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PERSPECTIVES

A review from
the Federal Reserve Bank
of Chicago

JULY/AUGUST 1984

High speed rail in the Midwest
1984 Bank Structure Conference highlights
Individual bank reserve management

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ECONOMIC PERSPECTIVES

July/August 1984
Volume VIII, Issue 4

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ISSN 0164-0682

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High speed rail in the Midwest

Herbert Baer and Donna Vandenbrink

For years, Amtrak has struggled to attract passengers on its routes in the Midwest, using technology developed half a century ago. During the same time, foreign railroads were developing new passenger rail systems that could profitably compete with air travel. Two of these systems, the French TGV and the Japanese Shinkansen, reach speeds of 160 mph, while the British HST operates at 125 mph.

The success of these systems, together with the apparent interest of American policymakers in promoting further investments in passenger rail service, has sparked a number of recent proposals for high speed rail systems throughout the nation, including the Midwest.[1] This interest is based largely on high speed rail's success in dramatically decreasing travel time between cities. Unfortunately, these systems are expensive to build—as much as 3.5 billion dollars—making their financial viability questionable. This article summarizes a larger study which analyzes high speed rail's economic prospects in three Midwestern corridors—Detroit to Chicago, St. Louis to Chicago, and Milwaukee to Chicago. Three technologies are analyzed: High Speed (125 mph); Very High Speed (150-160 mph); and Super Speed (250 mph). Combining the technologies and the corridors creates nine specific projects for examination.

Support from policymakers and private investors for high speed rail projects in the Midwest and elsewhere in the U.S. must await development of better estimates of capital costs, the size and timing of the projected revenues, and the extent of any secondary social benefits. Existing feasibility studies for projects throughout North America provide a wealth of detailed information on the costs and/or revenues of systems with different speeds, frequencies, and markets. However, a review of these studies indicates that they fail to explain how these factors interact to affect the cost, ridership, pricing, and profitability of high speed rail systems.

Like earlier feasibility studies, this study develops measures of the costs and revenues of high speed rail. But the study does not generate any new data; it is, in fact, based entirely on the existing body of high speed rail data.

It differs from existing studies in three ways. First, it attempts to explain the interaction between speed and frequency on the one hand, and costs and revenues on the other. Second, it compares competing technologies rather than intensively studying a single technology. Third, it attempts not only to provide bottom line answers, but also to identify the factors which are critical to the profitability of high speed rail systems.

Corridor choices

Experience suggests that successful high speed rail corridors should be between 250 and 500 miles in length, be heavily populated, have relatively high population densities, and, of less importance, have areas of population density distributed along the entire route.

Three Midwest rail corridors fill some or all of these requirements and are especially suitable for analysis: Detroit to Chicago, St. Louis to Chicago, and Milwaukee to Chicago. These three corridors allow us to consider the cost and profitability of high speed rail service in a number of different environments.

The Detroit-Chicago corridor is relatively long and urban. It covers a distance of a little under 300 miles and it includes the five larger metropolitan areas of Gary, Indiana, and Kalamazoo, Battle Creek, Jackson, and Ann Arbor, Michigan. This corridor contains over 13 million people and is the third most populous rail corridor served by Amtrak.

Herbert Baer and Donna Vandenbrink are economists at the Federal Reserve Bank of Chicago.

[1]Studies in the Midwest include Detroit to Chicago by Transmode, Inc. [2], Milwaukee to Chicago by Budd Co. [3] and Cleveland, Columbus, and Cincinnati by Dalton, Dalton, Newport [4]. For a more general overview of high speed rail technologies, see [5].

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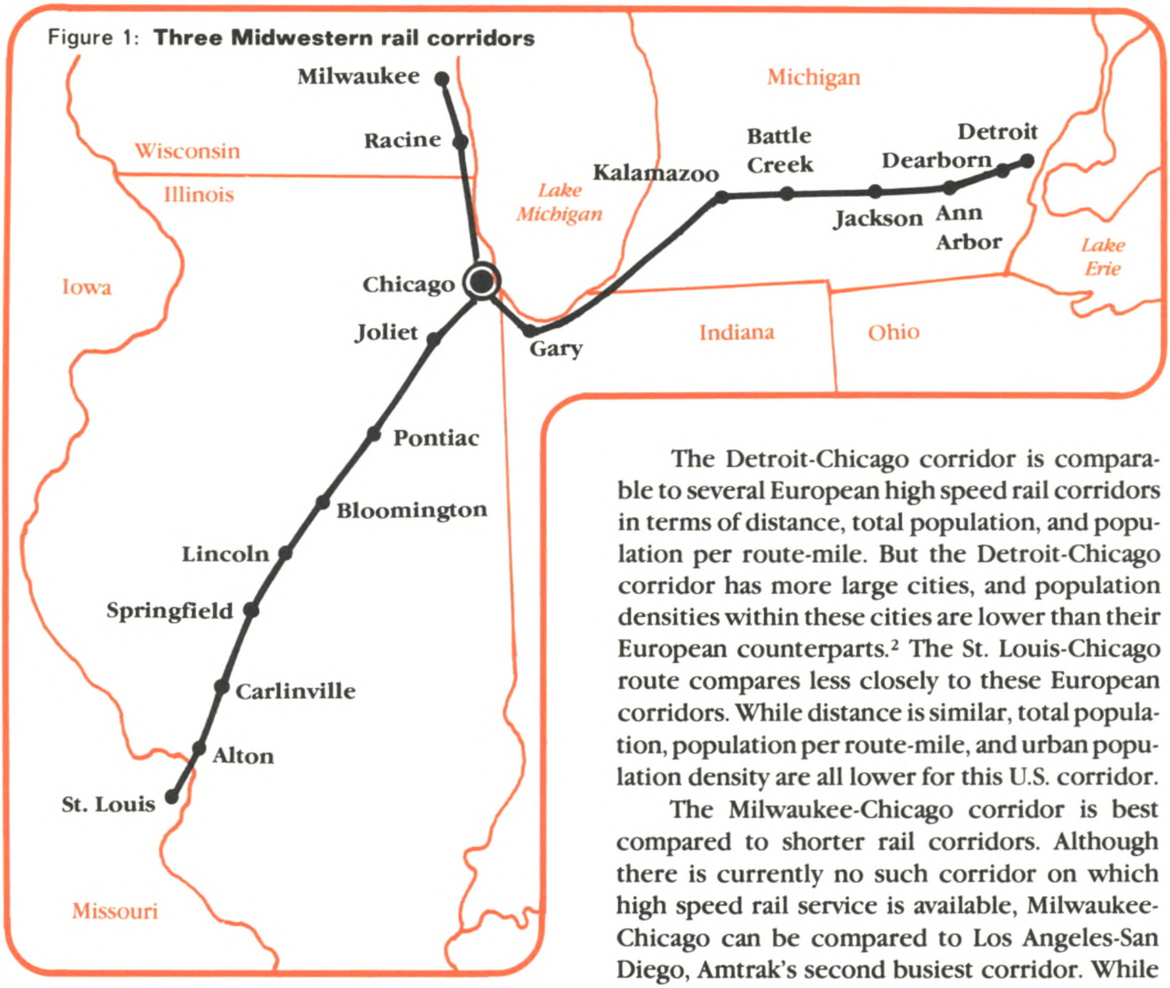

Figure 1: **Three Midwestern rail corridors**

The distance from St. Louis to Chicago is also just under 300 miles, but population in this corridor is more sparsely distributed than between Detroit and Chicago. The population in the St. Louis-Chicago corridor is about 9 to 10 million, and it is more highly concentrated at the two end points.

The Milwaukee-Chicago corridor presents a different case. It serves a population of almost 9 million, similar to that located in the St. Louis-Chicago corridor, but it covers a distance of just under 90 miles, making a dense concentration of potential travelers. In addition to the Milwaukee and Chicago metropolitan areas, this corridor includes the cities of Kenosha and Racine, Wisconsin.

The Detroit-Chicago corridor is comparable to several European high speed rail corridors in terms of distance, total population, and population per route-mile. But the Detroit-Chicago corridor has more large cities, and population densities within these cities are lower than their European counterparts.[2] The St. Louis-Chicago route compares less closely to these European corridors. While distance is similar, total population, population per route-mile, and urban population density are all lower for this U.S. corridor.

