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Federal Reserve Bank of St. Louis
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January 1984

In This Issue . . .

The articles in this *Review* focus on the performance of two different kinds of markets. The first article investigates whether options on Treasury bond futures are priced efficiently. The second article compares employment trends in the St. Louis area with those in the rest of the nation to see whether they have differed significantly over the past several decades.

In the first article of this issue, "Are Options on Treasury Bond Futures Priced Efficiently?" Michael T. Belongia and Thomas H. Gregory explain the fundamentals of options and futures markets and statistically investigate the efficiency of the market for options on Treasury bond futures.

In an efficient options market for Treasury bond futures, the risk of unexpected interest rate movements can be shifted from those with a high aversion to such risk to those willing to accept it at a market-determined premium. An inefficient market would price this risk incorrectly, producing "abnormal" returns to either purchasers or sellers of these options.

Using two separate tests based upon an option pricing formula first developed by Fischer Black, the authors were unable to find *ex ante* arbitragable profit opportunities. Thus, they conclude that the market for options on Treasury bond futures is efficient.

In the second article, "Employment Trends in St. Louis: 1954–82," G. J. Santoni describes the current employment distribution in the St. Louis labor market, compares longer-run growth in St. Louis employment with other similarly sized metropolitan areas and the nation, and assesses the recent growth in St. Louis employment in terms of these longer-run trends.

Santoni finds that, while the current employment mix in St. Louis is similar to that in the rest of the nation, the growth rate of local employment has been significantly lower than the nation's growth rate since 1954. Further, the slower growth in St. Louis employment is common to both the manufacturing and nonmanufacturing sectors.

Santoni points out that it does not appear that recessions have a differentially severe effect on the local labor market, when St. Louis' lower average employment growth rate is taken into account. In addition, the slow growth in St. Louis employment was not unusually aggravated by the substantial reductions in the work forces of the various auto manufacturing plants located in the St. Louis area in recent years. Finally, relatively slow growth in employment is not unique to St. Louis; other comparably sized and geographically located cities display the same pattern.

Are Options on Treasury Bond Futures Priced Efficiently?

Michael T. Belongia and Thomas H. Gregory

UNTIL recently, trading in commodity options has been viewed with a great deal of suspicion in the United States by both the general public and market regulators. The low margin required by option markets has led many people to believe that unsophisticated investors with limited resources were being encouraged to speculate and that commodity price movements could be manipulated by sophisticated speculators using a high degree of leverage.[1] Few people realized the useful role that speculators in futures and options markets play in assuming risk that others desire to avoid (thus providing hedging opportunities) and providing better estimates of future spot prices.[2]

The Commodity Futures Trading Commission (CFTC) is gradually lifting restrictions on option trading by allowing each commodity exchange to open trading in options on one of its futures contracts. The first phase of the CFTC pilot program introduced in 1982 saw eight commodity exchanges participate by offering options on several different futures contracts; these contracts covered three different stock market indices, two weights of gold, heating oil, sugar and U.S. Treasury bonds.[3] This article focuses on the pricing of options on Treasury bond futures.

The behavior of this particular option price series is interesting for at least two reasons. First, if the options market is efficient, no arbitrage opportunities will exist between any two option contracts.[4] Stated differently, an efficient options market is one in which the same market price will be observed for options with the same level of risk and rate of return. Because efficiency is one criterion that the CFTC is likely to consider when deciding the future of this market, it is important to assess whether the options market in U.S. Treasury bond futures contracts satisfies this criterion.

The second motivating interest of this study is the usefulness of Black's theoretical model in estimating the prices of American-type options on futures.[5] American options permit the holder to exercise the option at any time before the option contract expires. Most option pricing formulas, however, attempt to explain the prices of European options, which can be exercised only on the expiration date of the option contract.

Although the Black model is widely accepted as a theoretical representation of option price determination, some recent studies using stock options suggest that its predecessor, the Black-Scholes model, does not fit market data well.[6] Limited applications of the Black

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[1]A recent overview of problems associated with options trading in the early 1900s is provided in Wall (1983).

[2]One notable exception to this was Holbrook Working, who wrote extensively on the potentially useful role of speculators. The interested reader is referred to Working (1977).

[3]For more detail on the specifics of the CFTC pilot programs and a general background to options trading, see Wolf (1982); and Belongia (1983).

[4]Efficient markets are those that reflect all available information. Weak form market efficiency implies that all information contained in past price movements are fully reflected in current prices. Semi-strong efficiency suggests that current prices reflect all publicly available information. Strong form efficiency means that prices reflect all information, both public and private. A considerable body of empirical work suggests that heavily traded capital markets are at least semi-strong efficient. See Fama (1970).

[5]Black (1976).

[6]See, for example, Black and Scholes (1972); Gulteken, Rogalski and Tinic (1982); Finnerty (1978); Whaley (1982); and O'Brien and Kennedy (1982).

model to the pricing of London commodity options have produced contradictory results about market efficiency and the model's applicability.[7] In view of these results and the recent availability of options data from U.S. markets, it is of some interest to determine whether the Black model accurately describes the process by which prices on U.S. Treasury bond options are determined. From a different perspective, the research question is whether judgments about the observed behavior of option prices can be based on comparisons to prices predicted by this theoretical model.

This article first describes some basic principles of options contracts and their relationship to futures markets. The behavior of prices in the Treasury bond options market then is examined using a test proposed by Latane' and Rendleman.[8]

OPTIONS AND FUTURES IN THE CFTC PILOT PROGRAM

Options trading may be clarified somewhat by first comparing it with futures trading. A futures contract *obligates* the holder to buy (or sell) a specific volume of the underlying commodity at a specified price at some future date. An agreement to buy the commodity is a "long" futures position; a "short" position is an agreement to sell. If futures prices rise, holders of long positions realize a profit that is exactly offset by the losses of the holders of short positions that day, and vice-versa. Futures contracts are settled each day with debits or credits to the margin accounts of individuals holding a futures position. For example, if an individual bought a Treasury bond futures contract and, by the end of that day, Treasury bond futures "settled" at a higher price, he would realize a profit equal to the change in the value of the futures contract less transaction costs. He then would have the choice of liquidating the futures contract or holding it in hope of further price appreciation.

Futures contracts normally call for delivery of a homogeneous, standardized product. The delivery of homogeneous, standardized Treasury bonds is complicated by the fact that Treasury bond prices respond to factors such as coupon rates and callability features that are specific to individual issues of Treasury bonds. Thus, the Treasury bond futures contract, as specified by the Chicago Board of Trade, calls for delivery of a hypothetical 8 percent coupon Treasury bond not callable for at least 15 years from the date of delivery. If no call provision is present, the bond must not mature for at least 15 years from date of delivery.[9] These bonds have a face value of $100,000 at maturity. A price of 70 implies a contract valued at $70,000.

An option contract gives its purchaser the right, *but not the obligation*, to buy or sell a specified volume of a commodity for a set price at some future time. Within the CFTC pilot program, this right to buy or sell applies only to specific futures contracts and not to the physical commodities underlying those contracts. For example, the purchaser of a call option on Treasury bond futures buys the right to purchase a specific Treasury bond futures contract for a specified price prior to some agreed-upon future date.

