure increases in total banking capacity that are occurring because of the growth of incumbent banking institutions in a given market.

We examine this possibility in Table 3 through three different measures of changes in banking capacity. The first two regressions examine the branch growth pattern of incumbents as well as out-of-county banks before and after correction for closures and consolidation of branches. The effect of concentration on this measure, once again, is qualitatively similar to that found in all other entry

measures. Branches may not, however, accurately measure the true increments to banking service capacity created by new entry or branching activity. Ideally, we would like to know the design capacity of the new facilities to study capacity increments directly. In the absence of this data, we are able only to look at the actual activity attracted to the new facilities. In the third regression presented in Table 3, the rate of deposit growth represented by new branches (of either *de novo* or incumbent banks) is employed as a dependent variable. Once again, we observe a positive relationship between concentration and subsequent entry.

IV. Summary and Conclusions

The vigorous growth in the number of banks and branches in California in the 1970s has provided an opportunity to test the simple notion that new entrants will be attracted to markets with high concentration because high concentration is, according to the structure-performance hypothesis, associated with abnormally high profits. We, indeed, have observed a positive relationship between entry and the ambient level of concentra-

tion in the market, a finding that is consistent with, but not necessarily proof of, the notion that concentration and profit rates are positively correlated.²⁹ In addition, the rate of entry is enhanced, rather than retarded, by the presence of a large number of banking institutions. This finding is consistent with the argument that firms in a concentrated market not only enjoy higher profits, but are able to pursue entry-limiting pricing strategies more

TABLE 2
Studies of *De Novo* Bank Entry

	Rate of <i>De Novo</i> Bank Entry	Rate of <i>De Novo</i> Bank Exit	Net Rate of <i>De Novo</i> Bank Entry
Lagged dependent variable	-0.17 (2.0)	-0.15 (1.4)	-0.11 (1.5)
Herfindahl Index	1.6×10^{-5} (3.7)	3.9×10^{-6} (1.4)	1.2×10^{-5} (3.3)
Personal Income Growth	-8.3×10^{-4} (0.07)	-1.4×10^{-3} (0.16)	5.8×10^{-4} (0.05)
Population Growth	0.3 (1.3)	0.22 (1.4)	0.05 (0.25)
Number of Institutions	1.9×10^{-3} (0.84)	2.1×10^{-3} (1.4)	-2.5×10^{-4} (0.13)
Number of Branches	-1.1×10^{-4} (0.57)	-1.2×10^{-4} (0.94)	1.8×10^{-5} (0.11)
R ²	0.28	0.15	0.15
n	174	174	174

easily than in a market where there are few rivals of any size.

Although our findings provide support for those who believe structure influences performance, we are unable to extend the implications of our study to any particular prescription regarding anti-trust policy. We do not observe efficiency directly in structure-performance studies and thus are not in a position to conclude that the manipulation of market structure will necessarily make a market more effi-

cient. Conversely, although it is tempting to interpret the findings as evidence that entry can be relied upon to repair inefficiently structured markets, we have no way of evaluating whether the observed levels of entry are sub- or supra-optimal in the sense of *dynamic* efficiency. Anti-trust policymakers by necessity must bring their own judgment to bear on evaluating such evidence until a time when theory and empirical evidence can be more helpful.

TABLE 3
Studies of Alternative Entry Measures

	Total Branch Growth Rate	Net Total Branch Growth Rate	Deposit Entry
Lagged dependent variable	-0.05 (0.69)	0.02 (0.23)	-0.14 (1.6)
Herfindahl Index	1.6×10^{-5} (3.6)	1.2×10^{-5} (2.9)	4.5×10^{-6} (2.3)
Personal Income Growth	-2.5×10^{-4} (0.02)	-8.3×10^{-4} (0.07)	-6.1×10^{-4} (0.1)
Population Growth	0.42 (1.7)	0.21 (0.99)	0.2 (1.8)
Number of Institutions	7.0×10^{-3} (2.9)	4.3×10^{-3} (2.0)	7.0×10^{-4} (2.0)
Number of Branches	-4.3×10^{-4} (2.1)	-2.7×10^{-4} (1.5)	n.a.
R ²	0.43	0.21	0.27
n	174	174	174

FOOTNOTES

1. The model of perfect competition assumes that a market is characterized by unrestricted entry and exit, the absence of scale economies, homogeneous products and perfect information in addition to atomistic production.

2. Joe S. Bain, "Workable Competition In Oligopoly," *Economic Review*, May 1950, pp. 35-47.

3. Joe S. Bain, "Relation of Profit Rate To Industry Concentration: American Manufacturing, 1936 to 1940," *Quarterly Journal of Economics*, August 1951, pp. 293-324.

4. Bain knew the hazards of testing the hypothesis in this manner and pointed out that an observed structure-performance relationship was of interest only if entry, technological and demand conditions were the same across the sample and uncorrelated with market share concentration (see Bain, 1951).

5. Demsetz (1973) argued that some studies finding a positive relationship between market share concentration

and profits actually showed a relationship between *large* banking firms and profitability and that the expected higher returns by smaller firms were not found. His results, like those of most concentration-profit studies, however, were not particularly consistent and may suffer from some of the problems pointed out later in this paper.

6. Franklin R. Edwards, "Managerial Objectives in Regulated Industries," *Journal of Political Economy* February 1977, pages 147-162.

7. For a survey of the various criticisms of structure-performance models in banking, see D. Osborne and J. Wendell, "Research on Structure, Conduct and Performance in Banking: 1964-79," Oklahoma State University, July 1983, mimeo.

8. Common performance measures in these studies include profit rates, deposit rates, commercial loan rates, automobile loan rates, service charges and banking hours.

See Osborne and Wendell for an up-to-date review of the various surveys of this extensive literature.

9. In econometric modeling parlance, structure and entry would be related through an identity, and structure would be a redundant variable.

10. A firm employing an entry-limit pricing strategy adjusts price to maximize the present value of long-term profits taking into account the fact that the flow of new entrants is positively related to the profits enjoyed by incumbent firms. For a discussion of limit pricing in the context of banking, see Timothy H. Hannan, "The Theory of Limit Pricing: Some Applications for the Banking Industry," *Journal of Banking and Finance*, October 1979, pp. 221-234. See also, D. Hay, "Sequential Entry and Entry Detering Strategies in Spatial Competition," *Oxford Economic Papers*, July 1976, pp. 240-257.

11. See Weisacker (1983). One example of a potential cause of sub-optimal entry is the existence of positive externalities of the activities of one firm on another. Weisacker also argues that the existence of economies of scale in a game-theoretic oligopoly pricing context could lead either to sub- or supra-optimal entry from an efficiency standpoint.

12. In the traditional theory of the firm, there are no impediments to the exit of firms from the marketplace. Exit normally is viewed as occurring because of random processes related to the allocation of management skills, cash flow problems and other situations specific to the firm. There is no *a priori* reason to expect a relationship to exist between exit rates and concentration. In the banking industry, most firms exit by way of merger with another firm. True exit of capacity is observed, however, in the case of individual bank branches. Entry and exit processes for both banking firms and branches are studied below.

13. There has been considerable debate over the years concerning which, if any, demand or cost conditions confronting a firm can result in the erection of "barriers to entry." Bain (1951) argued that entry could be impeded if (1) incumbent firms enjoyed cost advantages not available to new entrants, (2) economies of scale existed or (3) products were differentiable. Stigler (1973) dismissed the second and third factors as barriers to entry and argued only for the case of incumbent cost advantages. Subsequent authors have argued that both views are inappropriate because they focus on entry *conditions* rather than the consequences on efficiency of the factors enumerated.

In particular, we are not concerned with barriers to entry *per se*, but rather whether certain cost or demand conditions can lead to sub-optimal entry and attendant efficiency losses. When viewed from this perspective, Bain's original list of factors have the *potential* to lead to sub-optimal entry and inefficient production, but the precise outcome depends upon numerous other assumptions (see Weisacker 1983).

In addition, factors other than those enumerated by Bain can lead to sub-optimal entry including positive externalities to production. (For example, a firm may have to spend a considerable amount of money to design a successful product or a marketing strategy. If the firm recognizes that it will be unable to keep its potential rivals from obtaining the same information subsequently without cost,

it may be deterred from entering the market.) For additional debate concerning the relevance or irrelevance of demand and cost conditions on entry, see Michael Spence, "Entry Capacity, Investment and Oligopolistic Pricing," *Bell Journal*, Autumn 1977.

14. Our study terminates in 1980, however, to avoid any perturbing influence of the major changes in banking legislation that occurred in 1980 and 1982 at the federal level and also because of lags in the availability of certain demographic and economic variables employed in the study.

15. The Herfindahl (or, more properly, the Herfindahl-Hirschman) Index is computed by squaring and summing the market share, in percent terms, of all firms in the marketplace. In our sample of California counties, this index ranges from about 1,000 to its theoretical maximum (10,000). Alternative measures of concentration frequently employed are the three-, four- and five-firm concentration ratios computed, respectively, by summing the market shares of the largest three, four or five firms in the marketplace.

We examined the use of the three-firm concentration ratio in lieu of the Herfindahl Index. For California, at least, there appears to be no important difference and we have chosen to report only the Herfindahl results in the tabulations that follow.

The Herfindahl Index presently is employed by the United States Department of Justice in formulating its merger guidelines. Presently, the Department of Justice considers any market with a Herfindahl Index in excess of 1800 to be concentrated. By this criterion, most of the county markets defined in this paper are concentrated.

16. See Osborne and Wendell (1983), Section V, for a discussion of this issue.

17. See Stoltz (1976) and Osborne and Wendell (1983).

18. See the evaluation of the work of Stolz (1976) in Osborne and Wendell (1983), Section V.

19. Hannan (1983), for example, used local labor market and employment pattern data to define nearly this many markets for the (much smaller) state of Pennsylvania. He did find, however, that his results were relatively insensitive to variation in the definitions of geographic market areas. Given the comparatively benign weather and high quality road system enjoyed by Californians, however, the relatively large size of the individual counties may not be inappropriate.

20. The rate stated in the chart is the rate occurring between the noted date and the two previous years. Thus, our data, while spanning 1972 to 1980, are able to report entry rates only from 1974 to 1980.

21. A simple, linear regression of deposit size in 1972 (SIZE) and a percentage change in deposits over the period (GROWTH) resulted in the following coefficient estimates and associated t-statistics:

$$\text{GROWTH} = 319.27 - 1.9 \times 10^{-5} \star \text{SIZE}, R^2 = 0.01, n = 95$$

(6.8) (1.0)

Performing the same regression on a county-by-county basis yields less consistent results, with occasional signifi-

cant positive or negative coefficients on the SIZE variable. The absence of a consistent pattern and the small samples involved prohibit us from drawing any conclusions about these findings contrary to the general implication that the growth rates are independent of size.

22. Gibrat's Law demonstrates that, if a firm's growth rate per period is a random, normally distributed variable, the firm's size distribution ultimately will become skewed even if the initial firm size distribution is uniform. Thus, industries and markets can become concentrated in the absence of economies of scale or entry barriers by virtue of randomness in the outcomes of management selection processes, marketing decisions and other internal decisions affecting growth of a firm.

Such a process of concentration would not in itself be expected to affect entry since each firm is, by definition, confronted with the same distribution of "luck" in every period and thus this aspect of entry conditions remains unchanged over time. Indeed, the finding of growth rates unrelated to size militates somewhat against explanations of concentration based on economies of scale since these are permanent features of size not independently drawn each period. Gibrat's 1931 work was articulated by Michael Kalecki, "On the Gibrat Distribution," *Econometrica*, April 1945.

23. The database used in this study was constructed using data from the period 1972 to 1980. Several of the variables used in this study are rate variables, such as the entry rate, and the rates of population and income growth, and these are constructed using level measures of these variables at the beginning and end of two-year periods because of data availability.

The results reported here were run separately on each cross section as well as in the pooled variant presented. The results are qualitatively unchanged in the sense that the signs of variables significant in individual cross sections remained the same in the pooled sample although the enlarged sample results in improved standard errors for the estimates. In the reported regressions, growth rates are in decimal form. The Herfindahl Index is measured with a maximum value of 10,000 and all other variables are in level form.

24. Presently, the Department of Justice considers an increase in the Herfindahl of 200 points or more to be significant.