The Milwaukee-Chicago corridor is best compared to shorter rail corridors. Although there is currently no such corridor on which high speed rail service is available, Milwaukee-Chicago can be compared to Los Angeles-San Diego, Amtrak's second busiest corridor. While total population in the Milwaukee-Chicago corridor is lower, population per route-mile and urban population density are both higher. However, the short distance between Milwaukee and Chicago limits the demand for higher speed technologies.

Technology choices

The term "high speed rail" encompasses a wide range of speed capabilities. We distinguish three types of high speed rail services according to the maximum commercial speed of the technology: High Speed (HS) covers trains capable of

[2]Population density in this sense is measured as the number of people living within a given distance from a station.

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reaching speeds of 120-125 mph; Very High Speed (VHS) includes those with a top speed of 150-160 mph; and Super Speed (SS) refers to trains which can reach speeds of 250 mph or higher.

Characteristics of our hypothetical High Speed technology are drawn from experience with the Amtrak Metroliner service in the Northeast Corridor (ultimately designed to function as a High Speed train) as well as the British High Speed Train (HST) inaugurated in 1976. The characteristics of our Very High Speed technology are based primarily on the French TGV technology in operation since October 1981.[3] The characteristics of our Super Speed technology are based on data for the German Transrapid-06 magnetic levitation technology, which is still undergoing development for commercial application. Vehicles for each technology are shown in Figures 2, 3, and 4.

High Speed and Very High Speed: Metroliner and TGV

The Amtrak Metroliner and the French TGV represent successive developments in the application of the conventional steel-wheel-on-rail technology.

[3]This technology seemed more suited to the Midwestern transportation environment than the highly capital-intensive Shinkansen technology.

Courtesy: GM Electromotive

Figure 2: **Amtrak's Metroliner engine**

Courtesy: TGV-US

Figure 3: **The French TGV, a Very High Speed Train**

Courtesy: Budd Co.

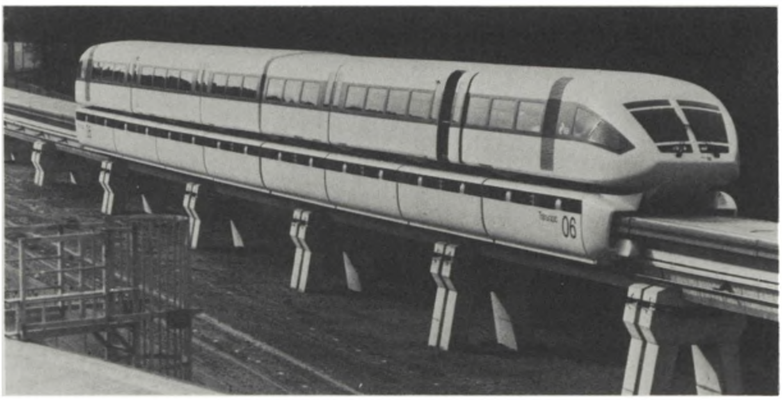

Figure 4: **The Transrapid-06, an experimental Super Speed maglev train**

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Speeds of 125 mph can be achieved without any fundamental changes in this vehicle technology. The major impediments to reaching service speeds of 125 mph with conventional rail passenger technology are the condition of the existing track and roadbed and the logistics of sharing right-of-way with low speed freight and passenger trains. Therefore, the implementation of the Metroliner-HS option focuses on improvements in track, roadbed, and signalling and control systems. The Metroliner equipment itself is essentially no different from that used for other intercity passenger service.

In contrast, the TGV represents the state of the art in steel-wheel-on-rail technology. The TGV vehicles were designed from the ground up to combine the best components from existing rail technologies and to incorporate the latest advances in aerodynamics, stability, and braking. Each TGV train has a fixed number of cars with one power car at each end of a string of articulated coaches. Adjacent coaches in the middle of the train share a single set of wheels, which are located under the articulated segments. This design reduces aerodynamic resistance and the number of axles, and increases passenger comfort. The lighter weight and higher speed resulting from these design improvements enable the TGV to climb steeper grades than other passenger trains. This permits savings in roadbed excavation and tunnel construction. The reduced weight of the TGV also reduces track maintenance costs. On the other hand, the operator's ability to adjust train capacity to demand patterns is limited because cars cannot be added readily.

Super Speed: Transrapid-06 Maglev

The use of magnetic levitation (maglev) and electromagnetic propulsion to provide contactless vehicle movement makes the Transrapid-06 (TR-06) technology radically different from either the Metroliner or the TGV. The underside of the TR-06 carriage (where the wheel trucks would be on a conventional car) wraps around a guideway. Magnets on the bottom of the guideway attract magnets on the "wraparound," pulling it up towards the guideway. This suspends the vehicles about one centimeter above the guideway. Changes in the polarity of other magnets in the guideway cause the vehicles to move forward or backward.

Maglev technology obliterates the familiar distinction between track and rolling stock in propulsion. Power-generating equipment is relocated from the conventional locomotive to the underside of each car and to the track and guideway structure of the TR-06.

The fact that the TR-06 is designed to wrap around an elevated central guideway rather than to move on ground-level track has both advantages and disadvantages. The guideway is incompatible with existing track and stations, and must be newly constructed and electrified. However, the elevated guideway can be adapted to varied terrain with much less excavation and construction than are needed to lay ground-level track. The maglev technology promises dramatic increases in speed, but it has not yet been proven commercially feasible. At present it is employed in only one commercial application, a low-speed people mover at Birmingham Airport in the United Kingdom. Although high-speed prototypes are already operating, it will be perhaps another 5 to 20 years before the technology can be made commercial in high-speed applications.

The impact on travel time

Speed is an appropriate characteristic by which to distinguish the many alternative high speed technologies, since it helps determine both rail demand and costs. On the demand side, differences in travel time affect the competitiveness of rail with respect to other modes of travel. Table 1 shows how travel times in the three Midwest corridors vary with the maximum speed of the rail technology. The travel time between Detroit or St. Louis and Chicago is between five and five and a half hours according to the current (1983) Amtrak schedule. The HS technology would reduce travel time to three-and-one-half hours; the VHS technology would bring the time down to a little under three hours; and with the SS technology the trip could be made in under two hours. Similarly, the current one-and-one-half hour trip between Milwaukee and Chicago

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Table 1
The effect of technology on rail travel times in three Midwest corridors

	Rail travel time between:		
	Detroit and Chicago	St. Louis and Chicago	Milwaukee and Chicago
	(minutes)	*(minutes)*	*(minutes)*
Current Amtrak service	333	320	89
High Speed	216	208	58
Very High Speed	176	170	45
Super Speed	110	106	29
Distance (in miles)	279	282	85

could be made in under an hour with the HS technology, in 45 minutes with the VHS technology, and in only a half-hour with the SS technology. It is easy to imagine that the reductions in travel time offered by the new high speed technologies might significantly enhance the attractiveness of rail travel in these Midwest corridors.

However, the potential demand for these travel-time savings must be weighed against the costs of implementing the various technologies. Differences in maximum attainable speed create different engineering, technological, and construction parameters that in turn affect the cost of a rail system. For example, Super Speed service with the magnetic levitation technology requires the construction of a new guideway structure along the entire route. High Speed service, on the other hand, can be implemented with improvements to existing rail rights-of-way without significant new roadbed construction.

An analytical framework

There are many yardsticks which could be used to evaluate these nine projects. Profitability is one such measure, and in this study we compare projects by focusing on the net present value of current and future profits (losses) that would be realized if fares and frequencies were chosen to maximize total profits.