If, before that date, the market price of that Treasury bond futures contract rises above a specific level (the sum of the exercise price, the price of the call option and any commission costs), the purchaser will find it profitable to exercise the rights of the call option. By doing so, he buys the futures contract (that is, holds a long position in the Treasury bond futures market) and obtains an immediate profit equal to the difference between what he paid for the futures contract (the exercise price of the call option) and the current market price, less the transaction costs.

The purchaser of a put option, conversely, purchases the right to sell a particular futures contract at a set price. In this case, if the futures price falls below a particular level, the purchaser will find it profitable to exercise the rights of the put option and, by doing so, enter into a short position in the futures market. This will enable the individual to sell futures contracts for Treasury bonds at a price above the current market price.[10] In practice, owners of both call and put options often choose to realize profits by selling the option

[7]Studies of London options include Hoag (1982); and Figlewski and Fitzgerald (1982).

[8]Latane' and Rendleman (1976).

[9]The CBT publishes tables of conversion factors that translate all of the deliverable Treasury bonds into 15 year, 8 percent coupon bonds. The conversion factors for bonds with coupons less than 8 percent are less than 1, and the factors for bonds with coupons over 8 percent are greater than 1.

[10]By selling the futures contract, the individual agrees to deliver a specific amount of Treasury bonds at a specified price at the expiration of the contract. Again, the individual realizes an immediate profit equal to the difference between what he sold the futures contract for (the exercise price of the put option), and that trading day's futures settlement price, less transaction costs. He also is faced with the decision to liquidate or hold further.

instead of exercising its privileges and entering into a futures market position.

The Commodity Option Contract

The key elements of a commodity option contract are the strike (or exercise) price, the futures contract to which the option applies and the premium. The premium — the price of the option — is competitively determined, whereas other elements of the option are part of the contract itself. An "in the money" call option is one whose strike price (the price at which the option owner may exercise the rights of the option) is less than the current price of the futures contract that underlies the option; a call option is "out of the money" if its strike price is greater than the price of the futures contract. The reverse is true for put options. For example, if the current futures price is at 75, call options whose strike prices are less than 75 and put options with strike prices greater than 75 are in the money. Call options with strike prices greater than 75 and put options with strike prices less than 75 are out of the money.

WHAT SERVICES DO TREASURY BOND OPTIONS PROVIDE?

One useful role that option and futures contracts play is to transfer the risk associated with adverse price swings from hedgers to speculators. Consider, for example, the manager of a pension fund who expected interest rates to rise. He could hedge against the risk of capital loss in the price of his bond holdings by selling Treasury bond futures. If rates did rise, losses in his long position (bond holdings) would be at least partially offset by gains in his short position (futures contracts).

Because an option's price changes in response to the price of its underlying commodity or security, options also can be used to hedge against risk. In fact, at the heart of the Black and Black-Scholes models is the assumption that a totally risk-free hedge can be constructed using options and either futures (Black model) or securities (Black-Scholes model).

How To Interpret Option Prices

Table 1, a reproduction of one day's report on trading in Treasury bond options, indicates that on September 13, 1983, options could have been bought on futures contracts dated for delivery in December 1983, March 1984 and June 1984; no options had yet been written on the September 1984 futures contract. The data in the table's first column show the strike prices of available options, while columns 2–4 give the premiums associated with call options at those strike prices.

Table 1
A Typical Summary of One Day's Trading in Options on Treasury Bond Futures

CHICAGO BOARD OF TRADE Treasury Bond Option Prices, 9/13/83, points and 64ths of 100 percent ($100,000)

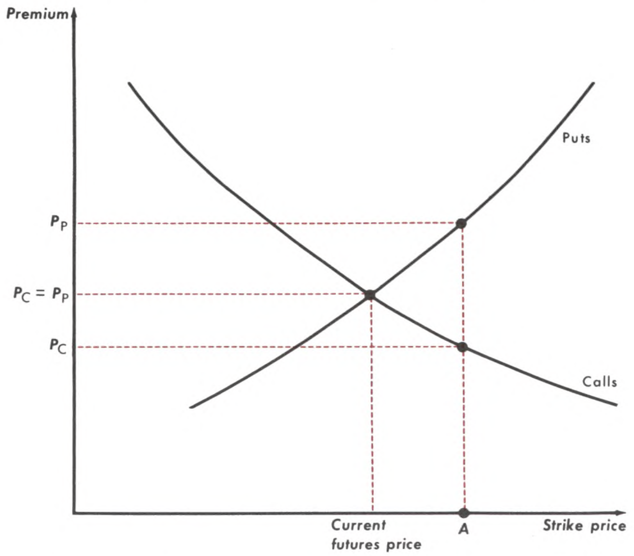
Strike Price	Calls — Settlement			Puts — Settlement		
	Dec	Mar	Jun	Dec	Mar	Jun
66	5–41	—	—	0–16	0–58	—
68	3–62	4–22	4–44	0–35	1–32	—
70	2–35	3–16	3–42	1–06	2–20	—
72	1–33	2–25	2–45	2–05	3–21	—
74	0–52	1–34	2–11	3–17	4–36	—
76	0–24	1–03	—	4–56	5–63	—
78	0–10	0–45	—	6–40	—	—
80	0–06	0–26	—	8–36	—	—
82	0–03	—	—	—	—	—

The data in the table show, for example, that call options on March 1984 Treasury bond futures had been written with strike prices between 68 and 80; the futures price on this date was 70-29/32. Therefore, the premium on a call option with a strike price of 68 is expected to be the highest premium since it offers the option purchaser the right to buy Treasury bond futures at a 2-29/32 discount to the current market price. The difference between this discount and the price of the call (4-22/64) represents the market's evaluation of the potential for future price appreciation of this contract.

The table also shows that call premiums fall as strike prices increase. Higher strike prices offer the option purchaser the right to buy Treasury bond futures at a price above the current market price. A buyer would purchase these options only if he expected futures prices to increase substantially above the option's strike price before the option's expiration date. This negative relationship between call option premiums and strike prices also is illustrated in figure 1.

The data in columns 5–7 of table 1 show the premiums on put options for the same strike prices listed

Figure 1
Relationship Between Premiums on Put and Call Options



P_P = premium on a put option with strike price = A.
P_C = premium on a call option with strike price = A.

in column 1. Because a put option gives the purchaser the right to sell Treasury bond futures, put option premiums tend to increase with strike prices; that is, the right to sell at a higher price has a greater value than the right to sell at a lower price. This relationship is depicted by the upward-sloping line in figure 1. In this and other respects, the properties of put options are the mirror image of properties associated with call options.

USING THE BLACK MODEL TO DERIVE CALL OPTION PREMIUMS

The Black model can be written as:[11]

(1) $P_c = e^{-rt} [F^*N(d_1) - X^*N(d_2)]$ (see insert).