25. Personal income growth and population growth are computed by county from data provided by the California Department of Finance.

26. Attempts were made to test this notion by inclusion of non-bank measures of the capacity of the county markets. In particular, the *level* of personal income and population in the county markets was included in the regression formulation. In every case, however, these variables proved statistically insignificant and had inconsistent signs.

27. The relatively poor statistical performance of the lagged entry rate variables in the regressions reported in this paper may suggest, in fact, that the lagged adjustment formulation simply is inappropriate. We have not eliminated the lagged variable from the regressions, however, because at the very least this variable may perform some modest role in controlling for cross-sectional variation in entry rates that is not explained by the variables included as arguments of our regressions.

28. In our sample, the mean rate of entry of new institutions is 15.2 percent (biennially). The mean rate of *de novo* bank entry (as a percent of total banks in the market) is 4.2 percent. Most *de novo* entry, however, involved one branch only. When compared with the total entry rate measured as the rate of change in the number of *branches*, the *de novo* entry figure appears somewhat larger, since branching growth is only 12.3 percent biennially in our sample period.

It is useful to note, however, that, for our sample at least, the rate of gross entry of banks exceeds the rate of gross entry of branches. Although it would be desirable to measure entry rates in terms of some meaningful measure of banking capacity, we were unable to do so and could only weight each form of entry similarly in these computations.

29. We also studied the relationship between concentration and profits directly in our work. However, because profit data are available only for the banking enterprise as a whole, whereas market concentration is measured at a local market level, we were forced to construct a concentration measure for the bank as a whole using deposit-weighted individual county concentration measures.

Whether because of this construction or because of the many problems with profit measures cited above, we were unable to find a consistent relationship between profitability and any of our structural or demographic variables.

Off Balance Sheet Risk in Banking: The Case of Standby Letters of Credit

Barbara Bennett*

Bank regulators and other analysts worry that the recent rapid growth in standby letters of credit (SLCs) outstanding is a response to more stringent capital regulation and has increased bank risk. This analysis traces the growth of such instruments primarily to the growth of direct-finance markets in a setting of increased overall economic risk. It also finds that SLCs are at least potentially riskier than loans. Although banks may be applying higher credit evaluation standards in partial compensation, the issuance of SLCs nevertheless may warrant some form of capital-related regulation.

The off balance sheet activities of commercial banks have attracted a lot of attention lately. Regulators, securities analysts and the financial press all have voiced concerns about the rapid growth in such contingent obligations as loan commitments, financial futures and options contracts, letters of credit, and foreign exchange contracts. Although they are not recognized as assets or liabilities on bank balance sheets (hence the term, “off balance sheet activities,” or OBS), these contingent claims involve interest rate, credit, and/or liquidity risks. Moreover, because they provide the opportunity for substantially greater leverage than is the case for banks’ lending and investment activities, OBS have the potential to increase banks’ overall risk.

Ironically, bank regulators’ efforts to control risk-taking through more stringent capital regulation may be partly responsible for the growth in OBS over the last few years. Because regulatory defini-

tions of capital adequacy currently do not include OBS, banks may have an incentive to shift risk-taking towards these relatively less-regulated activities. To correct this problem, the federal bank regulatory agencies are considering ways to factor OBS exposure into their formal evaluation of a bank’s capital adequacy. Consequently, regulators need to analyze the nature and degree of risk involved in each type of OBS as compared to banks’ other activities.

This article examines one off balance sheet activity that has grown quite rapidly over the last several years: standby letters of credit. The first section discusses the uses for standby letters of credit and the reasons for their growth. In the second section, a framework for analyzing the risks associated with standby letters of credit is developed. Unfortunately, data limitations make impossible any definitive statements about the impact of standby letters of credit on overall bank risk. Finally, the paper concludes with some observations about the regulatory treatment of standby letters of credit.

* Economist, Federal Reserve Bank of San Francisco. Research Assistance was provided by Kimya Moghadam and Julia Santiago.

I. The Market for Standby Letters of Credit

Of all the off balance sheet activities in which U.S. banks engage, the issuance of standby letters of credit (SLCs) has attracted the most attention lately. Many observers point to the rapid growth in SLCs outstanding over the last few years as well as the prominent role such instruments played in several recent bank failures — most notably, Penn Square National Bank in 1982 — as evidence that SLCs may be increasing bank risk significantly. SLCs outstanding grew from \$80.8 billion in June 1982 to \$153.2 billion in June 1985 — a 90 percent increase over the period. Moreover, most of that growth occurred at the 25 largest banks, which recorded more than a \$40 billion increase in SLCs outstanding.

A letter of credit (LC) is a contractual arrangement involving three parties — the “issuer” (the bank), the “account party” (the bank’s customer) and the “beneficiary.” Typically, the account party and the beneficiary have entered into a contract requiring the former to make payment(s) or perform some other obligation to the latter. At the same time, the account party has contracted with its bank to issue a letter of credit which, in effect, guarantees that by substituting the bank’s liability for that of the account party, the account party will perform according to the terms of the original contract with the beneficiary. Initially, the bank’s obligation under the LC is a contingent one because no funds are advanced to the beneficiary until that party presents the documents that are stipulated in the LC contract.

There are two types of LCs: the more traditional commercial letter of credit which generally is used to finance the shipment and storage of goods, and the standby letter of credit which is being used in connection with a growing variety of transactions, including debt issuance and construction contracts. Unlike the commercial LC, which is payable upon presentation of title to the goods that have been shipped, the SLC is payable only upon presentation of evidence of default or nonperformance on the part of the account party. As such, SLCs typically expire unused, in contrast to commercial letters of credit.

Because SLCs are payable only upon nonperformance on the part of the account party, they are a guarantee of either financial or economic perfor-

mance on the underlying contract.¹ The issuer of the SLC promises to advance funds to make the beneficiary whole in the event of the account party’s failure to perform according to the terms of the contract with the beneficiary. An SLC involving a financial guarantee requires the issuing bank to pay any principal or interest on debt owed the beneficiary by the account party should the latter default. According to a recent survey, just over half of banks’ SLCs outstanding backs some form of debt obligation.² An SLC backing a construction contract, in contrast, represents a performance guarantee and requires the bank to make a payment to the beneficiary if the contractor does not complete the project satisfactorily.

By issuing an SLC, the bank is assuming the risk that normally would have been borne by the beneficiary. However, it is the account party that arranges the SLC and compensates the bank for the risk. In return for paying the bank’s fee and reducing the beneficiary’s risk, the account party expects to obtain a higher price for the debt issued to or the services performed for the beneficiary.

In general, the account party will choose to arrange a standby letter of credit whenever the cost of the transaction (that is, the bank’s fee) is less than the value of the guarantee to the beneficiary (as measured by the premium the beneficiary is willing to pay for the account party’s debt or services with the SLC backing). The size of this differential between the bank’s fee and the beneficiary’s willingness to pay for the guarantee depends upon two factors.

First, the value of the guarantee to the beneficiary will depend on the creditworthiness of the issuing bank as compared to that of the account party and the relative costs of obtaining information about the creditworthiness of each. An SLC issued by a bank with a poor credit rating is not likely to be worth much to the beneficiary since the probability of that bank’s default on its obligation may be high. Likewise, an SLC issued by a small, unknown bank may have little value since the cost to the beneficiary of obtaining information to evaluate the bank may be greater than the cost of evaluating the account party and underwriting the risk itself.

These observations are consistent with the data presented in Tables 1 and 2, which show that most SLC issuance occurs at the largest banks and that the higher rated banks tend to do relatively more SLC business.

Second, the size of the differential will depend on the extent of the issuing bank's comparative advantage in underwriting the risk of default on the part of the account party. (Of course, the extent to which the bank's comparative advantage will be reflected in the fees the bank charges depends on the level of competition among issuers of SLCs). With respect

to most beneficiaries, the issuing bank's underwriting costs are likely to be substantially lower because the bank is better able to diversify the risk associated with SLCs and because the bank enjoys certain economies in credit evaluation. For example, the marginal cost of performing an evaluation of the account party is lower for the bank than for the beneficiary because the bank frequently has an ongoing relationship with the account party; this makes the cost of obtaining information much lower for the bank.

TABLE 1
SLC Issuance by Size of Bank
(Billions of dollars)

Year-End:	1979	1980	1981	1982	1983	1984	June 1985 (Percent share)
Banks with Assets of Over \$100 MM	34.1	45.7	69.9	98.3	117.4	144.3	153.2 (100)
25 Largest Banks	27.2	36.5	55.5	77.6	91.5	111.2	117.9 (77)
10 Largest Banks	24.3	32.0	47.9	65.0	77.1	92.4	96.3 (63)
15 Other Large Banks	2.9	4.5	7.6	12.6	14.4	18.8	21.6 (14)
All Other Banks	6.9	9.2	14.4	20.7	25.9	33.1	35.3 (23)

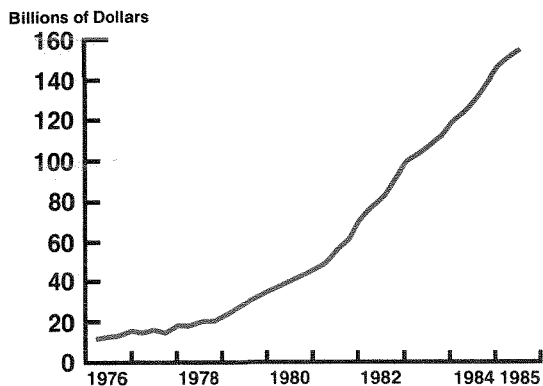
Source: Quarterly Reports of Condition

TABLE 2
SLC Issuance of 25 Largest Banks by Bank Rating*

	Dec 1982 (Billions of dollars)	June 1985	Percent Change
Large Banks (with assets over \$50 billion)	41.6	63.1	51.7
Aaa - Aa (4 banks)	33.4	51.7	54.8
A or less (1 bank)	8.2	11.4	39.0
Medium Banks (with assets of \$10-50 billion)	35.9	54.6	52.1
Aaa - Aa (11 banks)	21.9	37.4	70.8
A or less (8 banks)	14.0	17.2	22.9
Small Banks (with assets under \$10 billion)	0.1	0.2	100.0
A or less (1 bank)	0.1	0.2	100.0

*Ratings of banks based on latest evaluation in *Moody's Corporate Credit Reports*.

Chart 1
Standby Letters of Credit
of U.S. Commercial Banks



The Growth of SLCs

The almost exponential growth in SLCs outstanding since the late 1970s (see Chart 1) is just one manifestation of a rapidly growing general market for guarantee-type products. In addition to the SLCs that banks offer, surety and insurance companies are now offering such guarantees as credit-risk coverages (which guarantee repayment of principal and interest on debt obligations) and asset-risk coverages, such as residual value insurance and systems performance guarantees. This expansion in the types of coverages offered has given insurance companies a rapidly growing source of premium income. Between 1980 and 1984, the insurance industry's net premiums from such surety operations³ nearly doubled, rising from \$900 million to \$1.6 billion.⁴ Financial guarantees offered by other, specialized providers have grown rapidly as well. Municipal bond insurance, for example, was virtually nonexistent prior to 1981, but now supports an estimated 29 percent, or \$6.4 billion, of new issues of long-term municipal bonds.⁵

Two factors account for this growth in the market for financial guarantees in general, and SLCs in particular. First, the growth over the last ten to 15 years of direct-finance markets has increased the credit-risk exposure of investors who may prefer not to bear such risk. Such direct-finance markets as the commercial paper market have grown rapidly since the late 1960s because borrowers are able to obtain funds more cheaply from them than through inter-

mediaries such as banks. However, this decline in financial intermediation has also meant that the undiversified investors in such markets must bear more credit risk than if they were to invest in the deposit liabilities of commercial banks. Apparently, such an increase in credit-risk exposure is unpalatable to at least some portion of these investors because 15 percent of all dealer-placed taxable commercial paper is supported by some sort of legally binding guarantee and nearly all rated commercial paper also is backed by a bank loan commitment.⁶

The second reason that financial guarantees have grown rapidly over the last several years is that overall economic risk has increased over the same period. The rampant inflation of the late 1970s, the increased volatility of interest rates and business activity of the early 1980s, and the unexpected sharp deceleration in the rate of inflation in the middle 1980s have caused wide swings in asset prices and returns on investment. Consequently, the demand for instruments like SLCs and other guarantees that reduce the risk to the beneficiary has increased tremendously.