We chose this profit maximization criterion for three reasons. First, by focusing on the profit maximization (loss minimization) scenarios, we hoped to establish the circumstances under which the rail improvements could be made without governmental subsidies. Where we find that a subsidy would be necessary, our results also indicate the minimum subsidy required by each project. Second, since only a profit-making project would be able to attract private investment, our analysis points out the circumstances in which private participation in high speed rail development is most likely. Finally, breaking even under private profit-maximizing behavior is, in the absence of any negative externalities, a sufficient condition for a project to be socially desirable, although it is not a necessary condition. Social welfare would be maximized by setting railfares equal to long-run marginal social cost and providing a lump sum subsidy to the rail service operator. When a project fails this break-even test, a second more complicated test is needed to determine social desirability.[4]

A profitability analysis requires information on revenues (R), operating expenses (OE), capital outlays (K), the risky "real" (inflation-adjusted) interest rate (r), and the rate at which ridership (and hence revenues and operating expenses) are expected to grow over time (g). This information is combined to compute each project's net present value using the formula:[5]

$$NPV = \frac{R-OE}{r-g} - K$$

Outlays were estimated using actual and projected cost data for the High Speed and Very High Speed options and projected cost data for the Super Speed option. The passenger response to changes in speed, frequency of service, and rail fares was estimated using two intercity travel

[4]In this test, price is set equal to long-run marginal social cost. If, at these prices, revenues plus the weighted sum of consumers' surplus exceeds the project's costs then the project should be built and operated with government subsidies. Because this test requires knowledge of society's welfare function, it is best made by politicians and not economists.

[5]This formula ignores the presence of taxes. However tax effects are of secondary importance. A more detailed treatment would take account of income taxes including interest deductions, depreciation deductions, and investment tax credits. Our analysis indicated that taking these factors into account would have changed the absolute value of a project's net present value, but not its sign.

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demand models—one developed by the firm of Peat, Marwick, Mitchell and Co., the other developed by Transmode, Inc.[6]

Profits are maximized by varying both rail fares and service frequency. Service frequencies affect revenues, operating expenses, and capital outlays. An increase in the frequency of service raises capital outlays by increasing the portion of the route which must be double tracked so that trains moving in opposite directions may pass one another.[7] It also increases the number of vehicles needed for smooth operation of the system. An increase in frequency raises operating expenses by increasing labor, maintenance, and fuel expenses. Finally, an increase in frequency raises revenues by improving the availability of rail service. This is particularly important when there are fewer than 12 trains a day. The impact of increases in rail fares is principally confined to revenues.[8]

The following two sections summarize the results of our analysis, focusing first on capital outlays and then on overall profitability.

Capital costs

Rail projects are highly capital intensive. Our most expensive project required a capital outlay of $3.6 billion. The annual costs of financing the physical structure and construction outlays are often twice annual expenditures for operation and maintenance of the rail service. Track-related expenditures can account for over 70 percent of total capital outlays. Since these capital outlays are large—often exceeding a billion dollars—it becomes important to build only the minimum amount of track needed for smooth operation of the service. The amount of double track is the chief variable under the control of the designer. Limiting the amount of double tracking can reduce total capital outlays by as much as 80 percent below the outlays needed for a fully double-tracked system. Whether or not such savings will ultimately generate greater profits depends on the nature of passenger demand. Nevertheless, it is important to understand that this option is available.

Faster speeds and more frequent service both affect the amount of double tracking. Higher speeds increase the amount of double track needed for two trains to safely pass each other. Increases in service frequency increase the number of times trains must pass each other. The more times this occurs, the greater the portion of the route that will be double tracked. Other factors such as terrain and current track condition are also important to track-related expenditures but were ignored in our study.

The results of our cost analysis are shown in Table 2. These may be summarized as follows.

- Capital costs increase at an increasing rate with decreases in travel time. Going from the High Speed option to the Very High Speed option causes costs to increase by 95 percent but reduces travel time by 25 percent. Going from the Very High Speed option to the Super Speed option increases capital costs by an additional 110 percent but only leads to a 60 percent reduction in travel time.

- Because the number of trains per day is a principal determinant of the amount of track required, the frequency of service for which the system is designed can have a significant effect on its capital costs. In particular, going from 6 to 24 trains per day can increase the capital costs of the project by as much as 66 percent.

- Once the system is completely double tracked, the marginal costs of running another train fall dramatically.

- While changes in frequency are costly, their impact on capital cost is much less than changes in speed (technology). Holding the number of trains constant, moving from High

[6]Details of the Peat-Marwick-Mitchell model may be found in [7]. Details of the Transmode model may be found in [2] and an unpublished report. Both models are summarized in [1].

[7]It is assumed that once 60 percent of the route is double tracked (70 percent for the Super Speed option) the costs of switching and control make it desirable to double track the entire route.

[8]Fare increases could also reduce the vehicle component of capital cost. However, this is such a small part of total capital costs that it is ignored.

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Table 2
Cost estimates for three Midwest corridors
($ millions)

	Detroit-Chicago				St. Louis-Chicago				Milwaukee-Chicago			
Trains per day	6	8	12	24	6	8	12	24	6	8	12	24
High Speed System												
TOTAL CAPITAL COST	575	612	832	904	570	606	830	902	168	204	218	289
Annual O&M Cost	24	32	47	97	24	32	47	97	7	10	15	29
Very High Speed System												
TOTAL CAPITAL COST	1151	1261	1682	1738	1149	1260	1689	1745	309	309	420	543
Annual O&M Cost	30	39	60	119	31	40	60	120	9	12	18	37
Super Speed System												
TOTAL CAPITAL COST	2417	3042	3548	3612	2421	3046	3562	3636	590	590	590	1126
Annual O&M Cost	29	38	57	114	29	38	57	114	9	12	18	36

NOTE: O&M = operating and maintenance.

Speed to Very High Speed or Very High Speed to Super Speed tends to about double costs.

Profitability

As the reader can see from Table 2, service frequency is important in determining the capital costs of a high speed rail system. Armed with this result, we will now switch our focus from costs to profitability. In order to analyze profitability for each of the three technologies in each of the three corridors, we chose the rail fare and frequency of service which maximized project net present value.[9] In doing so, we assumed that, given the frequency of service, the cost of serving an additional passenger was zero.

In computing these present values we took into account two environmental factors: the rate of growth in passenger revenues (g) and the decision-maker's real discount rate (r). These two factors will obviously have an impact not only on project profitability but also on the characteristics of the profit-maximizing project. Changes in these factors are most likely to have an effect when annual operating and maintenance expenditures are small relative to capital costs, as is the case with the SS option.

The choice of appropriate rates of discount and growth is always plagued with uncertainty. However, discussions with a number of rail specialists led us to conclude that the real rate of discount should be at least 6 percent per year.[10]

Table 3 presents the results of our analysis using demand forecasts based on the Transmode model. Table 4 presents our results using the Peat-Marwick-Mitchell model. These results may be summarized as follows:

- Product pricing plays an important role in the ultimate profitability of a project.
- The High Speed option is generally more profitable (less unprofitable) than the Very High Speed option.

[9]Because in the Peat-Marwick-Mitchell model the demand for passenger rail services had a price elasticity less than one, any project could be made profitable by raising fares high enough. To overcome this problem we developed what we felt would be a reasonable set of fares. We used these fares to obtain forecasts of demand and revenues from the Peat-Marwick-Mitchell model (see Table 4). These fares were generally higher than the fares suggested by the Transmode model.

Both forecasts assume that business travelers pay 80 percent more than nonbusiness travelers.

[10]Based on discussions with British Rail and Amtrak. Private rail firms appear to employ a higher rate—somewhere between 11 and 16 percent.