The only two parameters of the model that are not directly observable are r, the risk-free nominal interest rate, and σ^2, the variance of expected future returns of the underlying futures contract. The risk-free nominal interest rate can be proxied, however, by the current market rate on Treasury bills with maturities near the expiration dates of the various futures contracts.[12] The determination of an appropriate value for σ^2, the expected variance of future returns, is the last piece of information needed to estimate the price of a particular option with the Black model.

The test of the Black-Scholes model suggested by Latane' and Rendleman provides an interesting approach to comparing theoretical and actual option prices. Their reasoning is that if the market is pricing options and risk efficiently, then, given r, the same estimate of σ^2 should apply to all options traded for a given futures contract on a particular day. For example, all options offered on October 26, 1982, for the December 1983 futures contract should yield the same implied expectation of future returns if the assumptions that underlie the Black model are true. This result holds because the same risk-free hedge can be constructed over this interval by constructing a portfolio using different options on the same futures contract, if markets are efficient.[13]

The Latane' and Rendleman test of the Black-Scholes model for data on stocks and stock options also can be used to test the applicability of the Black model for determining prices of options on futures contracts.[14] Their test involves the following steps. On a particular day, observe data on a variety of different options on futures contracts for the same commodity — for example, all of the data for options on U.S. Treasury bond futures shown in table 1. Insert these data, a value for r and a starting value of σ^2 into the Black model and solve for a final value of σ^2 that minimizes the differences between actual and estimated call option prices. If the Black model is a correct representation of commodity options pricing *and* if the market is pricing options efficiently, one would expect to find estimates of σ^2 that were nearly identical across all options traded that day for the same futures contract.[15] Con-

[11]Black (1976).

[12]Because Treasury bills are backed by the U.S. government, the risk of default generally is considered to be zero.

[13]In the abstract to their 1973 article, Black and Scholes assert "(i)f options are correctly priced in the market, it should not be possible to make sure profits by creating portfolios of long and short positions in options and their underlying stocks." Their use of the term "correctly priced" markets is synonymous with what we are calling efficient markets. Black's model uses the underlying futures contracts in place of the underlying stocks.

[14]A strict test of market efficiency would compare the yield on a safe asset with the yield on a portfolio of hedged options and futures with continuously changing hedge ratios. Our reasoning is, however, that if the Black model does not predict option prices well, either the model is incorrectly specified or markets are inefficient. Therefore, in the absence of any *systematic* relationship between actual and implied option prices, conclusions about market efficiency on the basis of our "buy and hold" strategy are still valid.

[15]We are indebted to Fischer Black for emphasizing the implied differences among estimates of σ^2 for the same contract and observation dates.

Interpreting the Black Model

This model was designed to price options on the futures contract of an underlying asset. As such, it is both a refinement of and equivalent to the original Black-Scholes option pricing model, which theoretically prices options on the underlying asset itself.

According to the Black model,

$$(2)\quad P_c = e^{-rt}\,[F^*N(d_1) - X^*N(d_2)],$$

where P_c = the price of the call option
F = the price of the underlying futures contract
X = the contract's exercise price
r = the risk-free rate of interest
t = the number of time periods before the option expires (expressed as a fraction of a year)
$N(d_1)$ and $N(d_2)$ = the cumulative normal density function evaluated at points d_1 and d_2.

$$d_1 = [\ln(\frac{F}{X}) + \frac{\sigma^2 t}{2}] / \sigma\sqrt{t}$$

$$d_2 = [\ln(\frac{F}{X}) - \frac{\sigma^2 t}{2}] / \sigma\sqrt{t}$$

and σ^2 represents the variance of expected future returns on the underlying futures contract over time. If all of the parameters of the capital asset pricing model hold and are constant, if σ^2 is constant, and if taxes and transaction costs are zero, these results can be derived by solving a differential equation for the change in the value of a hedged risk-free portfolio over time (given certain boundary conditions).

Although the model is difficult to interpret intuitively, certain general observations may be made. The use of the cumulative normal density function is a result of the assumption that returns on the futures contract follow a normal distribution. $N(d_1)$ represents the number of futures contracts an investor should sell per call option purchased in order to create a risk-free portfolio. For example, if $N(d_1)$ were estimated to be 0.5, it would imply that the investor should sell one futures contract for every two options he purchased. (Of course, since this ratio changes over time as market conditions change, an investor would have to adjust his portfolio continually if a risk-free hedge were to be maintained at all times.) As long as $[F^*N(d_1) - X^*N(d_2)] \geqslant 0$, then $P_c \geqslant 0$. This is always true given the relationships between $\ln(F/X)$, F, X, d_1 and d_2 (since σ and t are always positive). Thus, the price of a call option can never be negative.

If S equals the spot price of the security or commodity underlying a futures contract, and h equals the cost of holding this asset over time (e.g., interest and storage costs), then the substitution of Se^{ht} for F in the Black model yields the original Black-Scholes formula. In markets that fully reflect carrying costs, the models could be used interchangeably to value options; certain assumptions that underlie option pricing theory, however, imply that the Black model should be a more accurate representation of actual option prices than the Black-Scholes model.[1]

[1]These include institutional imperfections, relative market liquidities and the theoretical distributions of the underlying spot and future prices. See Asay (1982); and Samuelson (1965).

versely, if the different estimates of σ^2 are not very nearly identical, one can conclude either that the Black model does not estimate option prices accurately (given the use of Treasury bill rates as proxies for r) or that this market does not price options efficiently.[16]

[16]This conclusion also depends on several other assumptions as well. Because the Black model is derived for application to European options that do not have early exercise privileges, a debate has developed in the literature concerning what value, if any, can be attributed to the early exercise privilege of American-type options. Based on the work of Robert Merton, who argued that early exercise of stock options had no value unless dividends were involved, one might conclude that this problem is irrelevant in a study of options on commodity futures because dividends are not involved. Moreover, in practice, American options are almost never exercised before expiration. The reason is that the option has two potential sources of value: its immediate exercise value (if any) and its potential for price appreciation in the future. Thus, an investor — in most cases — will be able to realize a greater profit by selling the option instead of exercising it. In efficient markets, if we exclude options on assets that pay dividends, American and European options should be priced similarly. See Merton (1973).

ESTIMATION AND RESULTS

Observations on Treasury bond options were taken at six dates between October 1982 and April 1983.[17] On each of these six dates, data were gathered for actively traded options with large open interest. In total, data were gathered on 53 call options with different strike prices or futures contracts. On these same dates, interest rates were observed for Treasury bills maturing near the delivery dates of the various futures contracts; these values were used to represent risk-free rates of return (r).[18]

These data and starting values for the unobservable variance of expected future returns (σ^2) were used to find values for d_1 and d_2, the two points at which the cumulative normal density must be evaluated. Equation 1 then was solved for an estimate of the call option price. By using different values of σ^2, the Black model was solved iteratively until a value of σ^2 was found that minimized the difference between actual and estimated option prices to within ± one cent. The values of σ^2 that produced the minimum differences for the 53 option contracts considered are reported in table 2.