Banks' involvement in this market is at once an extension of their traditional lending business and, because SLCs are not funded, a significant departure from it. Like their lending business, banks' issuance of SLCs entails the underwriting of credit risk. In this area, banks enjoy certain economies of specialization that make them lower-cost issuers of financial guarantees. They can easily (that is, without cost) diversify the risk associated with SLCs. Also, banks typically have other lending and deposit relationships with their SLC customers. As a result, the marginal cost to banks of obtaining information to perform a credit evaluation for the purposes of issuing an SLC is very low. Moreover, in contrast to insurance companies, banks do not generally secure their guarantees with a formal collateral arrangement with the account party since they usually have the right to debit the account party's deposit accounts. This lack of a formal collateral arrangement makes banks' SLCs more attractive, but it also increases the bank's risk somewhat. (See the next section for a discussion of SLC risk.)

Given the enormous increase in the demand for guarantees, the fact that banks are low-cost issuers may be sufficient explanation for the rapid growth of

bank-issued SLCs over the last several years. However, banks also may have an incentive to respond to this demand since they can overcome binding regulatory constraints on their lending activities by doing so. For example, at current levels of interest rates, reserve requirements add an estimated 25 to 30 basis points to banks' cost of funds, making bank credit considerably less attractive than other sources of credit.⁷ Because SLCs are not funded and are therefore unaffected by reserve requirements, they represent a less costly way of assuming a given level of credit risk.

A more important regulatory constraint that undoubtedly has given banks incentive to issue SLCs is the move towards tougher capital regulation in recent years. Regulators began to express serious concern about bank capital adequacy in the late 1970s as the aggregate capital-to-assets ratio drifted to historically low levels. Then, in December 1981, the Federal Reserve Board (FRB) and the Office of the Comptroller of the Currency (OCC) issued "Capital Adequacy Guidelines" to pressure large banks into improving their capital-to-asset ratios. More formal standards for large banks were imposed in June 1983, and even more stringent standards were imposed on the industry as a whole in March 1985.

Economic theory suggests that the imposition of tighter capital regulations depresses the return on capital, causing a decline in the price of the regu-

lated firm's capital unless the firm can somehow compensate either by reducing its asset base or by increasing the riskiness of its portfolio. Because nonbank competitors are not similarly regulated, a move to shrink assets will not necessarily increase the return on bank capital. Thus, in the absence of other forms of portfolio regulation, capital regulation may induce banks to take on more risk.

Much of bank portfolio regulation is crafted to prevent banks from responding to this incentive, but regulators are concerned that banks' off balance sheet activities may not be adequately covered. The current capital adequacy standards do not formally account for banks' off balance sheet exposure. Consequently, when faced with capital-related limitations on asset growth, banks may have an incentive to shift risk-taking toward SLCs and other off balance sheet activities that do not "use up" capital.

In sum, the growth in banks' SLC issuance is a reflection of an increased demand for financial guarantees both as result of increased reliance on direct-finance as a source of funds and as a result of an increase in overall risk. Banks have been willing to respond to this demand by issuing SLCs because they enjoy certain cost advantages in doing so and because regulatory constraints on their lending activities make the issuance of SLCs more attractive. The next section presents a framework for analyzing the impact of SLC growth on bank risk, as well as an evaluation of the available evidence.

II. The Risk of Standby Letters of Credit

With the deregulation of many aspects of the banking business, banks have received expanded opportunities for risk-taking. Regulators worry that increasingly risky bank practices could bankrupt the deposit insurance system, which underwrites at least a portion of any increase in bank risk. If banks did not have deposit insurance or if that insurance were priced correctly, the cost of bank liabilities and the price of shareholder equity would fully reflect any increase in bank risk. However, since all banks currently are charged the same premium for deposit insurance regardless of riskiness, and since bank regulators apparently have been reluctant to close large, troubled banks, at least large banks have an

incentive to undertake more risk than they otherwise would.⁸

Consequently, bank regulators have attempted to reduce banks' opportunities (if not incentives) for risk-taking by adopting more stringent capital requirements for the industry. However, because such regulation may induce banks to try to take on more risk, bank regulators worry that the rapid growth in SLCs outstanding in recent years may be increasing overall bank risk, particularly since SLCs now equal 100 percent of aggregate bank capital. (See Chart 2.) Moreover, for the 25 largest banks, the average ratio of SLCs to capital is even higher — 165.4 percent. As a result, each of the three federal

bank regulatory agencies (FRB, OCC and FDIC — Federal Deposit Insurance Corporation) recently proposed that the current capital adequacy regulation be supplemented by risk-based capital guidelines that would explicitly take into account the relative riskiness of broad categories of bank assets and certain off balance sheet items, including SLCs.⁹

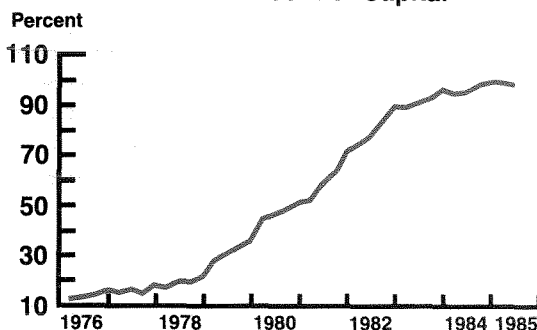
Ideally, risk-based measures of capital adequacy ought to reflect the effect of a bank's SLC exposure on overall risk, taking into account the extent to which SLC risk is correlated with other risk exposures. Unfortunately, such a measure is difficult to develop given currently available data and book-value accounting conventions. Neither can the markets for bank debt and equity provide more than an approximation for this measure since the existence of deposit insurance causes these markets to underprice bank risk. As a result, bank regulators can develop only crude measures of SLC risk based on a comparison with the riskiness of banks' loan portfolios.

Loans are the logical "benchmark" for rating the riskiness of SLCs because both instruments involve credit risk. At the same time, however, a comparison of the two is impeded by some of the differences in their risk characteristics. For example, unlike loans, SLCs generally do not entail interest rate risk and liquidity risk. If the issuing bank must advance funds under the terms of the SLC contract, the interest rate on the resulting loan to the account party typically varies with market rates (plus some mark-up). Moreover, because SLCs generally do not require a commitment of the bank's funds, the risk of loss associated with meeting related cash flow obligations is very small. On the other hand, because SLCs are not funded, they provide the opportunity for a much higher degree of leverage risk than is the case for loans.

An Options Framework

Options theory can be used to evaluate the relative riskiness of loans and SLCs. However, because the development of an econometric model to evaluate these two instruments is beyond the scope of this paper (and the available data), the discussion that follows is intended only to suggest how this framework might be useful to regulators.

Chart 2
Standby Letters of Credit Outstanding as a Percent of Capital



Virtually any financial instrument can be modeled as an option or a series of options. In this case, because the borrower/account party can default on its obligation to the bank, a loan and an SLC both implicitly contain a put option on the assets of the borrower/account party. In other words, the borrower (or the account party) has the right to sell ("put") its assets to the bank at an exercise price equal to the par value of its obligation to the bank. This option will be exercised if the par value of the obligation exceeds the market value of the underlying assets securing the obligation.¹⁰

Several factors determine the risk of exercise and hence, the value of this option. First, the option's value increases with increases in the exercise price, other things equal. As the par value of the loan or SLC obligation increases, so does the bank's risk. Second, the value of this put option varies inversely with the value of the underlying assets. As the value of the underlying assets securing the obligation falls, the cost of exercising the option also falls, increasing the bank's risk. Finally, the option's value rises with increases in the riskiness of those assets (that is, variance of their price). The greater the chance that the value of the underlying assets will fall substantially, the greater is the risk to the bank.¹¹

A comparison of the risk associated with SLCs and loans, then, requires an evaluation of all these dimensions of the two portfolios. Moreover, an evaluation of the impact of SLC risk on bank risk also requires an understanding of the extent to which the returns on the two portfolios are corre-

lated. Unfortunately, data on these aspects of banks' SLC and loan portfolios are not available.

Nonetheless, it still is possible to use an options framework at least to suggest how banks' SLC issuance may be affecting bank risk. To do so, assume that the characteristics of banks' loan and SLC portfolios that are most under management control are identical. In other words, for every given SLC there is also a loan to the same customer with the same term-to-maturity and par value. The essential difference between these two portfolios, then, lies in the relative strength of their collateral arrangements. The loans, for the most part, are formally secured by the borrowers' assets, while the SLCs are not.

In an options framework, this difference amounts to a difference in the relative costs of exercising the put options contained in the loan and SLC portfolios. Because the cost of exercising the SLC-related options is lower, other things equal, the likelihood that they will be exercised is greater, making the SLC portfolio riskier than the loan portfolio. Moreover, this lower cost of exercise means that the value of the SLC portfolio is more sensitive to changes in the variance of the prices of the underlying assets (that is, changes in the financial condition of the banks' customers). For this reason as well, the SLC portfolio is riskier.

In practice, of course, banks' SLC and loan portfolios are not identical. Thus, while SLCs may be riskier than loans in this one respect, banks probably manage the other aspects of the two portfolios in a manner that mitigates some of the greater risk arising from differences in the contractual terms of the loan and SLC instruments. Specifically, the creditworthiness of banks' loan and SLC customers may be very different. Bankers have indicated that, as a matter of policy, they try to reject SLC business from customers for whom default is even a remote possibility. This is in admitted contrast to lending policy, where the standards are somewhat more relaxed.¹² (For a discussion of the other ways banks manage SLC risk, see the Appendix.)

Evidence

The rather limited data on fees and loss experience suggest that banks do, in fact, manage the risk of the two portfolios differently. First, banks' SLC

fees apparently are lower than the implicit fees they charge on loans. The fees for SLCs for short-term, high quality credits range from 25 to 50 basis points and from 125 to 150 basis points or more for longer term and/or lower quality credits.¹³ By contrast, the implicit loan premium for large denomination, variable rate loans is approximately 240 basis points for both short- and longer term credits.¹⁴ This disparity in the fee structures of the two portfolios suggests that the creditworthiness of banks' SLC customers is higher than that of its loan customers.

This evidence on the relative riskiness of SLC and loan portfolios should be interpreted cautiously, however. Fees do not provide a measure of the expected return on equity. After netting out the higher administrative and other expenses associated with loans, it is likely that the expected return on and the risk of SLCs is at least as high as that for loans.

Similarly, the available evidence on the loss experience of loans and SLCs provides some evidence that the creditworthiness of banks' loan and SLC customers is different. Of course, loss experience technically does not measure credit risk because it is an *ex post* measure; however, there should be some correlation over time between risk and observed losses.

Data on SLC losses were last collected in 1978, when a special survey on SLCs was conducted by the staff of the Board of Governors.¹⁵ That survey found that the initial default rate on SLCs averaged 2.03 percent. But because more than 98 percent was recovered, the loss rate on SLCs was extremely low — only 0.03 percent. This low figure compares very favorably to banks' loan loss rate of 0.16 percent in 1979. According to bankers in the Twelfth Federal Reserve District, the loss rate on SLCs has increased somewhat since then, but, compared to loan losses now hovering around 0.65 percent, losses on SLCs still are very low.¹⁶ Once again, however, this evidence should not be interpreted as proof that the risk to bank capital from banks' SLC exposure is less than that from loans.

Finally, evidence from capital markets may provide some insights into the riskiness of banks' SLC portfolios. Of course, this evidence may be biased since prices will reflect the value of any perceived deposit insurance subsidy. Nonetheless,

as long as investors believe that they are not fully protected against loss, they will respond to perceived increases in bank risk by demanding a higher risk premium. Consequently, an evaluation of the market's reaction to the *growth* in SLCs outstanding over time should indicate whether bank risk also has increased.

In a study of the determinants of large banks' CD rates, Goldberg and Lloyd-Davies found that the market had not penalized banks for increasing SLC exposure between 1976 and early 1982.¹⁷ Their model explains the level of the CD rate as a function of the general level of interest rates and of various bank risk characteristics. The effect of banks' SLC exposure on CD rates is treated as having two components: a leverage risk effect (the ratio of bank capital to risky assets, including loans and SLCs) and a credit quality effect (the ratio of SLCs to risky assets — to allow for differences in the credit quality of the loan and SLC portfolios). Based on this model, they found that CD rates rose with increas-

ing leverage and fell with increases in SLCs as a proportion of total risky assets. Since these two factors tended to cancel each other, the net effect on bank risk of an increase in banks' SLC exposure apparently was negligible.