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Table 3
Characteristics of profit-maximizing high speed rail projects based on the Transmode Model

	Detroit-Chicago			St. Louis-Chicago			Milwaukee-Chicago		
	High Speed	Very High Speed	Super Speed	High Speed	Very High Speed	Super Speed	High Speed	Very High Speed	Super Speed
Present value *(million dollars)*									
when r – g = .06	105	-346	-1202	-7	-474	-1333	-128	-272	-413
.05	241	-185	- 959	107	-339	-1115	-120	-265	-378
.04	445	56	- 595	277	-137	-544	-108	-254	-325
.03	785	459	13	561	201	-245	- 88	-235	-237
.02	1465	1264	1228	1130	876	844	- 48	-198	- 60
Capital cost *(million dollars)*	575	1151	2417	575	1149	2421	168	309	590
Frequency	6	6	6	6	6	6	6	6	12
Optimal price as a percentage of current price	120%	140%	180%	120%	140%	180%	190%	220%	130%

Table 4
Characteristics of profit-maximizing high speed rail projects based on the Peat-Marwick-Mitchell model

	Detroit-Chicago			St. Louis-Chicago			Milwaukee-Chicago		
	High Speed	Very High Speed	Super Speed	High Speed	Very High Speed	Super Speed	High Speed	Very High Speed	Super Speed
Present value *(million dollars)*									
when r – g = .06	-345	-734	-1181	-586	-1151	-1888	-118	-234	- 90
.05	-222	-629	- 694	-590	-1141	-1781	-108	-159	10
.04	-125	-471	35	-595	-1139	-1621	- 92	-122	160
.03	38	-207	1251	-603	-1143	-1355	- 47	- 59	410
.02	395	319	3683	-620	-1435	-392	67	100	910
Capital cost *(million dollars)*									
when r – g = .06	575	1261	3612	570	1149	2421	168	309	590
.05	612	1261	3612	570	1149	2421	168	309	590
.04	612	1261	3612	570	1149	2421	204	309	590
.03	612	1261	3612	570	1260	2421	289	309	590
.02	832	1261	3612	570	1260	3562	289	420	590
Frequency									
when r – g = .06	6	8	24	6	6	6	6	6	12
.05	8	8	24	6	6	6	6	8	12
.04	8	8	24	6	6	6	8	8	12
.03	8	8	24	6	8	6	12	8	12
.02	12	8	24	6	8	12	12	12	12
Price as a percentage of current price	160%	180%	200%	160%	180%	200%	160%	180%	200%

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- The profit maximizing rail option in our three Midwest corridors most often involves only modest increases in frequency from the existing 3 to 5 trains per day operated by Amtrak. This optimal frequency is generally far below the levels provided in France, Great Britain, or Japan.

- Several high speed rail projects did appear to have the ability to be profitable, but only if the public sector discount rate of 6 percent were applied. If the rates used by private rail companies were applied, none of these projects would appear to be profitable.

Our findings concerning the importance of product pricing are, we believe, novel. We found that profit-maximizing pricing of new rail service could raise revenues by as much as 45 percent. Considering the sensitivity of profitability to pricing, it is surprising that few previous studies have spent much time addressing this issue. Profit-maximizing pricing can make it possible to conserve on expensive track by trading off lower fares for lower frequencies (and longer waiting times). Rail service also lends itself to various forms of price discrimination which make it easier to break even. For instance, promotional fares can permit the filling of off-peak trains which, given the track in place, can be relatively cheap to run. Finally, pricing which reflects the improved travel times available at higher speeds will make it more likely that the project will be able to break even.

Our conclusion concerning the relative profitability of High and Very High speed rail options is a direct outcome of the relatively small increase in ridership together with the doubling of construction costs created by moving from the lower speed option to the higher speed one.

Our result concerning the optimal number of trains per day for high speed rail service in the Midwest requires more discussion. The number of trains per day suggested by our models is far below the number observed in countries currently operating high speed rail systems. The French run 18 TGV trains a day in each direction between Paris and Lyon and an additional 14 TGV trains which use the system but do not stop at Lyon. The British run 20 trains per day in each direction between London and Newcastle. Finally, the Japanese run 79 Shinkansen trains each day in each direction on their Tokyo-Osaka route.

There are three possible explanations for the divergence between our results on frequency and existing overseas practice. First, the transportation environment in the American Midwest differs radically from that in France, Great Britain, or Japan. Population density is often cited as a major difference between the United States and foreign countries. However, it is not the density measured as population per route-mile which differs, but population per square mile at the end-points; European towns are typically more compact than American towns.[11] There are other differences in the transportation environment which also appear to be important. Cars cost more to purchase and operate abroad. In particular, gasoline is almost twice as expensive in these three countries as it is in the United States. Also, public transportation (primarily rail) is generally less expensive abroad than in the United States. Finally, European and Japanese incomes, and hence values of time, are lower than in the United States. All these factors tend to increase the demand for rail service and reduce the demand for other modes.

Second, all three foreign high speed rail projects were undertaken because of heavy demand for existing service. Demand and frequent service go hand in hand. However, excess demand is not a problem in any of the Midwest routes we examined.

Finally, the foreign rail companies may be pursuing a policy of welfare maximization rather than profit-maximization. When dealing with projects which have large fixed costs (we can view the single track between two points as the fixed cost and any additional track as a variable cost), economic efficiency is achieved not by maximizing profits or attempting to break even,

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[11] There are exceptions to this rule. They generally occur where an American city is situated next to a body of water or a mountain range. In these cases population densities may be higher than in European cities of comparable size. However, the number of people living within a given distance of downtown is still generally lower.

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but by setting price equal to the long-run marginal social cost of an additional unit of service. Such a policy would obviously entail much higher service levels than would a policy of attempting to maximize profits.

Conclusion

We find that some high speed rail projects in the Midwest may be profitable under some circumstances. Taking social benefits into account would increase the number of projects which society would find attractive. However, the reader should realize that profitable projects involve relatively few trains per day (six to twelve), assume that a "no frills" system is constructed, and assume that a "public sector" discount rate is employed. None of these projects is likely to be profitable if capital costs run out of control or if the difference between the real rate of interest and the annual growth in rail demand exceeds 6 percent per year.

Of the three technologies studied, the profitability results for the Super Speed magnetic levitation technology are the most difficult to interpret. The technology's relatively low projected operating costs make it ideally suited for highly traveled corridors.[12] Its high speed also permits it to economize on track construction in relatively short corridors. Unfortunately, on such corridors, access-egress time usually becomes important in generating riders and revenues, making it desirable to have many stops. However, frequent stops rob the system of much of the travel time savings obtained through higher speeds. The SS option presents special problems for forecasting. Cost estimates are a problem since the technology has never been placed in service commercially or built on a commercial scale. In addition, the range of travel times permitted by this option is so far removed from actual experience that the validity of our forecasting models becomes debatable. Nevertheless, the two models disagree on the profitability of the SS option in only one instance—between Milwaukee and Chicago—and even this disagreement diminishes once we take interest costs during construction into account.[13]

Our capital cost estimates are generally on the conservative side. If we have underestimated the amount of track realignment required for the High Speed or Very High Speed system, it is unlikely that any of the projects would be profitable. A decision to build an overly sophisticated system or an unexpected lengthening of the construction process would have a similar effect. Finally, more accurate assessment of the uncertainties involved in predicting revenues and construction costs (particularly in the Super Speed case) may decrease the attractiveness of these Midwest projects.

[12] See Table 2.

[13] See [1] for details.

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1984 Bank Structure Conference highlights

Since the turn of the decade, the financial services industry has undergone dramatic changes. The pace of nonbank entry into the industry has accelerated; banks and other depository institutions have become more aggressive and innovative in their product offerings and in their attempts to circumvent banking regulation; and legislators and regulators have become more responsive to the new and ever-changing financial climate.

The separation of banking and commerce has begun to disappear. "Nonbank banks," most of which have been organized since 1980, have swelled to more than 60 in number. Over half of these are owned by securities firms. In 1982, banks and S&Ls began to offer discount brokerage services, and more recently, a few have begun to lease space in their lobbies to insurance companies and real estate agents. Further, the market for many financial services is national, and for many suppliers, international. Today, interstate banking is an important topic in many state legislatures. Indeed, at least 19 states already have passed come sort of limited interstate banking legislation. Also, technical developments have allowed nationwide networks of automated teller machines to form, thus giving customers access to their funds anywhere in the country.

This new financial environment and its implications for depository institutions, regulators, the American public, and their elected representatives were discussed at the twentieth annual Conference on Bank Structure and Competition, held in Chicago at the Westin Hotel from April 23rd to the 25th. The conference, sponsored by the Federal Reserve Bank of Chicago, assembles academics, economists, regulators, bankers, and other practitioners in the financial services industry. This year's conference was attended by some 300 participants who discussed the key issues that the financial community now faces, including bank product and market expansion, the viability of small depository institutions, and current economic and regulatory issues.