The estimates of σ^2 in the fifth column of table 2, in general, suggest that estimates of the implied variation of future returns differ numerically across options written on the same futures contract on the same day. The spread between highest and lowest estimates of σ^2 range from 0.014 for options on September futures traded on February 23 to 0.110 for options on June futures traded on April 4. It is not clear, however, that it is possible to test whether these estimates of σ^2 are statistically different from one another. Unknown are the mean of expected returns, the number of traders determining the mean and variance of returns, and the shape of the distribution itself. Judgmentally, however, it would appear that these estimated differences are small. In half of the cases examined, the spread is 0.026 points or less. In economic terms, this result implies that, in one-half of the options examined, the range of estimates on expected variation of future returns was less than three basis points.

The last column of table 2 reports the *ex post* profit that could have been obtained — in the absence of transaction costs and taxes — if the individual option had been held until expiration. That is, the dollar figures listed show the change in the value of the option between the observation date and the last day it was traded. As the data indicate, options purchased on a particular day and held until expiration all tended to produce profits or losses, regardless of strike prices. In other words, no apparent *systematic* relationship between realized profits and certain characteristics of these options is revealed by the profit data in the table. The point with respect to judging market efficiency is that nothing in available market data indicate, *ex ante*, that these options would perform as they did. That is, none of the results in table 2 indicates a consistent *ex ante* signal for profit opportunities, a result consistent with an efficient market.

Testing the Model with Direct Estimates of σ^2

Another way to test the Black model might be to use historical price data to construct a proxy for the expected future variance of returns on the futures contract.[19] Given this estimate of σ^2 and using the Treasury bill rate to proxy the risk-free rate, we can obtain an implied value of a call option. If the Black model "predictions" represent the "efficient prices," an investor should buy those options that the model implies are underpriced and sell options that the model implies are overpriced. The results of this test are reported in table 3.

These results do not yield any consistent arbitragable profit opportunities. There is no apparent pattern either to the implied value of σ^2 or to the differences between the actual and implied call prices that, *ex ante*, would indicate profitable options. If an investor had bought *any* of the options in our sample on January 26, 1983, or any December 1982 call options on October 26, 1982, he would have earned a profit on the change in option prices. Likewise, anyone who bought March 1983 or June 1983 call options on November 23,

[17]The dates, which were not randomly chosen, are: October 26, November 23 and December 27, 1982; January 26, February 23 and April 4, 1983.

[18]The same risk-free hedge over different periods (using different futures contracts), may imply a different risk-free interest rate if the term structure of interest rates is not flat. That is, given a "normal" yield curve, the implied risk-free interest rate over a period of three months (the remaining duration of one option contract), should be less than the implied risk-free interest rate over a period of six months (the remaining duration of another option on a different futures contract), observed on the same day. Three-month and six-month Treasury bill rates were used to proxy the risk-free rate, depending on the remaining length of the option contract.

[19]Historical values for σ^2 were determined by estimating the variance of the log of the ratio of successive days futures contract prices, up to the date at which a particular observation was taken; this variance, when multiplied by 365, approximates an annualized rate of return.

Table 2
Estimating Sigma, Given the Risk-Free Rate

Trading date	Futures contract delivery date	Strike price (thousands of dollars)	Futures price (thousands of dollars)	Sigma value	Estimated Ex post profit
10/26/82	12/82	70	75.25	0.255	$2140.63
10/26/82	12/82	72	75.25	0.233	2375.00
10/26/82	12/82	74	75.25	0.265	1921.88
10/26/82	12/82	76	75.25	0.239	1890.63
10/26/82	12/82	78	75.25	0.244	1531.25
10/26/82	12/82	80	75.25	0.245	1140.63
10/26/82	3/83	76	74.56	0.249	−2671.90
11/23/82	3/83	74	76.75	0.200	−2312.50
11/23/82	3/83	76	76.75	0.285	−3750.00
11/23/82	3/83	78	76.75	0.277	−2828.10
11/23/82	3/83	80	76.75	0.289	−2218.80
12/27/82	3/83	70	77.13	0.207	−1546.90
12/27/82	3/83	72	77.13	0.203	−1734.40
12/27/82	3/83	74	77.13	0.202	−2171.90
12/27/82	3/83	76	77.13	0.193	−2359.40
12/27/82	3/83	78	77.13	0.191	−1453.10
12/27/82	3/83	80	77.13	0.189	−765.63
12/27/82	6/83	68	76.41	0.201	−453.13
12/27/82	6/83	70	76.41	0.199	−1531.30
12/27/82	6/83	72	76.41	0.196	−1937.50
12/27/82	6/83	74	76.41	0.205	−2125.00
12/27/82	6/83	76	76.41	0.192	−1906.30
12/27/82	6/83	78	76.41	0.192	−1687.50
12/27/82	6/83	80	76.41	0.186	−1234.40
1/26/83	3/83	68	73.75	0.107	1921.88
1/26/83	3/83	70	73.75	0.074	1890.63
1/26/83	3/83	72	73.75	0.063	1671.88
1/26/83	3/83	74	73.75	0.062	875.00
1/26/83	6/83	68	73.03	0.130	3078.13
1/26/83	6/83	70	73.03	0.149	1781.25
1/26/83	6/83	72	73.03	0.149	1156.25
1/26/83	6/83	74	73.03	0.154	718.75
1/26/83	6/83	76	73.03	0.158	281.25
1/26/83	6/83	78	73.03	0.166	0.00
2/26/83	6/83	68	75.59	0.206	484.38
2/26/83	6/83	70	75.59	0.179	−343.75
2/26/83	6/83	72	75.59	0.154	−437.50
2/26/83	6/83	74	75.59	0.152	−359.38
2/26/83	6/83	76	75.59	0.146	−296.88
2/26/83	6/83	78	75.59	0.141	−171.88
2/26/83	9/83	76	74.97	0.150	−2296.90
2/26/83	9/83	78	74.97	0.144	−1468.80
2/26/83	9/83	80	74.97	0.158	−968.75
4/04/83	6/83	68	76.22	0.252	15.63
4/04/83	6/83	70	76.22	0.192	−687.50
4/04/83	6/83	72	76.22	0.158	−640.63
4/04/83	6/83	74	76.22	0.148	−234.38
4/04/83	6/83	76	76.22	0.142	46.88
4/04/83	9/83	70	75.72	0.138	−5078.10
4/04/83	9/83	72	75.72	0.131	−4328.10
4/04/83	9/83	74	75.72	0.126	−2953.10
4/04/83	9/83	76	75.72	0.134	−2031.30
4/04/83	9/83	78	75.72	0.131	−1218.80