Such a result is perhaps not surprising for two reasons. First, the level of SLCs outstanding was low in relation to other risky assets and to capital for most of this period. Thus, the effects of rapid SLC growth (in percentage terms) may have been swamped by larger (absolute) increases in loan volume. Second, the regression covers a period when bank capital ratios generally were falling. Because banks were not constrained by capital regulation (at least not until the end of this period), they may have had less incentive to increase overall risk through SLC issuance. Moreover, it is significant that Goldberg and Lloyd-Davies found that, despite higher credit quality, increasing SLC exposure did not *reduce* bank risk.

III. Regulating Standby Letters of Credit

Bank regulators are concerned that the rapid growth in SLCs outstanding over the last several years is an indication that banks are attempting to take on more risk, in part, as a result of increasingly stringent capital regulation. This paper has suggested that while capital regulation may have played a modest role in the growth of SLCs, the primary reason for such growth has been an increase in the demand for financial guarantees generally. Whether this growth has increased bank risk is still open to question.

In some respects, SLCs are (potentially at least) more risky than loans, but the available evidence suggests that banks may be applying higher credit evaluation standards for SLCs than for loans to compensate for the riskier features of the SLC instrument. At the same time, however, this paper has suggested that it would be a mistake to infer from this evidence that SLCs necessarily pose less risk to capital than do loans. It is hard to believe that with the implicit subsidy to risk-taking provided by the deposit insurance system, banks actually would conduct their SLC business in a manner that entails *less* risk than lending.

Currently, bank regulators place only rather limited restrictions on banks' SLC activities. They require only that banks (1) include SLCs with loans for the purposes of calculating loan concentrations to any one borrower (the limit is 10 percent of capital) and (2) apply the same credit evaluation standards for SLCs as for loans. However, because of the greater riskiness of the SLC *instrument* as well as the greater potential for capital leverage with SLCs than with loans, some form of capital-related regulation of SLCs may be justified.

Capital adequacy regulation with respect to SLC exposure ought to do two things. First, from a bookkeeping perspective, it should ensure that institutions that are likely to experience larger losses also have a larger capital buffer to absorb those losses. Second, ideally, it should provide a structure that penalizes banks for attempting to increase overall risk through increases in SLC risk or leverage.

Accordingly, one can evaluate the risk-based capital adequacy concept that is under consideration at the federal bank regulatory agencies. Under this approach, SLCs outstanding would be added to assets for the purpose of calculating a new, risk-

based capital ratio. Moreover, because it is thought that at least certain types of SLCs may entail less risk than loans, those SLCs would be accorded a lower weight in the calculation of that ratio. For example, the FRB's proposed guidelines assign a weight of 1.0 to most types of SLCs, but a weight of only 0.6 to a few types, such as performance-related SLCs.

The advantage of this basic approach is that it is easy to administer. Also, it provides a means of ensuring that as banks' SLC exposure grows, so too will their capital buffer. The disadvantage is that it treats all SLC portfolios (and all loan portfolios, for that matter) as having the same level of credit risk. Clearly, this approach will impose a higher capital cost on the banks that have higher quality SLC portfolios than is the case for banks with lower quality portfolios. As a result, the former may have an incentive to compensate for this implicit penalty by taking on more credit risk in their SLC portfolios.

APPENDIX

Banks seek to manage SLC risk in several ways. First, through the fees they charge, banks require compensation in proportion to the risks they assume. Consequently, SLC fees vary with the term of the SLC and the credit rating of the account party. For short-term, high-quality credits, fees currently range from 25 to 50 basis points on the outstanding amount, while fees on longer term and lower quality credits range from 125 to 150 basis points or more.

Second, banks attempt to reduce credit risk on longer term commitments by requiring periodic (usually annual) renegotiation of the terms of the agreement. For example, SLCs backing the commercial paper of nuclear fuel trusts typically have a three-to four-year term, but are renewable each year at the bank's option. This arrangement helps protect the bank against deterioration in the creditworthiness of the account party over the term of the SLC.

However, such arrangements are not always adequate. One large bank that issues SLCs to back industrial development bonds analyzes its risk exposure in terms of the life of the bonds (usually 20 years). It has chosen this measure instead of the life of the SLC (typically five years) because at the

To overcome this problem, the regulators could, in theory, adopt a more sophisticated measure of SLC risk along the lines of the options model outlined in this paper. Such a measure would enable regulators to take variations in the credit quality of individual portfolios into account when assigning risk weights. However, it would be difficult to administer since considerably more data on the characteristics of individual portfolios would be needed. Instead, the regulators have chosen simply to recognize the inherent weaknesses in any capital adequacy ratio and to emphasize that such ratios — even those that attempt to adjust for risk — are meant only to supplement the bank examiner's judgement. Ultimately, they argue, the bank examiner must decide whether an institution's capital is adequate based on such qualitative considerations as the quality of earnings and management and overall asset quality as measured by the level and severity of examiner-classified assets.

expiration of the SLC, if the account party's financial condition has deteriorated such that it cannot obtain another SLC, the bondholders can declare the borrower in default under the terms of the bond indenture and thus require the bank to cover any losses.* In this case, the shorter term of the SLC does not necessarily limit the bank's exposure. Likewise, a bank may be liable for the repayment of commercial paper debt if it is unwilling to renew its SLC since the bank's unwillingness most likely would result in the account party's inability to refund its debt.

Third, although SLCs frequently are unsecured, the terms of the bank's contract with the account party provide another measure of protection against loss. Typically, the bank's agreement with the account party stipulates that the bank may: 1) require the account party to deposit funds to cover any anticipated disbursements the bank must make under the SLC, 2) debit the account party's account to cover disbursements, 3) call for collateral during the term of the SLC, and 4) book any unreimbursed balance as a loan at an interest rate and on terms set by the bank.** In the event of the account party's bankruptcy, such conditions, of course, do not pro-

tect the bank against loss in the same way that a formal collateral agreement would. Under most circumstances, however, they do provide sufficient incentive for the account party to satisfy the terms of the underlying contract.

A fourth way that banks can manage the credit risk involved in SLC issuance is through portfolio diversification. (This approach, of course, cannot reduce systematic risk.) Banks that specialize in issuing certain types of SLCs — backing commercial paper issued by nuclear fuel trusts, for example — still can diversify by buying and selling participations in SLCs. By selling a participation in an SLC it has issued, a bank in effect reinsures some of the risk. If payment must be made to the beneficiary and the account party is unable to make reimbursement, the issuing bank and the bank that purchased a share of the SLC will share in the resulting losses. Under a participation arrangement, the issuing bank will be liable for the full amount of the SLC only if the participating bank were to fail. Participations of SLCs accounted for 11 percent of the \$149.2 billion in SLCs outstanding as of March 1985.

Finally, in response to growing regulatory concern over banks' SLC exposure, banks are beginning to manage risk by placing limitations on SLC growth. A number of large banks have established some multiple of capital (for example, 150 percent) as a limit on the amount of their SLCs outstanding. In addition to administratively imposed limitations, the commercial paper market tends to limit SLC growth as well. Since SLC-backed commercial paper trades as an obligation of the SLC issuer, excessive SLC issuance will reduce the value of the issuing bank's guarantee as well as the price of its own commercial paper.

* Based on information from an informal survey of large banks in the Twelfth Federal Reserve District conducted in August 1985.

**See Lloyd-Davies' article on standby letters of credit in *Below the Bottom Line*, a staff study of the Board of Governors of the Federal Reserve System, January 1982, for a more detailed discussion of the contractual terms of the LC agreement.

FOOTNOTES

1. Historically, banking laws have prohibited banks from offering financial and performance guarantees in order to preserve the traditional separation between banking and commerce in this country. Standby letters of credit (and commercial letters of credit, for that matter) are not technically guarantees, however, since the issuing bank's obligation under an SLC is to advance funds upon presentation of certain documents regardless of whether the underlying contract between the beneficiary and the account party has been performed to both parties' satisfaction.

2. Senior Loan Officer Opinion Survey conducted by the Federal Reserve System in August 1985.

3. Insurers traditionally have issued surety bonds which are, technically, performance guarantees. Lately, they have become active issuers of financial guarantees. Revenue from these two lines of business are reported together as revenues from surety operations.

4. Eric Gelman, et al, "Insurance: Now It's a Risky Business," *Newsweek*, November 4, 1985.

5. Senior Loan Officer Opinion Survey, August 1985.

6. Senior Loan Officer Opinion Survey, August 1985.

7. This estimate is based on the opportunity cost, at current interest rates, of the 3 percent marginal reserve requirement on large CDs.

8. For a more detailed discussion of the deposit insurance system and the risk-taking incentives it creates, please see the articles by Barbara Bennett and David Pyle in the Spring 1984 issue of the Federal Reserve Bank of San Francisco's *Economic Review*.

9. The Federal Reserve Board's proposed rules on risk-based capital guidelines were set forth in *Federal Register*, January 31, 1986, p. 3976. The comment period for this proposal extends until April 25, 1986.

10. For unsecured debt and SLCs, the relevant price is the value of the bank's prorated share of the firm's assets in a bankruptcy proceeding.

11. Black and Scholes have shown that an option's value is determined by the riskiness of the underlying asset (that is, variance of return on the asset), the option's term to maturity, and the level of the risk-free interest rate, as well as the level of the exercise price and the market value of the underlying asset.

12. Based on information from an informal survey of large banks in the Twelfth Federal Reserve District conducted in August 1985.

13. *Ibid.*

14. Survey of Terms of Lending at Commercial Banks, May 1985, conducted by the Federal Reserve System.

15. Peter Lloyd-Davies, "Survey of Standby Letters of Credit," *Federal Reserve Bulletin*, December 1979, pp. 716-719.

16. August 1985 survey of large 12th District banks.

17. Michael Goldberg and Peter Lloyd-Davies, "Standby Letters of Credit: Are Banks Overextending Themselves?," *Journal of Bank Research*, Spring 1985, pp. 28-39.

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Arbitrage and Efficient Markets Interpretations of Purchasing Power Parity: Theory and Evidence

John Pippenger*

The theory of Purchasing Power Parity was the first well-developed theory of exchange rate determination. Although the efficient market approach is an important theoretical advance over the conventional arbitrage interpretation of purchasing power parity, many of the empirical implications of the two approaches are similar. As a result, at this time, the empirical evidence supports both views.

The adoption of more flexible exchange rates in the early 1970s spurred both theoretical and empirical research on purchasing power parity (PPP). The theoretical work refined existing ideas about the theory and led to a new version of PPP based on efficient commodity markets. The empirical research created an impressive body of evidence. This article reviews the theory behind two major approaches to purchasing power parity, the arbitrage and efficient markets approaches, and discusses the evidence relevant to each.

The arbitrage approach is discussed first. In spite of a widespread belief that arbitrage has

failed, particularly during the current float, the evidence provides substantial support for an arbitrage interpretation of purchasing power parity. The efficient commodity market approach to purchasing power parity initially proposed by Richard Roll (1979) is the newest version of PPP, and it is discussed more thoroughly. Although the efficient market approach is an important theoretical advance over the conventional arbitrage interpretation of purchasing power parity, many of the empirical implications of the two approaches are similar. As a result, at this time, the empirical evidence supports both views.

I. Arbitrage

Theory

The arbitrage version of purchasing power parity was the first well-developed theory of the determination of exchange rates. Although the roots of the theory go back at least to the period when gold from the New World began to influence prices in Europe, Gustav Cassel (1916) is gener-

ally credited with the first formal statement of the theory. The name, purchasing power parity, comes from Cassel's basic idea that exchange rates should, in time, adjust so that a given amount of currency buys the same bundle of goods in all countries. In other words, exchange rates tend to settle at the point where the purchasing power of a currency is the same, or at parity, in all countries.¹

As an example, start with a single commodity. It might be a quart of milk, a Sony Walkman®, a gallon of gasoline or a bushel of number 2 red wheat. Ignoring information and transaction costs, with effective arbitrage, the cost of buying

*Professor, University of California, Santa Barbara, and Visiting Scholar, Federal Reserve Bank of San Francisco. I have received helpful comments from several members of the FRBSF. I am also indebted to Nurhan Davutyan and John Mussachia.

the good in the United States at time t , $p(H,t)$, should equal the cost of the good in Great Britain at time t , $p(F,t)$, converted to dollars using the dollar price of the pound at time t , $S(t)$. That is, $p(H,t)$ should equal $S(t)p(F,t)$. This is commonly referred to as the law of one price. The law of one price implies that the domestic price of foreign exchange $S(t)$ equals the domestic price of the product $p(H,t)$ divided by the foreign price $p(F,t)$. If the product were wheat and the countries the United States and Great Britain, then the dollar price of pound sterling should equal the dollar price of wheat divided by the pound price of wheat.