Product expansion

Bernard Shull, professor of economics at Hunter College, pointed out that banking was separated from commerce some 200 years ago for fear that "the government-bank relationship . . . would lead to government intrusion into private market activities." The functions of banks have changed since then and, as many speakers concluded, so too should the list of banks' permissible activities.

Two presentations attempted to uncover the potential impact of banks' participation in the securities area by looking at the foreign experience. Laurie Goodman of Citibank and Christine Cumming of the Federal Reserve Bank of New York, after examining the financial markets in five countries, concluded that "countries with product line restrictions tend to have better developed financial markets. In countries where banks are able to offer a complete array of financial services, the banks are more likely to perform many of the functions of the marketplace." Anthony Santomero of the Wharton School looked at the financial structures of the countries that belong to the European Economic Community and examined the impact in those countries of banks holding equity securities in their portfolios. Santomero concluded that, on a macro-economic level, "the inclusion of equity in bank portfolios increases financial sector integration and reduces interest rate volatility." He added, however, that these results are usually accompanied by increased price instability in the real sector.

The discussion of banks' expansion into the securities area extended throughout the Conference. While some were debating the pros and cons of allowing banks to engage in securities-related activities, George Kaufman, professor of economics and finance at Loyola University and

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consultant to the Federal Reserve Bank of Chicago, argued that banks have already made significant inroads into the securities field and that, regardless of the Glass-Steagall Act, which separates investment and commercial banking, "banks can do almost anything they want to."

While Kaufman did list some securities-related activities that banks are prohibited by law from entering, he also pointed out that ways have been found around these restrictions. That banks have been so slow in circumventing the law is probably because the technology for doing so profitably is of recent vintage and there are more profitable opportunities elsewhere. There have been, however, quite a few aggressive and innovative banks in the securities area recently; among them are Citibank, Security Pacific, Bankers Trust, and Bank of America.

Geographic expansion

At the conference, the views on interstate banking were mixed. Some participants, however, did agree that the restrictions on geographic expansion should be removed, but a consensus on how to remove those restrictions would have been difficult to obtain, as the distinguished panel of speakers at the session on interstate banking illustrated.

The first to speak was Thomas Theobald, vice chairman of Citicorp/Citibank. Theobald, while all in favor of interstate banking, expressed strong doubts that regional interstate banking would be an improvement over the present system: "Instead of fifty protected markets, there would be a smaller number, but they would also be insulated against some of the most potent competitive forces in the industry." As a result, "customers would be prevented from seeking the best deal the market had to offer."

Thomas Storrs, former chairman and chief executive of NCNB Corporation, disagreed with Theobald. Storrs believes that size is a definite benefit in banking and that the drive by bankers to increase size and market share through mergers would lead to a banking oligopoly. According to Storrs, therefore, regional interstate banking is the best "means of producing additional banking companies capable of effective competition with money center banks and other large financial institutions."

The viability of small institutions

Discussion about expanding banks' product and geographic markets usually leads to concerns about the viability of small institutions. At this year's conference, a full day was devoted to the future of small banks and other financial firms. Among those to speak on this topic were Joel Bleeke of McKinsey Co. and Richard Wurzburg of the Bank Administration Institute (BAI).

After studying other industries that had undergone deregulation, Joel Bleeke found that four types of "winning" firms usually emerge. Included among the "winners" is the community firm, but one clear "loser" in other deregulated industries is the regional firm. According to Bleeke, as soon as the barriers to interstate banking are lifted, regional firms will be threatened by the "large national distribution companies" such as Merrill Lynch and Citicorp.

Richard Wurzburg discussed the results of an in-depth BAI/Arthur Andersen survey of hundreds of CEOs of banks and other financial institutions who were asked about their views on the future of banking. Wurzburg reported that most CEOs believe "community banks will tend to focus on personalized retail services to preserve the geographic niches they enjoy today," while large banks will primarily be wholesale institutions. Large banks, however, will devote "very significant attention" to upscale customers, thus competing directly with mid-size banks.

Both Bleeke and Wurzburg foresee a drastic reduction in the number of banks. In drawing parallels between financial services and the brewing industry, Bleeke projected that by the year 2000, the number of banks will have declined to 7,000, with between five and seven large national survivors. Most CEOs, according to the BAI/Arthur Andersen survey, would corroborate Bleeke's forecast as most see the number of banks falling to 9,600 by 1990, primarily as a result of a major industry consolidation. Furthermore, 50 percent of all banks expect to be involved in a merger or acquisition by the turn of the century.

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Regulatory issues

One factor that will play a major role in the future of all financial institutions—large or small, few or many—is the regulatory and legislative environment. As the speakers who commented on the current regulatory issues and the recommendations of the Bush Commission indicated, the future of regulation and of the financial sector is an interactive process. Andrew Carron, vice president at Lehman Brothers Kuhn Loeb, pointed out that structural changes in the financial sector "diminish the advantages and magnify the shortcomings of the current [regulatory] system." All the speakers seem to have agreed that changes in the financial structure necessitate legislative and regulatory changes, but the speed, nature, and implementation of those changes will have far-reaching implications for the financial services industry.

The Bush Commission, a task force headed by Vice President Bush and having as its members the heads of all the important regulatory agencies that deal with financial institutions, addressed the problems of regulatory structure. Two important recommendations of the Commission are, first, a move toward "functional" regulation and, second, increased state supervisory powers over state-chartered institutions. The first recommendation calls for the FHLBB to supervise those institutions classified as thrifts. A new regulator, the Federal Banking Agency (FBA), would supplant the Office of the Comptroller of the Currency and be responsible for all national banks and their holding companies, except for the 35 largest national bank holding companies. These, along with all state banks and their parent holding companies, would be supervised by the Fed. But according to the second recommendation, state banking agencies, after being certified by the federal agencies (the FBA, the Fed, and the FDIC), would assume the supervision of state-chartered banks.

All of those who spoke on the Bush Commission recommendations agreed that the proposals, if adopted, would be a step in the right direction. Some, however, found a few shortcomings. Leslie P. Anderson, professor of banking and finance at the University of Tennessee, intensely studied the failure of United American Bank and other "Butcher" banks. He noted that in this case seven different regulatory agencies, which were represented by various regions within each of the agencies, audited 40 different banks in two states, but never in unison. Consequently, the problems at the "Butcher" banks went uncorrected for some time. Anderson hoped that the Bush Commission recommendations would ensure that such a situation would not be repeated; however, he also expressed concern that the recommendations were not strong enough.

Gary Gilbert, from the Bank Administration Institute, also noted that the Bush Commission recommendations have a few shortcomings. In particular, Gilbert finds that a clear relationship between the Bush Commission proposals and broader goals in evaluating bank regulation—protection of the nation's money supply, preserving monetary stability, avoidance of excess concentration of financial and economic resources, and provision of adequate banking services—seems to be missing.

Several speakers at this year's Bank Structure Conference attempted to shed some light on possible regulatory and legislative responses to the changing financial environment. Robert A. Richard, director of the Supervisory Procedures Committee at the Conference of State Bank Supervisors, believes that each state should have the right to do what it wants for its own citizens. While Richard opposes a national policy on the powers of financial institutions, he is in favor of the Bush Commission proposal to certify state banking departments. He is, however, concerned about how certification would be implemented, and with regard to the regulation of bank holding companies, Richard prefers the current system. He is convinced that regulatory reform will change the states' role in the supervision and regulation of financial institutions. But only after such "reregulation" has begun will the direction of this change become apparent.

Lamar Smith, chief economist of the Senate Committee on Banking, Housing, and Urban Affairs, pointed out that Congress is being pressured to impose limitations on states' abilities to deregulate product and geographic markets, but

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that Congress has always been reluctant to interfere with states' rights, particularly in areas where states already have legislation. Smith guessed that Congress will continue to defer to states rights unless an unambiguous case can be made that the actions of the states were threatening the FDIC's insurance fund and would lead to potential significant financial cost to the federal government.

Research at the Chicago Fed

Indeed, the financial system is at a crossroads; very important legislative and regulatory decisions will affect the viability and strength of the financial sector and the economy for many years to come. The Conference on Bank Structure and Competition helps bridge the gap between economic theory and practice by providing an opportunity for academics, regulators, bankers, and other business practitioners to exchange ideas on pressing issues in the financial sector. The result has been better and more pertinent research on important and timely public policy issues.