Table 3

Implied Call Prices, Using Historical Sigma

Trading date	Futures contract delivery date	Strike price (thousands of dollars)	Futures price (thousands of dollars)	Treasury bill rate	Ex post profit
10/26/82	12/82	70	75.25	0.0796	$2140.63
10/26/82	12/82	72	75.25	0.0796	2375.00
10/26/82	12/82	74	75.25	0.0796	1921.88
10/26/82	12/82	76	75.25	0.0796	1890.63
10/26/82	12/82	78	75.25	0.0796	1531.25
10/26/82	12/82	80	75.25	0.0796	1140.63
10/26/82	3/83	76	74.56	0.0847	−2671.90
11/23/82	3/83	74	76.75	0.0795	−2312.50
11/23/82	3/83	76	76.75	0.0795	−3750.00
11/23/82	3/83	78	76.75	0.0795	−2828.10
11/23/82	3/83	80	76.75	0.0795	−2218.80
12/27/82	3/83	70	77.13	0.0791	−1546.90
12/27/82	3/83	72	77.13	0.0791	−1734.40
12/27/82	3/83	74	77.13	0.0791	−2171.90
12/27/82	3/83	76	77.13	0.0791	−2359.40
12/27/82	3/83	78	77.13	0.0791	−1453.10
12/27/82	3/83	80	77.13	0.0791	−765.63
12/27/82	6/83	68	76.41	0.0810	−453.13
12/27/82	6/83	70	76.41	0.0810	−1531.30
12/27/82	6/83	72	76.41	0.0810	−1937.50
12/27/82	6/83	74	76.41	0.0810	−2125.00
12/27/82	6/83	76	76.41	0.0810	−1906.30
12/27/82	6/83	78	76.41	0.0810	−1687.50
12/27/82	6/83	80	76.41	0.0810	−1234.40
1/26/83	3/83	68	73.75	0.0808	1921.88
1/26/83	3/83	70	73.75	0.0808	1890.63
1/26/83	3/83	72	73.75	0.0808	1671.88
1/26/83	3/83	74	73.75	0.0808	875.00
1/26/83	6/83	68	73.03	0.0795	3078.13
1/26/83	6/83	70	73.03	0.0795	1781.25
1/26/83	6/83	72	73.03	0.0795	1156.25
1/26/83	6/83	74	73.03	0.0795	718.75
1/26/83	6/83	76	73.03	0.0795	281.25
1/26/83	6/83	78	73.03	0.0795	0.00
2/26/83	6/83	68	75.59	0.0796	484.38
2/26/83	6/83	70	75.59	0.0796	−343.75
2/26/83	6/83	72	75.59	0.0796	−437.50
2/26/83	6/83	74	75.59	0.0796	−359.38
2/26/83	6/83	76	75.59	0.0796	−296.88
2/26/83	6/83	78	75.59	0.0796	−171.88
2/26/83	9/83	76	74.97	0.0797	−2296.90
2/26/83	9/83	78	74.97	0.0797	−1468.80
2/26/83	9/83	80	74.97	0.0797	−968.75
4/04/83	6/83	68	76.22	0.0864	15.63
4/04/83	6/83	70	76.22	0.0864	−687.50
4/04/83	6/83	72	76.22	0.0864	−640.63
4/04/83	6/83	74	76.22	0.0864	−234.38
4/04/83	6/83	76	76.22	0.0864	46.88
4/04/83	9/83	70	75.72	0.0871	−5078.10
4/04/83	9/83	72	75.72	0.0871	−4328.10
4/04/83	9/83	74	75.72	0.0871	−2953.10
4/04/83	9/83	76	75.72	0.0871	−2031.30
4/04/83	9/83	78	75.72	0.0871	−1218.80

1982, or December 27, 1982, or any September 1983 call options on February 23, 1983, or April 4, 1983, would have incurred losses. Some options that the model implied were underpriced eventually rose in price; others, however, declined further. Similarly, higher variance of expected returns is associated with both profitable and non-profitable options; relatively lower estimates of σ^2 yielded the same mixed results.

Additional evidence of market efficiency is shown by the absence of any consistent relationship between strike price and profit or loss. Profits are sometimes negatively associated with strike prices (for example, June 1983 options on January 26, 1983), while on other occasions losses are negatively associated with strike prices (September 1983 options on April 4, 1983). Thus, generally no predictable *ex ante* pattern between strike prices and profits can be identified.

CONCLUSIONS

The trading of options on commodity futures has been permitted only recently in the United States. Because the success and future of the CFTC's pilot program in options trading will depend, in part, on judgments about pricing efficiency, it is of interest to compare actual prices with those of a model whose fundamental assumption is that option pricing *is* efficient. In those instances where the Black model estimates of option prices differed from observed market values, we were unable to find consistent arbitragable profit opportunities. Thus, we were unable to reject the assumption that Treasury bond option prices are "efficient" in the fundamental economic sense.

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Employment Trends in St. Louis: 1954–82

G. J. Santoni

DURING the last few years, economic activity has been depressed in both St. Louis and at the national level.[1] Some observers have argued that St. Louis' economy was particularly sluggish during the recent recession and is recovering at a rate that is lagging behind the national recovery.[2]

The relatively poor economic performance of the St. Louis metropolitan area is alleged to have had important consequences for local employment opportunities. Since it is generally thought that the area's depressed economy was due to the slump in automobile production, many commentators are pinning their projections for a recovery in the labor market on the current expansion in the area's auto industry.[3] Others have argued that the longer-term prospects for the labor market in the St. Louis metropolitan area depend upon more fundamental forces than those capricious circumstances that have buffeted the U.S. auto industry in recent years.[4]

This article will describe the current employment mix in the St. Louis labor market, compare the longer-run growth in employment opportunities in St. Louis to other similarly sized metropolitan areas and the nation, and assess the recent past in terms of this longer-run view.

THE 1982 EMPLOYMENT PICTURE IN ST. LOUIS

Chart 1 presents the 1982 percentage distribution of employment by industrial sector in the St. Louis Standard Metropolitan Statistical Area (SMSA).[5] For comparison, a similar distribution for the United States is also given.

The data in chart 1 suggest that the distributions of employment in St. Louis and in the United States in 1982 were quite similar. In both areas, nonmanufacturing employment amounted to about 80 percent of total nonagricultural employment, and manufacturing employment accounted for about 20

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[1]The St. Louis area is defined to be the St. Louis Standard Metropolitan Statistical Area (SMSA), which includes St. Louis City; Franklin, Jefferson, St. Charles and St. Louis counties in Missouri; and Clinton, Madison, Monroe and St. Clair counties in Illinois.

[2]See *St. Louis Post-Dispatch* (September 13, 1983). For an exception to this view regarding St. Louis' relatively slow recovery, see Wagman (1983).