The arbitrage interpretation of purchasing power parity rests on a weaker version of the law of one price that does not require zero information and transaction costs. For some goods, $p(H,t)$ may be less than $S(t)p(F,t)$. For actual or potential exports by the United States, the price differential would reflect the information and transaction costs associated with shipping goods to Great Britain. For actual or potential imports, the excess of $p(H,t)$ over $S(t)p(F,t)$ reflects the cost of moving the goods from the U.K. to the U.S. If the information and transaction costs are roughly the same in both directions, then the price in the U.S. of a broadly based *bundle* of goods, $P(H,t)$, should tend to equal the price of that bundle in the U.K., $P(F,t)$, converted into dollars at the going exchange rate, $S(t)$. If there are goods for which the information and transaction costs exclude any possibility of international trade, then this version of PPP implicitly assumes that there is no systematic difference in their relative prices between any two countries.

$$S(t) = \frac{P(H,t)}{P(F,t)} \quad (1)$$

Equation 1 describes absolute purchasing power parity. That is, it describes the relation between the level of exchange rates and relative price levels. This version of the theory is not widely used for at least three reasons. First, in spite of relatively little research, there is a general consensus that it is not very accurate. Second, while price indices are easy to find for almost all countries, information about the price of identical

bundles of goods in different countries is difficult to locate. Third, for many purposes, it is the change in exchange rates that is important, not the level.

For these reasons, almost all empirical work on PPP has concentrated on the relative version of the theory, which explains changes in the exchange rate. Let $S(0)$ be the exchange rate in some base period, and $P(H,0)$ and $P(F,0)$ be the domestic and foreign price of the broadly based bundle of goods in the base period. The relative version of PPP says that the change in the exchange rate from the base period 0 to some later period t equals the relative change in the price of the bundle of goods in the two countries.

$$\frac{S(t)}{S(0)} = \frac{P(H,t)/P(F,t)}{P(H,0)/P(F,0)} \quad (2)$$

The right hand side of this equation can be rearranged into a more familiar form — a ratio of price indices. With a little manipulation, the right hand side of equation 2 becomes $[P(H,t)/P(H,0)]/[P(F,t)/P(F,0)]$. The numerator of this ratio is simply a price index for the United States, P^H , and the denominator a price index for the foreign country, P^F . Both indices have the same base period and use identical weights. Equation 3 uses these price indices to describe the relative version of purchasing power parity.²

$$\frac{S(t)}{S(0)} = \frac{P^H}{P^F} \quad (3)$$

Most empirical research on PPP involves regressing the log of the ratio of exchange rates on the log of a ratio of price indices:

$$\ln(s) = \alpha + \beta \ln \left(\frac{P}{P^*} \right) + z \quad (4)$$

where z is an error term; $\ln(x)$ is the natural log of x ; S equals $S(t)/S(0)$; P is a domestic price index; P^* a foreign price index; and the price indexes usually are consumer or wholesale indexes, or GNP deflators not based on identical bundles of goods.³ The usual interpretation of equation 4 is that it supports PPP when estimates of α are not different from zero, estimates of β are not significantly different from one, and the R^2 is high.⁴

Evidence

Most of the evidence concerning the arbitrage version of purchasing power parity has come either from estimating equations like 4 or analyzing the behavior of real exchange rates (which are actual exchange rates divided by the rates implied by PPP). This section concentrates on regression results. The behavior of real exchange rates is covered in the section dealing with the evidence for efficient commodity markets. For an extensive review of the results of regression analysis, see Officer (1976). Dornbusch (1985) provides a briefer review that covers most of the relevant research through 1984.

The general consensus on this empirical research is that, while regression results may provide some support for PPP during the 1920s, they provide almost no support for the theory during the 1970s.⁵ However, this conclusion is too negative for two reasons. First, recent evidence not available to Officer or Dornbusch supports PPP. Second, in many cases, the rejection of PPP is based on a misinterpretation of the regression results.

As an example of some of the evidence not available to Officer or Dornbusch, Mark Rush and Steven Husted (1985) report long-run support for PPP between the U.S. and several countries. For other combinations of countries, their results are mixed. In addition, Craig Hakkio (1984) combines time series and cross section analysis, and obtains results that provide strong support for PPP. Although Tahmoures Parsai's (1982) research indicates that other factors influence exchange rates, his estimates of the relationship between price levels and exchange rates also support PPP and are not sensitive to the inclusion of other variables. As Paul Krugman (1978) points out "... one must be cautious in determining the extent of and the reasons for failure of PPP to hold, for the world has laid statistical traps for the unwary."

The following sections use the arbitrage approach to PPP to examine why PPP might appear to fail and to show how these apparent failures can be statistical traps. They also review the evidence concerning the relative importance of the various sources for failure. The last section

provides some examples of how regressions can be misinterpreted.

Different Weights

From an arbitrage point of view, the weights in price indices must be the same. Using consumer or wholesale indices or GNP deflators violates this requirement. The following example illustrates the problem. Suppose the United States produces only wheat and Great Britain produces only cloth. Some real shock causes the price of wheat to rise ten percent in both countries and the price of cloth to fall ten percent. If the law of one price holds, then PPP holds and the exchange rate should not change.

But consider what happens if one tests PPP using equation 4 and GNP deflators. The GNP deflator in the U.S. rises ten percent because it contains only wheat. The GNP deflator for the U.K. falls ten percent because it contains only cloth. The exchange rate is constant, but the ratio of the price indices rises. Because the indices do not have identical weights, estimates of equation 4 can reject purchasing power parity even though the theory holds exactly.

From an arbitrage perspective, different weights introduce a form of measurement error into relative price levels. As an example, suppose the variance in the ratio of price indices, σ^2 , comes from two independent sources: pure monetary shocks for which PPP holds exactly, σ_M^2 , and movements in the ratio of price indices that come from changes in relative prices with unequal weights, σ_W^2 .

$$\sigma^2 = \sigma_M^2 + \sigma_W^2$$

Under these conditions, ordinary least squares yields the following estimate for B:

$$\text{plim } \hat{B} = \frac{1.0}{1.0 + \frac{\sigma_W^2}{\sigma_M^2}} \quad (5)$$

As inflationary shocks dominate measurement error, estimates of B and the R^2 approach unity. But as monetary shocks decline relative to the measurement error, R^2 declines and estimates of B approach zero even though PPP in the form of equation 3 holds exactly regardless of the relative

importance of monetary shocks and measurement error.

For a number of years, the Federal Statistical Office of Germany has used identical bundles of goods to calculate absolute purchasing power parities for several countries.⁶ John Mussachia (1984) compares the results of testing PPP with this data and conventional price indices. The results suggest that, except perhaps for very stable relative price levels, different weights are not a major source for the observed errors in purchasing power parity.

Simultaneity

Even if purchasing power parity held exactly and there were no problems with price indices, tests of equation 4 still could yield a low R^2 and estimates of β close to zero. Under the arbitrage version of PPP, neither price levels nor exchange rates are exogenous variables. As a result, there is the possibility of bias due to simultaneous equations. Krugman (1978) provides a simple example of simultaneous equations bias in PPP. In his model, the central bank attempts to stabilize the exchange rate by expanding the domestic money supply as the domestic price of foreign exchange falls. This stabilization policy biases the estimate of B toward zero because it causes the error term in equation 4 to be correlated with the ratio of price levels, violating one of the assumptions of ordinary least squares (OLS) regression.

Two stage least squares (2SLS) is the standard way to deal with this problem. The first stage of 2SLS develops a proxy variable. If this variable is a good proxy for the original explanatory variable, e.g., p^H/p^F , and it is also independent of the error term in the original regression, then substituting the proxy for the original explanatory variable in the second stage regression eliminates the correlation with the error term and eliminates the bias.

Although OLS estimates of equation 4 are subject to bias due to simultaneous equations, this bias does not appear to be a major reason that regressions often fail to support PPP. Measurement error due to unequal weights and some of the other sources for errors in PPP described below also introduce bias and cause the error term in equation 4 to be correlated with the ratio of price levels. These other

sources for bias appear to be more important for two reasons. If the conventional arbitrage version of PPP were correct and simultaneous equations bias *per se* were the problem with the regressions, then the real exchange rate would not behave as though it were very close to a random walk. In addition, when the test equation for PPP is reformulated so as to reduce the bias from these other sources, two stage and ordinary least squares yield essentially the same results.⁷

Information and Transaction Costs

Tradables. In discussions of PPP, it is customary to divide goods into two categories: tradables, for which information and transaction costs as well as other impediments are zero, and nontradables, for which these impediments effectively prevent trade. The assumption of no impediments for tradables is analytically convenient, but not very accurate. Transaction costs and tariffs introduce errors into the law of one price even for widely traded goods such as wheat and oil. Although these impediments can introduce errors into PPP, the errors are bounded. Once the pound price of wheat converted into dollars at the going exchange rate exceeds the dollar price of wheat by the cost of shipping wheat plus any tariff, arbitrage presumably prevents the next shock from widening that gap. (See Aizenman, 1984a and 1984b, for a detailed discussion of how transaction costs introduce errors into PPP and how these errors can bias the estimate of B toward zero.) As a result, if the errors in PPP were primarily the result of the effects of information and transaction costs for tradables, then real exchange rates should not behave like random walks.

Work by Richard Roll (1979), Michael Darby (1980), John Pippenger (1982), and Michael Adler and Bruce Lehman (1983) indicates that real exchange rates behave randomly, which implies that the predictive error in PPP is unbounded. Although some new evidence presented below indicates that the errors are bounded, the boundaries appear to be very wide and/or very weak. The behavior of real exchange rates, therefore, suggests that the errors in purchasing power parity are not primarily due to the effects of trade impediments on tradables.

Dynamics. Purchasing power parity is usually viewed as primarily a theory of the long-run deter-

mination of exchange rates. Actual and parity rates can diverge in the short-run, but in the long-run they tend to converge.⁸ Almost every asset model of the exchange rate implies this kind of behavior. Indeed, many asset models assume PPP fails completely in the short-run but holds exactly in the long-run.

A dynamic interpretation of PPP implies that equation 4 is misspecified. In a dynamic framework, the current exchange rate depends on both current and lagged relative price levels and, perhaps, lagged exchange rates. See Hodgson and Phelps (1975) for an attempt to estimate a dynamic version of equation 4.

If market forces tend to bring actual and parity rates into equality in the long-run, then changes in the deviation from PPP must be correlated. Suppose the actual rate is above the rate implied by PPP. If the error is random, then that gap is as likely to increase as decrease. Any move above parity is as likely to be followed by a further move away from as a move toward parity, and the changes in the error are uncorrelated. But if there are market forces at work bringing actual and parity rates together, then the gap is more likely to decrease than increase. Beyond some point, any move above parity eventually is followed by a movement back toward parity, and there is negative serial correlation in the changes in the error. Since, as mentioned earlier, the predictive errors for PPP behave almost like random walks, a dynamic version of equation 4 does not appear to be appropriate.

The evidence concerning the behavior of real exchange rates raises serious questions about the view that purchasing power parity is essentially a long-run theory. Although there is evidence that real rates do not behave exactly like random walks, the deviation from a random walk is so slight that it does not indicate any strong tendency for actual and parity rates to converge in the long-run. Opponents of PPP will be tempted to interpret this pattern as evidence that the theory does not hold much better in the long-run than in the short-run. However, the efficient commodity market model of purchasing power parity discussed below suggests a different interpretation. From that perspective, the observed behavior of real exchange rates suggests that commodity markets influence exchange rates in both the long-run and short-run.