Under the guidance of Karl A. Scheld, Director of Research at the Federal Reserve Bank of Chicago, and Harvey Rosenblum, Vice President and Associate Director of Research and the host of the Bank Structure Conference, the research staff at the Chicago Fed studies, throughout the year, important issues faced by the financial community. Gillian Garcia and Herbert Baer, for example, recently examined the dynamic adjustment in the market for MMDAs and presented their findings at the 1984 Bank Structure Conference. These and others at the Chicago Fed have studied various aspects of banking deregulation, competition, and the future of the financial services industry.

At this year's Bank Structure Conference, Silas Keehn, President of the Federal Reserve Bank of Chicago, in looking back at the 1983 Conference said that "the thing that impressed me most was the fact that events that seemed incredible a year ago seem ordinary and commonplace now." Whatever lies ahead for the financial sector, whether incredible or ordinary, will be on the mainstage of coming Bank Structure Conferences and the subject of continuing research at the Federal Reserve Bank of Chicago.

— Christine Pavel

The Proceedings of the 1984 Conference on Bank Structure and Competition will be available in early Fall 1984. Copies can be obtained for a price of $10.00 each from:

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Federal Reserve Bank of Chicago
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Next year's Bank Structure Conference will be held May 1-3, 1985, in Chicago.

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Individual bank reserve management

Vefa Tarhan

Reserve requirement regulations, and the actions that banks take to satisfy these rules in their reserve management decisions have important monetary policy implications. For this reason, it is not surprising that a particular reserve accounting regime generates a great deal of interest. This article wilf examine the bank reserve management process both under the new, contemporaneous reserve requirement regime (CRR, in effect since February 1984), and the previous system. Additionally, the potential implications of the change in the reserve accounting system for the environment in which banks make their reserve management decisions will be discussed.

The lagged reserve requirement regime (LRR), instituted by the Federal Reserve in 1968, was subjected to considerable criticism in recent years, especially after October 1979 when the Fed switched to an operating strategy of targeting monetary aggregates rather than interest rates to control the money stock.

It was in response to mounting criticism against LRR that the Fed, in June 1982, decided to abolish LRR in favor of a more concurrent reserve accounting system. This new system has been in effect since the beginning of February 1984. Under LRR, a bank's required reserves in a given week were computed on the basis of its deposit holdings two weeks previous. In general, a truly contemporaneous system would be a regime in which banks are required to maintain reserves against their deposit holdings in the same period. The system currently in effect is not truly contemporaneous, as will be discussed below.

This paper is organized as follows: First, the environment in which banks make their reserve management decision is examined. Second, a brief description of the new reserve accounting system is presented. Lastly, the possible implications of the new regime for the individual bank and the environment in which it operates are analyzed.

In the first section a model of bank reserve management behavior is presented. This model is estimated for a large individual bank for the LRR period. Because the change in reserve accounting has taken place only recently, there simply is not enough data to repeat the estimation of this model for the new regime. However, some aspects of the problem (for example, the type of instruments that the banks use in satisfying their reserve requirements) are not expected to be different under the two accounting regimes. Thus, the empirical results based on data generated by the LRR regime may still be useful in a CRR world in revealing the manner in which reserve adjustment decisions are made.

Reserve management process with LRR

At the start of a given reserve settlement week under LRR, the individual bank had complete information on its level of required reserves (as determined by the level of its deposits two weeks ago). Two other factors that the bank knew were the vault cash it held two weeks prior to the current period, and the reserves it carried over from the previous week. The vault cash counted towards satisfying the reserve requirements of the current week. Carryover, on the other hand, could be positive or negative and, depending on the sign, reduced or increased the reserve requirements of the current period. The bank's problem, then, was to obtain reserves to satisfy its requirements at minimum cost. Of course, the bank had the option of holding reserves that were exactly equal to the required amount, or up to two percent more or less than this amount, depending on the level of reserves it wanted to carry over to the next period. However, a bank could not have a negative carryforward for two consecutive weeks.

Even though the required reserves under LRR were predetermined, the bank still had

Vefa Tarhan is an associate professor of finance at Loyola University of Chicago.

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uncertainty throughout the reserve settlement week regarding its reserves disequilibrium. The source of this uncertainty lay in the interaction of its depositors with other banks in the system. Anytime a depositor of the bank in question writes a check to or receives a check from the depositor of another bank, the reserve balances of the two banks will be affected in opposite directions by the amount of the check. For example, assume individual A who has an account with Bank A writes a check to individual B who deposits this check in his account at Bank B. As a result of the clearing process, Bank A's balances at the Fed will be reduced and Bank B's increased by the same amount. Under any reserve accounting system, it is essential for efficient reserve management that a bank attempt to forecast such changes in its reserve balances. Most banks form expectations about the potential actions of their depositors (especially customers with large accounts, since their activities are more likely to produce substantial shocks). But of course banks cannot be expected to be 100 percent accurate in their forecasts. Under LRR, the unanticipated

A glossary of variables in the reserve management process:

Federal funds transactions. Interbank borrowing and lending of excess reserves of banks. A bank whose reserve balances are less than its reserve requirements will typically be in the market to purchase (borrow) such funds.

Discount window borrowings. Bank borrowings from the District Federal Reserve Bank. These funds are used to satisfy the bank's reserve requirements.

Reserve carryover. In a given week a bank's reserves may not be exactly equal to its required reserves. Under LRR a bank could carry forward a surplus or deficit up to two percent of its required reserves provided it does not carry forward deficits two weeks in a row. As explained below, the provision is essentially the same for the current regime except during the one-year transition period.

Repurchase agreements (RPs). Acquisition of funds through the sales of securities, with a simultaneous agreement by the seller to repurchase them at a later date. If the RP transaction is executed with a depositor of another bank, it constitutes a source of reserve funds in the current period for the bank which is the party to the RP. Under both CRR and LRR, if the party to the transaction is the bank's own depositor it reduces the reserve requirements of the bank (in the current period under CRR, and two weeks hence under LRR).

Reserve balances. Funds that the bank has at the District Federal Reserve bank. These funds could change as a result of the bank's activities (Fed funds transactions, discount window borrowings and repayments, and sales and purchases of securities to and from the Fed) or as a result of the actions of the bank's depositors that involve depositors of other banks. The later component is exogenous to the bank and defined as the variable Z_t in the text.

Reserve requirements. Banks are required to hold reserves against their deposits of the current period under a truly CRR regime whereas under LRR they hold reserves in the current period against their deposits of two weeks ago. The determination of reserve requirements is explained below.

Other sources of reserves. A bank in need of funds can also sell its Treasury bills, issue CDs or borrow in the Eurodollar market. Mostly due to the transactions costs involved, partially arising from the fact that these instruments have longer maturity, and the reserve management problem is inherently shorter term (one week under LRR), these instruments are typically not used for purposes of satisfying reserve requirements.

Reserve disequilibrium (imbalance). Describes the situation where reserve balances are more or less than the required reserves. Equilibrium can be restored by using the instruments discussed above (plus loans and investments of the bank). As explained above, some of these instruments enable the bank to reach reserve equilibrium by affecting the bank's required reserves, others by changing the level of the bank's reserve balances.

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component of changes in an individual bank's reserve balances (forecast errors) represented the main source of uncertainty about the size of its potential reserve imbalance.

Another factor that introduces uncertainty in the reserve management decision under any reserve accounting regime has to do with the price of funds to be used as reserves. Especially important in this regard is the issue of when to acquire the reserves in question. If interest rates are expected to fall sufficiently later on in the week, it may pay the bank not to purchase funds at the beginning of the week. This means that the bank should attempt to forecast the cost of obtaining reserves over the course of the reserve settlement week. The bank may also be interested in forecasting the cost of funds in the current reserve settlement week relative to the next period. This may be an important determinant for its carryover decision. Other things being equal, if the interest rates are expected to increase next week, the bank would like to carry forward a surplus. Based on these forecasts, the bank decides on the timing of reserve position adjustment as well as the mix of adjustment instruments to be used.