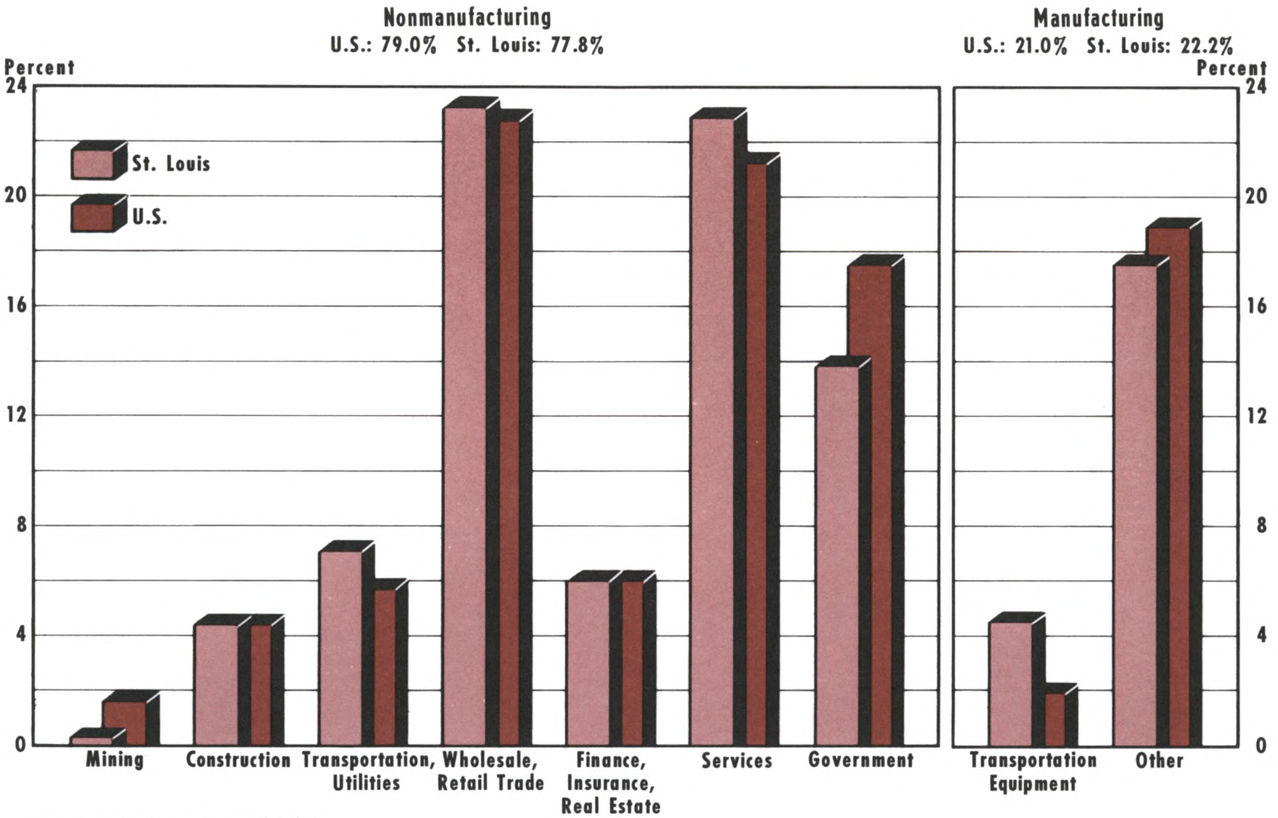
[3]*St. Louis Post-Dispatch* (September 20, 1983); *St. Louis Globe-Democrat* (August 17, 1983); and *St. Louis Globe-Democrat* (September 19, 1983).

[4]See Gilbert (1973); Kester (1983).

[5]The numbers are obtained by dividing employment in each sector by total nonagricultural employment and multiplying by 100.

Chart 1

Percentage Distribution of Employment in 1982: St. Louis and U.S. [1]



Source: U.S. Department of Labor

[1] As a percent of Total Nonagricultural Employment.

percent. Much of the St. Louis work force (about 45 percent) was employed in wholesale/retail trade and services. The same was true at the national level.

Two differences seem to stand out in chart 1: employment in government and in transportation equipment. Since government employment by geographic sector is related to whether the national capital, state capital or county seat falls within that sector, we might expect government employment in the St. Louis SMSA to be less than it is at the national level.

Employment in transportation equipment amounted to 4.6 percent of total nonagricultural employment in the St. Louis SMSA and only 2 percent at the national level. This industry includes motor vehicle, aircraft, ship and boat, and railroad equipment manufacturing.

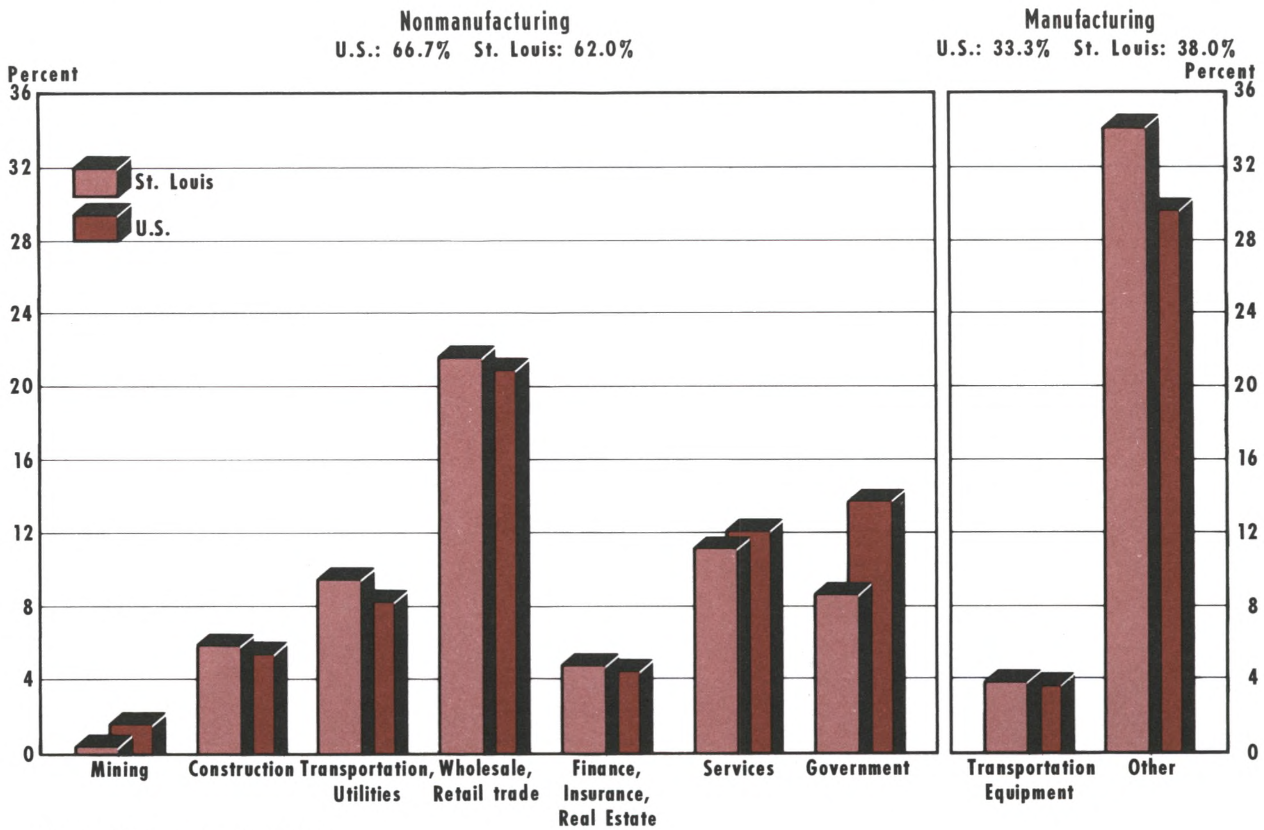
St. Louis employment in motor vehicle manufacturing, a subcategory of transportation equipment, amounted to about 1 percent of total nonagricultural employment in 1982. At its peak in 1978, St. Louis employment in motor vehicle manufacturing accounted for slightly more than 2.6 percent of total nonagricultural employment. Consequently, although events in the automobile industry may have a larger effect on the local economy than they do on the national economy, the percentage impact on employment locally would appear to be fairly small.