Nontradables. As mentioned earlier in discussing PPP, it is convenient to divide goods into two groups: tradables with no impediments and nontradables where transaction costs or trade restrictions effectively prohibit trade. For tradables, the law of one price holds and so does equation 3 as long as the bundle contains only tradables. When price indices contain nontradables, real shocks can cause PPP to fail.

Take concrete as an example of a nontradable. Suppose some shock raises the price of concrete in the U.S. and lowers the price of concrete in the U.K., but all other prices in both countries are unchanged. With no change in the prices of traded goods, the exchange rate is unchanged. But a price index including concrete rises in the U.S. and falls in the U.K. Purchasing power parity fails because the change in relative prices between tradables and nontradables is different in the two countries.

The distinction between the structure of the errors for tradables and nontradables is important. If the errors in PPP are due primarily to shocks that affect tradables, then the errors are bounded. If the errors are due primarily to changes in relative prices for nontradables, no such restriction applies. A given shock might raise the relative price of concrete in the U.S., but the next shock might either accentuate or offset the effect of the first shock.⁹

From an arbitrage perspective, changes in capital flows, tastes or technology can introduce large persistent errors into PPP by causing relative prices between tradables and nontradables to change differently in different countries. This interpretation of the effects of such shocks helps explain why it is so difficult to find any empirical regularity between a given type of shock and the error in PPP. Under some circumstances a larger capital flow might cause the relative price of concrete to rise in a country; under others, the relative price might fall.

Changes in relative prices for nontradables not only introduce errors into PPP, they also bias the estimate of B toward zero. Suppose the variance in the ratio of price indices is σ^2 and part of this variance comes from purely monetary shocks, σ_M^2 , for which PPP holds perfectly. In addition, there is another element, σ_R^2 , that comes from real shocks. If these different sources for the variance in the ratio of price indices are uncorrelated, then σ^2 equals σ_M^2

plus σ_R^2 , and a variation of equation 5' describes the estimate of B.¹⁰

$$\text{plim } \hat{B} = \frac{1.0}{1.0 + \frac{\sigma_R^2}{\sigma_M^2}} \quad (5')$$

As inflationary shocks dominate real shocks, the R^2 and estimate of B approach unity. As monetary shocks disappear, the R^2 and estimate of B approach zero even though PPP holds perfectly for monetary shocks and real shocks have not increased. In other words, under these conditions, regression results do not depend on just the effectiveness of arbitrage and PPP, they also depend on the degree of monetary coordination in the two countries. On the one hand, the real shocks can be relatively large, but if the differences in the rates of inflation are also very large, then the R^2 and B are close to unity. On the other hand, even if the errors in PPP due to real shocks are very small, a sufficient degree of monetary coordination can make the ratio σ_R^2/σ_M^2 such that the R^2 and B are not statistically different from zero. As a result, PPP can appear to fail when the errors are relatively small, and to succeed even though the errors are relatively large.

Since the behavior of real exchange rates is very close to a random walk, from an arbitrage perspective, the errors in purchasing power parity appear to be dominated by changes in relative prices for nontradables. Some shock raises the relative price of haircuts or concrete in the United States, but not in Great Britain. If the price of traded goods remains constant, the U.S. price level rises relative to the price level in the U.K., but the exchange rate does not change. If the next shock is as likely to reinforce as reverse the first, then the errors in PPP behave like a random walk.

This interpretation of the error structure must be taken as tentative for several reasons. First, direct tests of the effectiveness of arbitrage for traded goods suggest that the law of one price does not hold as a reasonable approximation even for traded goods. See, for example, Peter Isard (1977) and J. David Richardson (1978). These results, however, are suspect because they are based on subcategories such as leather products in price indices in different countries that do not refer to identical, or even very similar, products. In addition, when the indices are

wholesale, they tend to reflect posted prices rather than the actual prices at which trade takes place. When market prices for individual products such as Malaysian rubber are used, the results provide more support for arbitrage. See, for example, Liliane Crouhy-Veyrac, Michel Crouhy and Jacques Melitz (1980) and Aris Protopapadakis and Hans Stoll (1984).

Another problem with this interpretation of the errors is that almost everything is tradable. Concrete is traded internationally and tourists get haircuts. If almost everything is tradable, but the boundaries generated by impediments are very wide and not very rigid for many commodities, then the boundaries for real exchange rates could be quite wide and not very rigid. In that case, real exchange rates would behave like a random walk with wide and flexible boundaries, which is consistent with evidence discussed later. Errors of this type would not eliminate the kind of bias described in equation 5'; they would just make the problem more complex.

The efficient commodity market model discussed below provides still another possible interpretation of the observed errors in PPP. In that context, efficient international speculation in commodities in the absence of trade generates a random walk in real exchange rates.

Examples

Paul De Grauwe, Marc Janssens and Hilde Leliaert (1982), De Grauwe and Marc Rosiers (1984) and Davutyan and Pippenger (1985) show that the predictive errors for PPP tend to be relatively large when there are large differences in the rates of inflation. If, as seems likely, these errors are the result of changes in the relative prices for nontradables, then regression estimates of equation 4 will give the best results when, in terms of the predictive error, PPP works the worst. The reason is that, even though monetary instability tends to increase σ_R^2 , it also makes σ_R^2/σ_M^2 very small.¹¹

The dependence of regression results on the degree of monetary coordination not only leads to a misinterpretation of the evidence, it also invites specification search. Advocates of PPP can find episodes where regressions appear to support the theory, and those who oppose it can find situations in which the same regressions appear to reject PPP.

Estimates of equation 4 for the United States and Canada during the 1970s and early 1980s in the first half of Table 1 provide an example of the importance of relative monetary stability, and illustrate how specification search can influence regression results. An examination of the regression errors for France from the 1920s and 1970s illustrates why it is incorrect to conclude that PPP worked during the 1920s but failed during the 1970s.

The first half of Table 1 shows estimates of equation 4 using monthly data from January 1972 to December 1977, and January 1978 to February 1984. During the first period, price levels in the two countries moved together very closely. Wholesale prices in Canada rose only five percent more than in the United States. For that period, both β and the R^2 are effectively zero. During the later period, the Canadian price level rose 15 percent more than the price level in the United States. For that period, the R^2 is respectable and the estimate of β is not statistically different from unity. Using the usual criteria of R^2 and β , anyone wishing to reject PPP could use the earlier period and anyone wishing to support PPP could use the later period.

Although estimates for the earlier period appear to reject PPP and estimates for the later period support the theory, this interpretation of the evidence is misleading. Although the R^2 and β are closer to unity for the later period, this is primarily

because there is more variability in both exchange rates and relative price levels during the later period. In other words, σ_M^2 is larger in the second period. The fact that the standard errors are identical in the two periods means that the amount of variation in the exchange rate that cannot be explained by PPP is identical in the two cases, which indicates that σ_R^2 is the same in both periods. PPP worked just as well in the earlier period as in the later. The difference between the two periods is primarily that σ_R^2/σ_M^2 is smaller in the second period because σ_M^2 is larger.

The bottom half of Table 1 shows Frenkel's results for France in the 1920s and 1970s using two stage least squares. Based on the estimates of R^2 and β , the results for the 1920s appear to support purchasing power parity while those for the 1970s reject the theory. The widespread belief that PPP worked in the 1920s but failed in the 1970s is based on similar results for a number of countries.¹²

However, if one interprets the standard errors of the regression as an index of the effects of real shocks, the evidence does not support the conclusion that purchasing power parity worked in the 1920s and failed in the 1970s. Indeed, those errors suggest just the opposite. The standard error for France in the 1920s is 0.054, but it falls to 0.029 in the 1970s.¹³ The large R^2 and β during the 1920s is simply a reflection of the fact that a very large proportion of the variability in the exchange rate can

TABLE 1
Monthly Estimates of Equation 4 Using Wholesale Indices

Country	Period	α	β	$R^2/$		
				Standard Error	Durbin Watson	p
Canada	Jan. 1972	-0.02	0.25	0.03	1.07	0.82
	Dec. 1977	(0.01)	(0.16)	0.010		
	Jan. 1978	-0.15	0.82	0.37	1.62	0.73
	Feb. 1984	(0.00)	(0.12)	0.010		
France	Feb. 1921	1.183	1.091	n.a.	1.70	0.58
	May 1925	(0.157)	(0.109)	0.054		
	June 1973	-1.52	-0.18	n.a.	2.26	0.86
	July 1979	(0.03)	(0.37)	0.029		

Sources: Canada, Davutyan and Pippenger (1985) Table 5. France, Frenkel (1981) Tables 1 and 2.

Note: Canadian estimates use SAS autoreg corrected for one period serial correlation. French estimates use two stage least squares. Standard errors in parentheses. No base period.

be explained by monetary shocks. In other words, the R^2 and estimates of B are close to one for the 1920s because σ_M^2 is large, not because σ_R^2 is small. The fact that the absolute size of the standard error is smaller during the 1970s means that amount of the variability in the exchange rate that cannot be explained by PPP is smaller during the 1970s. Since there was much more monetary coordination during the 1970s, this result indicates that the R^2 and

estimate of B for that period are low because σ_M^2 is low, not because the errors due to real shocks, σ_R^2 , are large. If purchasing power parity was a success in the 1920s, it did not collapse in the 1970s.

The widespread belief that PPP collapsed in the last decade is based on a serious misinterpretation of the evidence that ignores the econometric traps involved in estimating purchasing power parity.

II. Efficient Commodity Markets

A number of studies referred to earlier indicate that real exchange rates behave like a random walk. To explain these random walks, Roll (1979) developed a theory based on speculation in efficient international commodity markets. Roll's theory expands the traditional view of purchasing power parity in two ways. It uses speculation rather than arbitrage and stresses intertemporal transactions. Since most international trade involves time and some element of speculation, this approach is a significant advance in terms of realism over the traditional arbitrage approach to purchasing power parity.¹⁴

Under the arbitrage approach, a trader buys a good this month at home and sells it this month in another country. Since the presence of risk is never mentioned in such an analysis, there is an implicit assumption that all prices are known with certainty. In Roll's model, there is no physical transfer of commodities. Instead, speculators in one country speculate on changes in exchange rates and changes in commodity prices in the other country.

Intertemporal Speculation without Trade

As an example of Roll's approach, consider a speculator who buys a commodity in a foreign country in month $t-1$ for sale in that country the next month t . If $p(F,t-1)$ is the cost of the good in the foreign country in $t-1$ and $S(t-1)$ is the domestic price of foreign exchange that month, then the domestic price of the foreign good in $t-1$ is $S(t-1)p(F,t-1)$. The return from the sale of the commodity is $S(t)p(F,t)$, where $S(t)$ is the exchange rate in t and $p(F,t)$ is the price the speculator receives for the good in the foreign country. Since the natural log

of the return over the cost is approximately the percentage difference between the two, the gross rate of return from this transaction is

$$\ln \left[\frac{S(t)p(F,t)}{S(t-1)p(F,t-1)} \right] \quad (6)$$

Whether or not the speculator engages in such a transaction depends on the net return, which is the difference between the return from foreign speculation and a similar domestic transaction. Let $p(H,t-1)$ be the domestic price of the good in $t-1$ and $p(H,t)$ the price in t . Under these conditions, equation 7 describes the net return r_s from intertemporal international speculation.

$$\begin{aligned} r_s &= \ln \left[\frac{S(t)p(F,t)}{S(t-1)p(F,t-1)} \right] - \ln \left[\frac{p(H,t)}{p(H,t-1)} \right] \\ &= \ln \left[\frac{S(t)p(F,t)}{p(H,t)} \right] - \ln \left[\frac{S(t-1)p(F,t-1)}{p(H,t-1)} \right] \quad (7) \end{aligned}$$

If international commodity speculation is efficient, then, based on the information available in period $t-1$, the expected net return should be zero.¹⁵

$$E \left[\frac{r_s}{Z(t-1)} \right] = 0 \quad (8)$$

where E is the expectations operator and $Z(t-1)$ is the information available in $t-1$.

Equations 7 and 8 imply equation 9, where u_t is an uncorrelated random variable with zero mean.

$$\ln \left[\frac{S(t)}{p(H,t)/p(F,t)} \right] \\ = \ln \left[\frac{S(t-1)}{p(H,t-1)/p(F,t-1)} \right] + u_t \quad (9)$$

In the terminology of efficient markets, equation 9 means all the information relevant for determining the real exchange rate next period is already fully reflected in the current real exchange rate.