A bank may use several reserve adjustment instruments to eliminate the disequilibrium in its reserve position. These instruments include the bank's level of earning assets (EA), federal funds purchases, repurchase agreements (RPs), discount window borrowings, excess reserves, and reserve carryover. Each of these items operates by affecting either the bank's current reserve holdings or its required reserves. In LRR, changes in EA and the induced changes in deposits affect both the current reserve balances and required reserves two weeks hence. The other items, with the exception of RPs that the bank executes with its own depositors, affect only current reserves.

Like EA, RPs with its own customers lower the bank's required reserves two weeks later.[1]

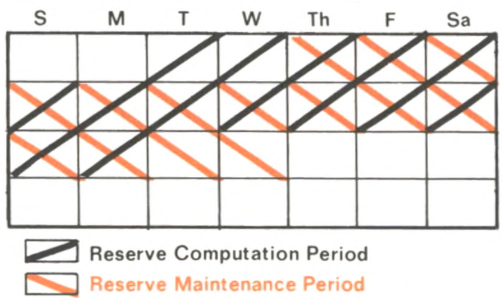
[1]In the current period, an RP transaction may somewhat affect a bank's reserve position even when the RP is executed with one of the bank's depositors: If the level of excess reserves is positively related to the level of deposits, this will free some reserves since the RP extinguishes some deposits. The quantitative importance of this, however, is probably insignificant considering that the excess reserves/deposits ratio is very small for most banks.

Federal funds purchases and RP transactions constitute the biggest source of reserves for most large banks.

It should be noted that since a bank does not know the level of its reserve balances for a given day until one day later, the carryover provision can be utilized to account for any last minute discrepancies. In other words a bank may try to purchase enough reserves to meet its requirements, and if its reserve balances change at the last minute, it can carry forward the surplus or deficit resulting from such changes. In this sense, carryover can be thought of as a passive reserve adjustment tool.

The same tool can also be used in a more aggressive manner. An individual bank may *plan* on a deficit or surplus carryover based on its forecast of next week's interest rates in comparison with the current levels. That is, when a bank expects the Fed funds rate to rise next week it may carry forward a surplus deliberately. In the case of an expected fall, a deficit will be carried over. This contrasts with the first use of carryover mentioned above, where the bank allows the events to determine its carryover position. In reality, a sophisticated bank probably makes use of the carryover provision in a manner which combines both types of use.

Reserve computation and maintenance periods for transaction deposits



The 14-day reserve computation period is the period over which required reserves based on daily average deposit liabilities are calculated. The 14-day reserve maintenance period is the period over which the daily average reserve holdings of a depository institution must equal its required reserves.

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Reserve management under a concurrent reserve accounting system

In a purely contemporaneous regime (CRR), the environment in which a bank makes its reserve management decisions is somewhat different. To begin with, since required reserves under such a regime are not predetermined, a bank has uncertainty regarding the level of its required reserves, in addition to the uncertainty about its holdings of reserve balances. However, this does not necessarily translate into an environment with more uncertainty about the size of the reserve disequilibrium than under LRR. The reason is that unanticipated changes in a bank's reserve balances move in the same direction as the unanticipated changes in its required reserves. The comparison of uncertainty under the two systems is addressed later on.

As far as instruments of reserve management are concerned, an individual bank will have two additional tools under a concurrent regime. First, RPs with its own depositors will alleviate a bank's reserve imbalance by affecting its required reserves in the current period, whereas the effect of such transactions under an LRR is felt two weeks hence. The significance of this tool may vary from bank to bank depending on what portion of its RP transactions the bank executes with its own depositors. More importantly, an individual bank can eliminate its current period reserve disequilibrium under CRR by changing the level of the earning assets (loans and investments) which directly affect the level of its deposits and thus change its required reserves. By contrast, changes in a bank's earning assets portfolio under LRR affected its required reserves two weeks down the road. Thus, a bank under CRR has more instruments of adjustment since it can move towards equilibrium not only by obtaining and disposing of reserves (which alter its reserve balances), but by also taking actions which affect its required reserves.

A model of individual bank reserve management under LRR

This section describes a model of individual bank reserve management under LRR, and summarizes the results obtained from the estimation of the model for a large money center bank.[2] Even though the model is estimated using data from the LRR period, the results will shed some light on how banks may approach the problem under the current system. It is assumed that the bank uses the following instruments in its reserve adjustment process: net federal fund purchases (purchases-sales=NFF_t), discount window borrowings (BOR_t), reserves to be carried over from the current period to the next period (CO^t_{t+1}), and adjusted excess reserves (AER_t).[3] It should also be noted that the fed funds data includes RPs.

The model specifies that the bank chooses the optimal reserve management portfolio. This choice is dependent on the conditions that the bank inherits (its required reserves and vault cash, both determined two periods ago, and the reserves carried over from week t-1 to week t), as well as the exogenous forces it expects to experience during the current period (forecasted federal funds rate for the current period, forecast of the intertemporal spread on the funds rate [funds rate next week—the funds rate in the current week], and the forecast of exogenous changes in its reserve balances [Z_t]).[4]

It is assumed that the bank's goal is to select profit optimal values for its reserve adjustment tools given the predetermined variables and expected values for the exogeneously determined component of its reserve balance and interest rates. In solving this problem, the bank has to

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[2]For a more detailed description of the model as well as the empirical results see Vefa Tarhan, "Bank Reserve Adjustment Process and the Use of Reserve Carryover Provision and the Implications of the Proposed Accounting Regime" *Staff Memoranda* 83-6, Federal Reserve Bank of Chicago, and Paul Spindt and Vefa Tarhan "Bank Reserve Adjustment Process and the Use of Reserve Carryover as a Reserve Management Tool—A Microeconometric Approach" *Journal of Banking and Finance*, March 1984.

[3]Adjusted excess reserves refer to excess reserves adjusted for reserve carryover in the following manner: AER = reserve balances-required reserves-reserves carried over from the previous week.

[4]All the forecasts in this study were generated using a time series approach. Implicit in this methodology is the assumption that the bank uses the past data on a variable to form expectations about the future movements of that variable.

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satisfy a constraint which is similar to a balance sheet identity. The constraint in question is that total reserve sources has to be equal to total reserve uses. In the framework used here sources of reserves are federal funds purchases, borrowings from the Fed, vault cash, carryover position inherited, and Z_t. Uses of reserves on the other hand are required reserves, adjusted excess reserves, and reserves to be carried from period t to t + 1. The equations are derived from this constrained minimization problem.

The equations were estimated for a large money center bank using weekly data covering the period from January 8, 1969 to September 26, 1979. The results indicate that the sample bank in question seems to manage its carryover position aggressively: The relationship between the reserves it carried forward and the forecast of the funds rate spread between next week and the current period was found to be positive and significant. In response to a decrease in the forecasted level of the sample bank's reserve balances (caused by the interaction of its depositors with other banks), it was found that the bank increases its weekly net Fed funds purchases and borrowings from the Fed. Furthermore, the results reveal that the bank finances the increases in its required reserves almost entirely in the Funds market.

It was also found that this bank did not use the discount window to satisfy its required reserves in a systematic manner. (In fact the relationship was surprisingly negative.)

Additionally, it was found that an increase in vault cash two weeks ago results in a net decline of Fed funds purchases and an increase in adjusted excess reserves. When reserves carry over inherited increases, on the other hand, reserves carried forward to the next week decline, and excess reserves increase. These results conform with a priori expectations: First, an increase in a source item should cause other source variables to decline or use items to increase (and an increase in use variables should cause other use variables to decline or source variables to increase). This appears to be the case. Second, the importance of the Fed funds market, especially for large banks, is confirmed by the results, in the sense that the response of the NFF instrument dominates the reaction of all the other sources when the bank acts to eliminate the reserve disequilibrium.

The new reserve accounting system

Now we turn to a brief description of the new regime and the possible implications of this system for the individual bank.

The new reserve accounting regime combines elements of both the CRR which was in effect prior to 1968 and the LRR which was in effect until February 1984. The reserve computation period is 14 days (Tuesday to Monday). The reserve maintenance period for transaction deposits covers the period from the first Thursday after the start of the reserve computation period to Wednesday of two weeks later.[5]

Furthermore, the carryover allowance is 3 percent of a bank's required reserves for the first six months of the implementation, the next six months it will be 2.5 percent, and after February 1985 it will be 2 percent.