HAS MUCH CHANGED OVER THE PAST 28 YEARS?

Chart 2 presents the 1954 percentage distribution of employment by sector for St. Louis and the nation. A comparison of charts 1 and 2 reveals several interesting differences. First, there has been a shift in employment from manufacturing to nonmanufacturing sectors in both St. Louis and the nation. In St. Louis, manufacturing employment accounted for 38 percent of total nonagricultural employment in 1954, but only 22 percent in 1982. A similar shift occurred at the national level. In this case, manufacturing employment amounted to about 33 percent of total nonagricultural employment in 1954, but only 21 percent in 1982.

Chart 2

Percentage Distribution of Employment in 1954: St. Louis and U.S. [1]



Source: U.S. Department of Labor

[1] As a percent of Total Nonagricultural Employment.

Note also that, in 1954, a greater proportion of St. Louisans were employed in manufacturing when compared with the national employment mix: 38 percent for St. Louis and 33 percent for the nation. By 1982, however, the proportion of St. Louisans employed in manufacturing had fallen to about the national average.[6]

The reduced concentration of employment in the manufacturing industries has been offset by increased employment in government and service industries. In the St. Louis area, the proportion of individuals employed in manufacturing fell by 15.8 percentage points between 1954 and 1982 (from 38.0 to 22.2 percent), while the proportion of people employed in government and service industries increased by 16.9 percentage points.

Though somewhat smaller in magnitude, a similar shift occurred at the national level over this period. As noted earlier, the resulting 1982 employment mix in the St. Louis area was roughly the same as the nation's.

An exception to this general decline in manufacturing employment in the St. Louis area was employment in transportation equipment manufacturing. This grew from 3.9 percent of St. Louis nonagricultural employment in 1954 to 4.6 percent in 1982; at the national level, however, it fell from 3.7 percent in 1954 to 2.0 percent in 1982.

LONGER-TERM EMPLOYMENT GROWTH IN ST. LOUIS RELATIVE TO THE UNITED STATES

While the current employment mix in St. Louis is about the same as the national mix, the growth rate in local employment has been substantially below that of

[6]There is some ambiguity in these numbers. The definition of the St. Louis SMSA was changed a number of times between 1954 and 1982. The relative decline in manufacturing employment may have been solely due to this redefinition.

Table 1

Average Annual Growth Rates in Employment from 1955 to 1982: St. Louis SMSA and United States

	Average Annual Growth Rates: 1955–82			
	St. Louis SMSA	U.S.	Difference[2]	t-statistic
Nonmanufacturing:	1.95%	2.91%	−0.96	3.04*
Mining	−0.95	1.88	−2.83	2.05*
Construction	0.43	1.62	−1.18	0.92
Transportation and Utilities	0.17	1.09	−0.92	2.89*
Wholesale and Retail Trade	1.59	2.63	−1.04	4.17*
Finance, Insurance and Real Estate	2.04	3.24	−1.19	5.01*
Services	3.45	4.29	−0.84	4.33*
Government	2.43	3.02	−0.59	1.69
Manufacturing:	−0.71	0.81	−1.53	6.00*
Transportation Equipment	1.39	0.36	1.03	0.70
Total Nonagricultural Employment	1.18	2.36	−1.18	7.24*

*Significantly different from zero at the 5 percent level.

[1]The years 1958 and 1963 are excluded in calculating the mean growth rates to control for changes in the definition of the St. Louis SMSA in these years.

[2]For statistical purposes, the difference is the average of the paired differences between St. Louis and U.S. growth rates at each point in time. As a result of rounding, the numbers in this column may not correspond exactly to the differences between the average growth rates in the first two columns.

[3]U.S. Department of Labor, Bureau of Labor Statistics, *Report on Employment.*

[4]U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings, United States, 1909–78.*

the nation. Table 1 presents the average annual growth rates in nonagricultural employment by industrial sector for the period 1955–82 for St. Louis and the nation. The annual growth rate in total nonagricultural employment for St. Louis was 1.18 percent; nationally, total nonagricultural employment grew at an annual rate of 2.36 percent. The difference, −1.18 percent, is statistically significant, which means that the observed slower growth for St. Louis is unlikely to be simply an artifact produced by chance variation in the data.

Further, significantly slower growth in St. Louis employment is common to both the manufacturing and nonmanufacturing sectors. Moreover, the slower growth in nonmanufacturing employment is not concentrated in any particular category but seems to be a fairly general phenomenon. The differences between local and national growth rates are statistically insignificant only for construction and government.

Interestingly, the difference between the local and national employment growth rates in the transportation equipment industry is statistically insignificant; the reported difference could have occurred by "chance" or measurement problems even though the actual growth rates were identical. Thus, despite recent events in the auto industry, the transportation equipment industry does not appear to have contributed to the generally slower long-run growth rate.

WAS THERE A CHANGE IN EMPLOYMENT TRENDS IN THE LATE 1960s?

Since some observers have claimed that St. Louis' employment problems became particularly severe beginning in the mid-1960s, tables 2 and 3 split the 1954–82 period in half at 1968.[7] By doing so, we can examine the growth rates in total nonagricultural employment during the two subperiods. Table 2 considers the earlier period, 1955–68, and table 3 considers the more

[7]See R. Alton Gilbert, "Employment Growth in St. Louis," pp. 9–15.

Table 2

Growth Rates in Total Nonagricultural Employment from 1955 to 1968: St. Louis SMSA and United States

Year	St. Louis SMSA[1]	U.S.[2]	Difference
1955	2.41%	3.31%	−0.90
56	1.51	3.36	−1.85
57	−0.45	0.92	−1.37
58[3]	−1.28	−2.94	1.66
59	1.95	3.72	−1.77
60	0.94	1.71	−0.77
61	−2.36	−0.35	−2.01
62	0.87	2.83	−1.96
63[3]	4.31	1.97	2.34
64	3.18	2.84	0.34
65	3.92	4.17	−0.25
66	5.36	5.03	0.33
67	2.22	2.93	−0.71
68	1.69	3.13	−1.44
Mean	1.77[3]	2.80[3]	−1.03[3]
t-statistic	3.08*	6.69*	4.25*

*Significantly different from zero at the 5 percent level.

[1]U.S. Department of Labor, Bureau of Labor Statistics, *Report on Employment.*

[2]U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings, United States, 1909–78.*

[3]Data for 1958 and 1963 are excluded in calculating the mean to control for changes in the definition of the St. Louis SMSA in these years.