Consider the following implication of equation 9. Suppose the price of wheat in Canada this month times the current price of the Canadian dollar does not equal the current price of wheat in the United States. According to equation 9, that difference is as likely to increase as to decrease in the next month. Given efficient international speculation without trade, market forces do not work toward restoring the law of one price. Since this is true for every commodity, it holds for arbitrary bundles of commodities.¹⁶ As a result, there are no market forces at work restoring long-run equality between actual exchange rates and the rates implied by purchasing power parity. Real exchange rates perform a random walk because, no matter what the gap between the actual and parity rate is in one period, the gap is as likely to grow as to shrink in the next period.¹⁷

Intertemporal Speculation with Trade

Without trade, speculators can only guess whether an expected change in a price at home $p(H,t)/p(H,t-1)$ will equal the domestic value of the change in the price of the same good in a foreign country — $S(t)p(F,t)/S(t-1)p(F,t-1)$. In this type of speculation, the level of the exchange rate is irrelevant. Halving or doubling $S(t)$ and $S(t-1)$ does not alter $S(t)p(F,t)/S(t-1)p(F,t-1)$. When speculation involves trade, the returns depend on the level of exchange rates. If the price of pound sterling rises with no change in the product price in the U.S. or U.K., it becomes relatively more profitable to buy in the U.S. "this" period for sale in the U.K. in the "next" period.

Consider an exporter who buys a good at home this period, ships it, and sells it abroad next period.

Using the earlier notation, the gross return from this transaction is $\ln - \{[S(t)p(F,t)]/p(H,t-1)\}$. The net return, which is the incentive for such activity, depends on the return from similar domestic transactions. If the speculator buys the good at home one month and sells it at home next month, the return is $\ln[p(H,t)/p(H,t-1)]$. The net return from speculation with trade, r_t , is the difference between these two gross returns.

$$r_t = \ln \left[\frac{S(t)p(F,t)}{p(H,t-1)} \right] - \ln \left[\frac{p(H,t)}{p(H,t-1)} \right] \\ = \ln \left[\frac{S(t)p(F,t)}{p(H,t)} \right] \quad (10)$$

The net return is the percentage error in the law of one price. If $S(t)p(F,t)/p(H,t)$ is unity, the law of one price holds and the return from additional intertemporal international trade is zero.

The arbitrage version of the law of one price is based on international trade at known prices within a given time period where, ignoring transaction costs, arbitrage eliminates any net return. An efficient market version involves intertemporal trade with expected prices where the *expected* net return is zero given all currently available information.

$$E \left[\frac{r_t}{Z(t-1)} \right] = 0 \quad (11)$$

Equations 10 and 11 imply the conventional law of one price with an error term that reflects the uncertainty about future prices.

$\ln[p(H,t)] = \ln [S(t)p(F,t)] + e_t$ (12) where e_t is an uncorrelated random variable with zero mean.

Although the argument has been developed in terms of a single commodity, exactly the same reasoning applies to any arbitrary bundle of commodities. In an efficient market without transaction costs, the expected return from buying any bundle at home this period and selling it abroad next period cannot exceed the expected return from buying at home and selling at home.¹⁸ Efficient commodity markets with trade imply the absolute version of purchasing power parity with an error term.

$$\ln[S(t)] = \ln \left[\frac{P(H,t)}{P(F,t)} \right] + \gamma_t \quad (13)$$

where $P(H,t)$ and $P(F,t)$ are the home and foreign price of an identical bundle of goods, and γ_t is an uncorrelated random variable with zero mean.

Since the discussion has ignored the transaction costs associated with trade, the source of the error term γ in equation 13 is the same as the source for the error u in equation 9. They both come from imperfect information. In equation 9, imperfect information generates a random walk in real exchange rates because expected returns depend on expected changes in prices and exchange rates. With trade, expected returns depend on the level of prices and exchange rates, and so deviations of the actual rate from the rate implied by parity are uncorrelated. If they were correlated, expected net returns from trade would not be zero and trade in international commodity markets would not be efficient.

Recognizing the information and transaction costs associated with trade provides a link between the arbitrage version of PPP and the efficient market interpretation with trade. In the conventional arbitrage version of PPP, these costs introduce errors that are larger in the short-run than in the long-run. An efficient market interpretation of PPP with trade essentially adds an error term like γ to the arbitrage version.¹⁹ Equation 14 describes the relative version of an efficient market interpretation of PPP with trade and transactions costs.

$$\ln \left[\frac{S(t+1)}{S(t)} \right] = \ln \left(\frac{P^H}{P^F} \right) + v_t + g_t \quad (14)$$

where both v and g are error terms with negative serial correlation.²⁰ The term g has negative serial correlation because it represents the temporary deviations of the actual rate from parity generated by imperfect information.²¹ The term v has negative serial correlation because it is due to transaction costs that allow only limited deviations between actual exchange rates and those implied by PPP. This negative serial correlation is reinforced when these costs are effectively zero in the long-run. In the case where transaction costs are zero in the long-

run, deviations of the actual rate from parity are not only bounded, they also tend to disappear in the long-run.

To see the relation between an efficient market interpretation of PPP with trade and Roll's interpretation without trade, consider the following example. Suppose Roll's speculation in wheat between the U.S. and Canada generates a random walk for the real wheat exchange rate between the two countries. If $\$/\C is the U.S. price of the Canadian dollar, W is wheat in the U.S. and WC is wheat in Canada, then speculation without trade causes $(\$/\$C)/[(\$/W)/(\$C/WC)]$ to perform a random walk. As a result, in the absence of any other influences, the real wheat exchange rate will drift off toward plus or minus infinity in time.

But long before that happens, trade takes place. Suppose this morning the price of wheat in Winnipeg converted to U.S. dollars is less than the price expected next week in Chicago. If the price difference exceeds the transportation costs, there is an incentive to buy wheat in Winnipeg, load it on a train and ship it to Chicago for sale next week. From that point on, real exchange rates no longer behave like a random walk. Any further downward movement in the real wheat exchange rate is resisted by wheat moving from Canada to the United States. The shipments of wheat put upward pressure on Canadian wheat prices, downward pressure on wheat prices in United States, and increase the demand for Canadian dollars. Since the same argument holds for every commodity, efficient international commodity markets with trade imply that changes in real exchange rates should show evidence of negative serial correlation and should not be random walks.

Evidence

Roll (1979), Darby (1980) and Mussachia (1984) analyze monthly real exchange rates for many countries during the 1970s while Pippenger (1982) and Adler and Lehman (1983) use annual data over long periods.²² The tests include regressions, autocorrelations and spectral analysis, and in each case real exchange rates appear to behave as though they were random walks. Although a random walk is consistent with efficient international commodity markets

without trade, trade should impose boundaries on real exchange rates. The evidence presented next suggests that such boundaries exist.

These tests combine autocorrelation and spectral analysis with a technique used by Roll (1979). Roll tests his model by calculating the means of regression coefficients for many pairs of countries. The advantage of this approach is that it can reveal patterns that are so weak that they are not observable for any given pair. A regression coefficient might be statistically insignificant for 20 different pairs of countries, but if it is positive for all of them then it is almost certainly positive. Unfortunately, Roll's regressions were not designed to test for the presence of the kind of barriers that exist with trade. Since autocorrelation and spectral analysis are natural ways to test for such barriers, Tables 2 and 3 apply Roll's technique to autocorrelation and spectral estimates respectively.

Autocorrelation

As pointed out earlier, one implication of both the arbitrage view of PPP and efficient markets with trade is that real exchange rates are bounded by "reflecting barriers" and changes in real exchange rates have negative serial correlation. Although Roll (1979), Darby (1980) and Mussachia (1984) all find no evidence of negative serial correlation for

monthly data in the 1970s, combining the results from several countries suggests that reflecting barriers do exist.

The technique is simple: obtain the autocorrelation estimates for 13 lags for 24 real exchange rates using wholesale indices and end-of-month exchange rates from the International Financial Statistics tape for 1976.7 to 1983.12.²³ Compute the average autocorrelation estimate at each lag using the 24 pairs of countries and, in addition, take the mean of these averages. The reason for computing the mean of the averages at the various lags is that reflecting barriers are probably not identical for the various countries; their differences would lead to different lag structures. If the series are true random walks, there should be no evidence of either negative or positive correlation. If there are reflecting barriers, then there should be some evidence of negative serial correlation.

Table 2 shows the average autocorrelation estimates. For these countries the real exchange rate is not a random walk. Five of the lags are significant at the one percent level,²⁴ but there is no clear pattern of negative serial correlation because two of these estimates are positive. The mean of the 13 autocorrelation estimates, however, is negative and significant at the ten percent level. The average autocorrelations are not consistent with a random walk, but

TABLE 2
Average Autocorrelation Estimates

Lag	Estimate	t-Statistic
1	-0.065	-3.29***
2	-0.017	-0.92
3	0.028	1.24
4	-0.021	-1.29
5	0.017	0.82
6	-0.063	3.80***
7	0.058	2.83***
8	0.019	1.56*
9	-0.018	-1.52*
10	0.052	2.59***
11	0.028	1.12
12	-0.012	-0.59
13	-0.100	4.36***
Mean	-0.007	-1.41*

*Significant at ten percent level, single-tailed.

**Significant at five percent level, single-tailed.

***Significant at one percent level, single-tailed.

they provide only weak support for the existence of reflecting barriers. Spectral analysis yields stronger results.

Spectral Analysis

One natural interpretation of the concept of the short-run is that it refers to short cycles. A similar relationship between cycle length and the length of the run holds for the intermediate and long-run. For income and employment, the short-run might refer to cycles of up to two years and the long-run to cycles longer than the business cycle. In the context of highly organized markets such as the foreign exchange market, the short-run is more likely to refer to a period of a few days or a few months at most. Cycles as long as a couple of years almost certainly would correspond to the long-run, and the concept of the intermediate-run would apply to cycles from a few months up to perhaps a year. Given this association between the length of the run and the length of cycles, spectral analysis allows us to see how much of the variance in a variable, such as the change in the real exchange rates, comes from the short-run, intermediate-run, and long-run.²⁵ If changes in real exchange rates are uncorrelated, as

implied by a random walk, then the short-run, intermediate-run and long-run all contribute equally to the variance. In Figure 1, which shows average estimates for spectral density, that implication of a random walk is shown by the solid horizontal line at $1/\pi$ or 0.318.²⁶

If there are barriers that restrict long-run movements in real exchange rates, they would reduce the long-run component of the variance for changes in real exchange rates. As an example, suppose the traditional dynamic view of PPP is correct. In the short-run, a variety of shocks drive actual rates away from PPP, but in the long-run, market forces bring actual and parity rates back into equality. In that case, there are short-run changes in the real exchange rate, but no long-run changes because in the long-run the real exchange rate is constant at 1.0. In other words, none of the variance in changes in real exchange rates comes from the long-run. A dynamic interpretation of PPP implies that the spectral density estimates in the figure are above $1/\pi$ for short cycles and below $1/\pi$ at long cycles.

Pippenger (1982) shows that spectral density estimates for annual changes in real exchange rates are essentially constant regardless of the length of

TABLE 3

Average Spectral Density Estimates for 24 Countries

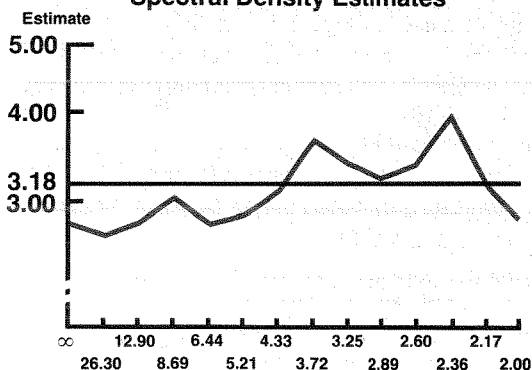
Cycle Length in Months	Estimate	Estimate - $1/\pi$	t-Statistic
2.00	0.286	-0.032	-1.24
2.17	0.319	0.001	0.04
2.36	0.394	0.076	4.21***
2.60	0.337	0.019	1.03
2.89	0.326	0.008	0.81
3.25	0.339	0.021	1.16
3.72	0.364	0.046	2.01**
4.33	0.310	-0.008	-0.40
5.21	0.287	-0.031	-1.61*
6.49	0.280	-0.038	-2.17
8.69	0.303	-0.015	-0.76
12.99	0.279	-0.039	-2.77***
26.31	0.269	-0.049	-2.75***
∞	0.280	-0.038	-1.57*

*Significant at ten percent level, single-tailed.