As far as transaction deposits are concerned, the last two days of the reserve maintenance period is somewhat like the LRR regime. During these two days the instruments that an individual bank can use to eliminate reserve disequilibria are confined to those that move the bank towards equilibrium by affecting its level of reserve balances. Changing its level of required reserves ceases to be an option during the last two days of the reserve maintenance period. These days may be crucial both for the individual bank and the Fed. They are important for the bank because its decision regarding what portion of the adjustment to postpone to the very end may prove to be costly, if the funds rate during the last two days turns out to be drastically different than what the bank expected. They are crucial to the Fed because the banks may have substantial reserve deficiencies that

[5]The reserve maintenance period for other reservable liabilities (non-personal time deposits and Eurodollar liabilities) is the same as it is for transaction deposits. But the reserve computation period for such liabilities covers the 14-day period (Tuesday to Monday) which starts 30 days before and ends 17 days before the reserve maintenance period. Vault cash held during the same reserve computation period counts as reserves during the maintenance period.

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will require heavy use of the discount window or necessitate a large dose of reserves injection to the system. Assuming an operating procedure which targets non-borrowed reserves, it is conceivable that the Fed funds rate will behave very differently during these days than during the first twelve, at least in the early days of implementation of the new reserve accounting system. However, in a way, banks have unlimited carryover from the first 12 days of the reserve maintenance period to the last two days. This being the case, once banks become familiar with the factors that enter into the fed-funds forecasting procedure under the new system, their actions may eventually reduce this potential first 12 days-last 2 days discrepancy in the funds rate. And, if the Fed is successful in conveying its policy intentions regarding both its discount window administration and its open market operations, the potential for large fluctuations in the funds rate may be eliminated.

Although the last 2 days under the new CRR are similar to the situation under LRR, the *dimension* of the problem is drastically different for two reasons: 1) Compared with the LRR system, banks will have much less information about the system's demand for required reserves. Under LRR, banks could better estimate the level of required reserves for the whole system, whereas now they do not have as much information. (Money supply figures were announced on Fridays when the banks were two days into the reserve maintenance period.) Thus their funds rate forecast may be less accurate; and 2) there are only two days to adjust and not a week. Thus the funds rate may change drastically during the last 2 days unless the Fed is successful in conveying its intentions.

The new reserve accounting regime and the individual bank

In this section the possible effects of the new system on individual bank behavior is examined. The discussion will be confined to how the system may affect the uncertainty surrounding the bank's reserve management decision and whether or not bank earning asset behavior may change.

For an individual bank, a crucial question regarding the new system is how it may affect the uncertainty surrounding its reserve management environment. The issue can be thought of as having two components: uncertainty about the *size* of disequilibria the bank is likely to face, and uncertainty concerning the *price* of adjustment to a given disequilibrium. On both accounts there are forces working in opposite directions, making it necessary for the issue to be settled empirically. However, at this stage any empirical attempt to resolve the problem has to rely on data generated by LRR and thus must be interpreted with caution. Below, a preliminary test of the first component of uncertainty an individual bank faces is presented; then, a procedure for the analysis of the second component is discussed.

Let Z_t represent the change in a bank's reserve balances caused by the interaction of its depositors with other banks and RR_t represent its required reserves. $\hat{Z}_t$ is the forecast of Z_t. The unanticipated portion of exogenous changes in an individual bank's reserve balances (errors on Z_t) represent the only source of uncertainty regarding the size of reserve disequilibria under LRR. But when subjected to a CRR regime, the bank will also have to be concerned with the unanticipated component of its required reserves (forecast errors on RR_t).

Under CRR reserve, disequilibrium for an individual bank can be defined as

$$RDt = Z_t - RR_t.$$

The uncertainty in this regime will be represented by the variance of forecast errors on RD_t (which is equal to the sum of the variance of forecast errors on Z_t and RR_t minus twice the covariance between the two errors). However the errors in question are offsetting: A one-dollar change in Z_t is likely to produce a reserve imbalance which is less than a dollar. For example, when the bank has a one-dollar decline in its reserve balances as a result of an action of its depositor, its reserve deficiency will be less than one dollar since a one-dollar decline in its deposits will lower its required reserves by an amount determined by the appropriate reserve requirement ratio. Thus, the forecast errors on RR_t and Z_t are positively correlated. Depending on the size of the correlation coefficient the uncer-

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tainty under CRR as measured by the variance forecast errors on RD_t might be less than the uncertainty under LRR (variance of forecast errors on Z_t). While the correlation is probably high, it is likely to be less than one since it is possible for change in RR_t not to have an effect on Z_t. Factors such as changes in the composition of the bank's deposits can affect its required reserves (because required reserve ratios vary across different deposit categories) but not its reserve balances.

For the sample bank, variance of forecast errors on Z_t (LRR regime) and RD_t were compared. The calculations showed that the uncertainty regarding the size of the reserve disequilibria would be slightly less (about 6 percent) under a pure CRR regime with a one-week settlement period than it was under the LRR system which was in effect prior to February 1984. The conclusion to be drawn from this is not that there is necessarily less uncertainty for the bank under a CRR type regime, especially since the evidence in question is confined to the sample bank, but that it is not likely to be substantially different between the two regimes.

The issue of whether or not the funds rate will become more volatile is more difficult to analyze. One approach to this question is to compare the frequency of reserve disequilibria individual banks face in the two regimes under the assumption that the funds market acts as the "shock absorber" for any reserve discrepancies. The variance of the forecast errors on reserve discrepancies under the LRR system is equal to the variance of forecast errors on Z_t. In a CRR regime it is equal to the sum of the variances of forecast errors on Z_t and RR_t minus twice the covariance between the two. However, it should be noted that a change in Z_t for one bank has no implications for the funds rate if it involves another bank (since the two banks will be at opposite ends of the funds market, their activities will cancel each other out with no impact on the funds rate). Therefore, holding excess reserves and discount window borrowings constant, it is only the unanticipated changes in Z_t resulting from the Fed's actions that are relevant for the analysis.[6] The issue of uncertainty regarding the price of adjustment will probably not be resolved for several years.

It is possible that banks will have larger forecast errors in their attempts to predict the funds rate with the new reserve requirement system than with the system which was in effect prior to February 1984. The reason is that they no longer have as much information on the most important component of demand for reserves—the required reserves for the banking system. Banks were able to form much more accurate estimates of the required reserves of the banking system under the old regime.[7]

One of the criticisms of the LRR was that it potentially could create an environment in which the Fed had no choice but to validate the deposit created by the banking system with a two-week lag. However, a study that compared individual bank behavior before and after 1968, when LRR was instituted, concluded that bank behavior regarding its earning asset portfolio decisions was not significantly different under the two regimes.[8] This result is not entirely unexpected if one believes that what governs bank earning asset expansion is the expected costs and returns of these assets over a multi-period horizon. Unless a reserve accounting regime changes the relation between expected costs and returns, there is no reason to think banks will create more or less deposits because of a particular reserve accounting regime. On the basis of this evidence, it can be argued that the individual bank earning asset creation process is not likely to change after February 1984.

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[6]The comparison then amounts to the variance of open market operations (OMO) under LRR and the sum of Var(OMO) + Var(RR) - 2 Cov(OMO,RR) under CRR. Hence, the manner in which the Fed intends to conduct its OMO under CRR becomes a crucial factor.

[7]Money supply figures are announced with a 10-day lag; thus on Fridays under LRR the banks had complete information about the amount of required reserves that the system needs for the reserve settlement week that started the previous day. It is conceivable that under LRR the announcement caused them to revise their forecasts of the funds rate for the rest of the reserve maintenance period. Under the new regime, since they have no deposit figures to use in their forecasting procedure, such forecasts are likely to have wider confidence intervals.

[8]See Vefa Tarhan and Paul A. Spindt "Bank Earning Asset Behavior and Casualty Between Reserves and Money: Lagged Versus Contemporaneous Reserves Accounting" *Journal of Monetary Economics*, August, 1983.

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