Table 3

Growth Rates in Total Nonagricultural Employment from 1969 to 1982: St. Louis SMSA and United States

Year	St. Louis SMSA[1]	U.S.[2]	Difference
1969	2.19%	3.60%	−1.41
70	−0.63	0.68	−1.31
71	−1.20	0.42	−1.62
72	0.27	3.47	−3.20**
73	2.76	4.14	−1.38
74	0.66	1.90	−1.24
75	−2.50	−1.70	−0.80
76	2.14	3.12	−0.98
77	3.34	3.82	−0.48
78	4.35	5.00	−0.65
79	2.52	3.54	−1.02
80	−2.26	0.65	−2.91
81	−0.15	0.83	−0.98
82	−2.13	−1.73	−0.40
Mean	0.67	1.98	−1.31
t-statistic	1.11	3.45*	5.98*

*Significantly different from zero at the 5 percent level.

**Lies outside the 95 percent confidence interval which equals −1.31 ± 1.76.

[1]U.S. Department of Labor, Bureau of Labor Statistics, *Report on Employment.*

[2]U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings, United States, 1909–78,* and *July 1983 supplement.*

recent period, 1969–82.[8]

Before making this comparison, it is important to note that Jefferson County was added to the St. Louis SMSA in 1958 and Franklin County was added in 1963. Notice that the difference between the growth rates in St. Louis and U.S. employment is positive and large in these two years (see table 2). These observations are excluded from the analysis because including them would bias upward the growth rates for St. Louis in these two years. Excluding the data for 1958 and 1963, the results in table 2 show a statistically significant difference of −1.03 percent per year between the growth of total nonagricultural employment in the nation and that for St. Louis. Thus, over this 14-year period, employment growth in St. Louis was substantially slower than that in the rest of the nation.

The data in table 3 indicate that the slower growth that characterized St. Louis employment during the 1955–68 period has persisted over the more recent period. The second column indicates that the average annual growth rate in total nonagricultural employment for St. Louis, .67 percent, is statistically indistinguishable from zero over this period. Employment growth at the national level, however, is significantly positive. Just as in the earlier period, more recent employment growth in St. Louis was substantially slower than that for the nation as a whole.

Further, the average difference between the local and national annual growth rates during the 1969–82 subperiod, −1.31 percent, is statistically indistinguishable from the earlier difference shown in table 2.[9] The data in tables 2 and 3 appear to indicate that there has been no substantive change in the differentially slower

[8]The period begins in 1955 rather than in 1954 because 1954 is our first observation of total employment and this observation is used in calculating the 1955 growth rate.

[9]t-statistic = .85.

employment growth in St. Louis between the two subperiods.[10]

ARE RECESSIONS PARTICULARLY SEVERE IN ST. LOUIS?

The data in table 3 are also useful in analyzing whether employment in the St. Louis area was particularly hard hit during the recent recession when compared with the rest of the nation. The past recession began in the third quarter of 1981 and ended in the fourth quarter of 1982. The data in table 3 indicate that St. Louis employment growth was below the national average in 1981 and 1982, *but* the differences do not appear to be "unusual." As the previous analysis has pointed out, average employment growth locally has been below the national average since 1955. The difference between local and national growth rates was unusual (in the sense that the difference exceeded a 95 percent confidence interval) only in 1972. Consequently, the recent recession does not seem to have singled out St. Louis, at least in terms of employment growth.

In fact, recessions generally have not had a differentially severe impact on the local labor market. Recessions occurred in 1970, 1974, 1980, and from the third quarter of 1981 through the fourth quarter of 1982. St. Louis employment growth has not slowed unusually relative to the national average during any of these recessions.

Further, the slow growth in St. Louis employment was not unusually aggravated during the years of substantial reductions in the work forces of the various auto manufacturing plants located in the St. Louis SMSA. The work forces of these plants fell from a 1978 peak of about 27,000 workers to about 9,000 in 1982. Yet the growth rate in St. Louis employment was not unusually depressed relative to the national average in any of these years.

This evidence suggests that the problem of relatively slow employment growth in St. Louis is neither the result of problems confronting domestic auto manufacturers in recent years nor the result of differential effects of business cycles on the St. Louis labor market. Instead, the slower growth in St. Louis employment when compared with overall employment growth in the nation is a phenomenon that has been fairly constant over the past 28 years.

Table 4

Growth Rates in Total Nonagricultural Employment from 1969 to 1982: St. Louis SMSA Vs. Average of Comparable SMSAs[1]

Year	St. Louis SMSA[2]	Four SMSAs[2]	Difference
1969	2.19%	2.28%	−0.09
70	−0.63	−0.83	0.20
71	−1.20	−1.55	0.35
72	0.27	0.84	−0.57
73	2.76	2.76	0.00
74	0.66	1.71	−1.05
75	−2.50	−2.95	0.45
76	2.14	0.89	1.25
77	3.34	1.78	1.56
78	4.35	3.55	0.80
79	2.52	2.81	−0.29
80	−2.26	0.00	−2.26
81	−0.15	−2.11	1.96
82	−2.13	−3.55	1.42
Mean	0.67	0.40	0.27
t-statistic	1.11	0.66	0.89

*Significantly different from zero at the 5 percent level.
[1]The four SMSAs are Baltimore, Chicago, Cleveland and Pittsburgh.
[2]U.S. Department of Labor, Bureau of Labor Statistics, *Employment and Earnings, States and Areas 1939–78*, and *1977–80 supplement.*

IS THE EMPLOYMENT SITUATION IN ST. LOUIS UNIQUE?

Although the growth rate in St. Louis employment has been substantially lower than the national growth rate, it is not necessarily lower than employment growth rates in similar metropolitan areas. Table 4 presents the annual growth rates of total nonagricultural employment for St. Louis and the average of four other comparably sized and geographically located SMSAs for the past 14 years. These comparable SMSAs are Baltimore, Chicago, Cleveland and Pittsburgh.[11]

As the last column of the table indicates, the growth rate of employment in St. Louis fluctuates around the

[10]Clinton and Monroe counties in Illinois were added to the St. Louis SMSA in 1970. Due to their relatively small size, however, they do not appear to have significantly distorted the estimated growth rate for 1970.

[11]The selection was restricted to cities located outside the Sun Belt and of roughly the same size as St. Louis in 1982.

average employment growth for the four other SMSAs. On average, however, it does not differ significantly from their average growth rates. St. Louis' relatively slow rate of growth in nonagricultural employment, when compared with employment growth in the nation, is not unique; it is shared by other comparable SMSAs.

CONCLUSIONS

The mix of nonagricultural employment has changed both in the St. Louis SMSA and at the national level since 1954. Employment in manufacturing industries has declined in relative importance while employment by government and in the service industries has increased. Concentration of employment in manufacturing industries was relatively high in the St. Louis area in 1954 but has declined to about the national average. A notable exception is transportation equipment manufacturing. While the percentage of individuals employed in this industry had declined at the national level since 1954, it has increased in St. Louis.

The average rate of employment growth in St. Louis has consistently been lower than the national average since 1954. Once this lower average growth rate is taken into account, it does not appear that recessions have a differentially severe effect on the St. Louis labor market. Finally, relatively slow growth in employment is not unique to St. Louis; other comparable SMSAs display the same pattern.

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