**Significant at five percent level, single-tailed.

***Significant at one percent level, single-tailed.

Chart 1
Spectral Density Estimates



the cycle. Since Mussachia (1984) obtains similar results for monthly data during the 1970s, an approach like the one used for autocorrelations is applied to the spectral estimates. That is, the estimate for the two-month cycle is the mean of the spectral density estimates for the twenty-four real exchange rates in that cycle.

The broken line in the figure shows the average special density estimates for the countries used earlier. These estimates and their deviation from $1/\pi$ are given in Table 3. If there were no reflecting barriers and real exchange rates perform a random walk, then the spectral density estimates should not

be significantly different from $1/\pi$. If there were reflecting barriers, the estimates should be above $1/\pi$ at the shorter cycles and below $1/\pi$ for long cycles.

The pattern for the spectral estimates in the figure allows one to reject the idea that the real exchange rate performs a random walk. Instead, it supports a dynamic interpretation of PPP. There is a clear tendency for the estimates to lie below $1/\pi$ for the longest cycles. Table 3 shows that, although the estimate at the shortest cycle is below $1/\pi$ (although not significantly so at even the ten percent level), the next six estimates all are above $1/\pi$. At the seven longest cycles, all estimates are below $1/\pi$ with two significant at the ten percent level, one at the five percent level, and two estimates significantly below $1/\pi$ at the one percent level. For these countries as a group and for this time period, real exchange rates do not behave as a random walk. The spectral density estimates strongly support the existence of elastic reflecting barriers that restrain long-run movements in real exchange rates. These barriers may be quite wide and very elastic, but they do appear to exist. The pattern shown in the figure and Table 3 does not refute Roll's basic idea of efficient international commodity markets, it simply indicates that, beyond some point, trade limits the movement in real exchange rates.

III. Accept or Reject?

In most people's mind, the decision to accept or reject a theory involves two closely related, but different, issues. The first is whether the theory is the best available and the second is whether it is accurate. There is a good deal of support for the arbitrage and efficient market interpretations of purchasing power parity. After allowing for the economic and econometric effects of information and transaction costs, the evidence supports the basic implication of purchasing power parity — that substantial and prolonged changes in relative price levels are associated with roughly proportional changes in exchange rates.

Even more important, no theory can explain either the level or change in exchange rates over time and across space as well as purchasing power parity. The only serious contender is the asset approach to

exchange rates and, at this time, that approach has failed.²⁷ There is no choice. In the strict sense, we must accept purchasing power parity because it yields the best predictions.

Most of the objections to PPP are related to the accuracy of the theory. Even if it is the best available, many people are unwilling to accept a theory unless it achieves some minimal level of accuracy. Performing only slightly better than demon chance is not good enough. The problem with this aspect of acceptance is that it is almost entirely subjective. Is the glass half full or half empty? Is an error of ten percent large or small?

Table 4 illustrates the problem. It shows the "real" German mark price of the United States dollar, French franc, British pound and Canadian dollar from 1975 to 1985 using identical bundles.²⁸

At one extreme, from 1975 to 1985, the actual mark price of the French franc rose only four percent more than implied by PPP. At the other, the mark price of United States' dollars rose 56 percent more than implied by PPP.²⁹ For these countries on average, the actual rate rose 28 percent more than predicted by PPP. Relative PPP as an explanation of exchange rates certainly is not impressive for this time period and these countries.

The errors for absolute PPP in Table 4 range from a minus 22 percent for Great Britain in January 1977 to 59 percent for the U.S. in January 1985. That is, in January 1985, the actual mark price of the dollar was 59 percent higher than predicted by purchasing power parity based on the bundle of goods used by the German Federal Statistical Office. Although individual errors are quite large, the average error

for each of the four countries over the 10 years is much smaller. They range from -2 percent for France to 10 percent for Canada. The average error for all the countries combined over the 10 years is only 2 percent. Deviations from absolute PPP can be very large, but, on average, the theory is amazingly accurate.³⁰

Whether or not the occasionally large errors justify rejecting purchasing power parity, or the small average error warrants acceptance, is up to each individual to decide. The way one uses PPP will play an important role in that decision. For policy-makers, the potential for large errors means potentially serious mistakes when policy is based primarily on PPP. For scientific purposes, the occasionally large errors are challenges for future research rather than potential disasters.

TABLE 4
Real German Exchange Rates Using Identical Bundles

Period	Country Pairs				AVERAGE
	DM/US	DM/FF	DM/UK	DM/CAN	
	Relative				
Jan 1975 to Jan 1985	0.56	0.04	0.19	0.35	0.28
	Absolute				
Jan 1975	0.92	0.93	0.70	1.00	0.89
Jan 1976	1.02	1.05	0.88	1.15	1.03
Jan 1977	0.97	0.92	0.78	1.08	0.94
Jan 1978	0.88	0.89	0.82	0.91	0.88
Jan 1979	0.81	0.94	0.79	0.79	0.83
Jan 1980	0.81	0.99	0.94	0.79	0.88
Jan 1981	1.02	1.06	1.28	0.99	1.09
Jan 1982	1.11	1.03	1.15	1.13	1.11
Jan 1983	1.19	0.98	1.00	1.21	1.09
Jan 1984	1.40	0.96	1.08	1.41	1.21
Jan 1985	1.59	1.01	1.01	1.52	1.28
Average	1.06	0.98	0.95	1.10	1.02

Data: Absolute PPP, German Federal Statistical Office. Actual exchange rates, end of month from IFS tape.

IV. Summary

The evidence supporting the arbitrage version of purchasing power parity is stronger than generally realized. Rejection of the theory often rests on a misinterpretation of the evidence. Regressions can yield low coefficients and R^2 s even though the predictive errors are relatively small. In addition, in the absence of rapid inflation, the average predictive error for absolute PPP appears to be quite small.

Those who insist on a high degree of accuracy might reject the theory because individual predictive errors are sometimes very large. In terms of relative predictive power, however, one must choose between the arbitrage and efficient commodity markets versions of PPP. Over time and space, no other theory about exchange rates is as consistent with the evidence. The only other serious contender, the asset approach, has failed so far.

Accepting either an arbitrage or efficient market version of purchasing power parity implies nothing about the direction of causation. In addition, acceptance is not an assertion that other influences are not important. The exceptionally strong dollar in the 1980s suggests that other factors are indeed important. One of the advantages of the arbitrage approach is that it provides a way of thinking about how real shocks, such as changes in capital flows or technology, drive actual rates away from the rates implied by PPP.

Whether an arbitrage or efficient markets approach to purchasing power parity is the right choice is less clear. Standard interpretations of the

arbitrage version imply that the errors in PPP should be primarily short-run in nature. The evidence, however, indicates that the predictive errors are almost as large in the long-run as in the short-run. The fact that the predictive error behaves in the fashion of a random walk — with wide elastic reflecting barriers — tends to favor the efficient market interpretation. But Roll developed the efficient commodity market model in order to explain random walks in exchange rates, so random behavior does not constitute a true test of the theory. Until some new implications of the efficient commodity market model are derived and tested, the evidence appears to support both the arbitrage and efficient market approaches.

The choice between the two models is important. The arbitrage version is consistent with the attempt to build asset models to explain the behavior of exchange rates. Since the conventional arbitrage version of PPP is essentially a theory about the long-run behavior of exchange rates, and the asset approach concentrates on the short-run, there is no inherent conflict between the two. The efficient commodity markets model, however, implies that commodity markets play a key role in the short-run determination of exchange rates. This approach is inconsistent with most existing asset models of the exchange rate because they exclude any role for efficient commodity markets in the short-run determination of exchange rates.

FOOTNOTES

1. For a more thorough review of the theory underlying PPP, see Lawrence Officer (1976) and Rudiger Dornbusch (1985).
2. Although the relative version of PPP in general requires weaker assumptions than the absolute version, it does involve at least one important assumption that the absolute form does not require. Relative PPP implicitly assumes that the base period describes an equilibrium or normal situation.
3. Although equation 4 is the basic test equation, several studies include lags, e.g., John Hodgson and Patricia Phelps (1975), or other explanatory variables, e.g., Richard Dino (1977).
4. In many cases, the left hand side of the equation is simply $\ln[S(t)]$ and α is an estimate of the log of the base period exchange rate. In that case, a nonzero estimate for α does not reject PPP.
5. See in particular Jacob Frenkel (1981).
6. For a description of this data, see W. Kohlhammer (1970).
7. See Nurhan Davutyan and John Pippenger (1984).
8. This dynamic view of PPP implicitly assumes that transaction costs decline with the length of the run. The discussion of the nature of costs by Armen Alchian (1959) suggests a number of reasons for this decline.
9. Since the difference between tradables and nontradables is one of degree, not kind, this argument overstates the case. The basic point, however, is valid. The structure of the error terms should be substantially different depending on whether it is related to tradables or nontradables.
10. Since real and monetary shocks can be, and apparently are, correlated, the problem is more complex than in this simple example.
11. The effects of transaction costs on tradables, which is what Aizenman (1984a and b), De Grauwe, Janssens and Leliaert (1982) and De Grauwe and Rosiers (1984) stress, and different weights, reinforce the bias from changes in relative prices for nontradables.
12. Although similar results hold for a number of countries, they do not hold for all. Price levels in Canada and the United States moved together very closely in both the 1920s and early 1970s, and estimates of R^2 and β reject PPP in both periods. In addition, estimates for inflationary countries in the 1970s such as Israel, Argentina and Brazil yield results that are similar to the results for France in the 1920s. See Davutyan and Pippenger (1985).
13. This result is not particular to France. The average standard error for the regressions that Frenkel reports for the 1920s is 0.102, but it falls to 0.029 for the 1970s.
14. See Alan Shapiro (1983) for a discussion of efficient commodity markets and purchasing power parity.
15. If there is no risk premium and futures prices equal expected prices, then a similar argument holds for a form of international arbitrage without trade.
16. Instead of the arbitrage approach to PPP used here, Roll (1979, p. 142) uses a welfare approach. "When relative prices are not assumed to be constant, the continuously compounded rate of inflation must be measured by another log price change, that of the price index relevant to the speculator's purchasing power."
17. Technically, the error is a martingale. But because it is more widely recognized, the term random walk is used throughout instead of the more accurate martingale.
18. With transaction costs, the expected net return would have to at least cover those costs before goods would be shipped.
19. When international trade involves buying either at home or abroad in $t-1$ for sale at home in t , there is no international uncertainty and γ disappears.
20. Since the errors are correlated with both sides of equation 18, from an econometric perspective it would be more accurate to write this equation as $\{1n\{[S(t+1)/S(t)]/(p^H/p^F)\} = v_t + g_t$.
21. More formally, g has first order negative serial correlation because it is the first difference of an uncorrelated random variable γ .
22. Roll's data cover more than the 1970s. They run from 1957 to 1976.
23. The countries are Argentina, Australia, Brazil, Canada, Germany, Italy, Israel, Japan, U.K., and U.S. To avoid any undue weight on inflationary episodes, for Argentina, Brazil, and Israel, only real rates with the U.S. are used. The time period, number of lags and countries were selected before the tests were conducted.
24. The t -tests are based on the observed standard deviation, not the theoretical standard deviation which would assume independence.
25. See Jenkins and Watts (1968) for a detailed discussion of spectral analysis.
26. Spectral density is the normalized spectrum. It has the same relation to the spectrum that autocorrelation has to autocovariance. When frequency is measured in radians, the observed frequencies run from 0 to π . Since the estimates of the spectral density must sum to unity, the estimates must equal $1/\pi$ to be constant across frequency.
27. See, for example, Graham Hacche and John Townend (1983) and Waseem Khan and Thomas Willett (1984).
28. The series start in 1975 because there is a break in the German data in 1974.
29. For the U.S. dollar, relative PPP even gets the direction wrong. It predicts a 21 percent fall in the mark value of the dollar when the value of the dollar actually rises 35 percent.
30. With rapid inflation, the average predictive errors are much larger. See Davutyan and Pippenger (1985), Table 2.

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