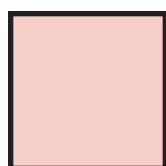
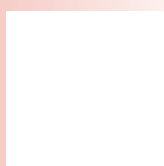


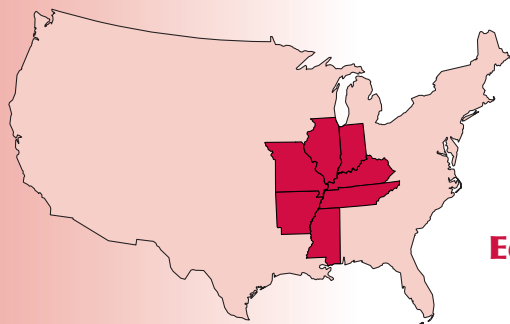
Federal Reserve Bank of St. Louis

REGIONAL ECONOMIC DEVELOPMENT

VOLUME 3, NUMBER 2 2007



**Selected Papers from the Third Annual Conference of the
Business & Economics Research Group (BERG)**



**Forecasting Real Housing Price Growth
in the Eighth District States**

David E. Rapach and Jack K. Strauss

**Educational Attainment and Recovery from Recessions
Across Metropolitan Areas**

Bryan Bezold

**Transferable Tax Credits in Missouri:
An Analytical Review**

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**How Well Are the States of the Eighth
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**The Economic Impact of
Broadband Deployment in Kentucky**

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Editor's Introduction

Thomas A. Garrett

The Center for Regional Economics—8th District (CRE8) at the Federal Reserve Bank of St. Louis sponsored the third annual conference of the Business and Economics Research Group (BERG) in St. Louis in June 2007. Researchers from university economics departments and centers for business and economic research located within the Eighth Federal Reserve District presented a wide variety of papers on economic issues relevant to District states.¹

This issue of *Regional Economic Development* contains five papers from the third annual BERG conference. David Rapach and Jack Strauss of Saint Louis University forecast real housing price growth for Eighth Federal Reserve District states using an autoregressive distributive lag model. Bryan Bezold of the St. Louis Regional Chamber and Growth Association explores the relationship between educational attainment in metropolitan

areas and the speed at which metropolitan areas recover from recessions. Paul Rothstein and Nathan Wineinger from Washington University in St. Louis provide an analysis of Missouri's tax credit programs and whether the design of each program is consistent with its intended economic purpose. Gary Wagner and Erick Elder from the University of Arkansas at Little Rock use a Markov-switching regression model to describe economic expansions and contractions in Eighth Federal Reserve District states and to forecast the probability that each state's revenue balance will not be adequate to weather a recession. David Shideler and Narine Badasyan of Murray State University and Laura Taylor from Connected Nation, Inc., use county-level data for the state of Kentucky to assess whether broadband infrastructure influences the industrial competitive of Kentucky's counties.

¹ The third annual BERG conference agenda, along with BERG members and past events, can be found at <http://research.stlouisfed.org/berg/>.

Thomas A. Garrett is an assistant vice president and economist at the Federal Reserve Bank of St. Louis.

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Forecasting Real Housing Price Growth in the Eighth District States

David E. Rapach and Jack K. Strauss

The authors consider forecasting real housing price growth for the individual states of the Federal Reserve's Eighth District. They first analyze the forecasting ability of a large number of potential predictors of state real housing price growth using an autoregressive distributed lag (ARDL) model framework. A number of variables, including the state housing price-to-income ratio, state unemployment rate, and national inflation rate, appear to provide information that is useful for forecasting real housing price growth in many Eighth District states. Given that it is typically difficult to determine a priori the particular variable or small set of variables that are the most relevant for forecasting real housing price growth for a given state and time period, the authors also consider various methods for combining the individual ARDL model forecasts. They find that combination forecasts are quite helpful in generating accurate forecasts of real housing price growth in the individual Eighth District states. (JEL C22, C53, E37)

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The rollercoaster ride of the housing market continues to receive considerable attention in the popular and financial press. There is currently speculation of a precipitous drop in housing prices in certain regions of the country after the sharp rise in housing prices ("bubble"?) over the past decade. Policymakers are keenly interested in housing price fluctuations and their potential impact on household consumption spending, as evinced by numerous comments by former Federal Reserve Chairman Alan Greenspan and current Chairman Ben Bernanke. This interest appears warranted: The median household now holds more of its wealth in housing than in stocks and has greater access to cash through refinancing backed by housing wealth (Greenspan and Kennedy, 2005).

Given the substantial interest in housing price fluctuations, the present paper investigates fore-

casts of real housing price growth in the individual states of the Federal Reserve's Eighth District (Arkansas, Illinois, Indiana, Kentucky, Missouri, Mississippi, and Tennessee). We focus on forecast horizons of four and eight quarters because these horizons are relevant to forecasting over the business cycle, and most recent discussions of housing price fluctuations focus on possible swings in housing prices over business-cycle horizons.¹ We consider a large number of potential predictors (25) of real housing price growth for each state. This is motivated by a sizable literature that examines the determinants of housing prices using in-sample

¹ The literature on forecasting housing prices in the United States at the aggregate or state level is relatively sparse, especially compared with the massive literature on forecasting economic variables such as U.S. gross domestic product (GDP) and inflation. The extant literature on forecasting housing prices in the United States tends to focus on long-run trends (Hendershott and Weicher, 2002).

David E. Rapach is an associate professor of economics and Jack K. Strauss is the Simon Professor of Economics at Saint Louis University. The authors acknowledge financial support from the Simon Center for Regional Forecasting at Saint Louis University. The authors thank participants at the 2007 Eighth District Business and Economics Research Group (BERG) conference and a referee for very helpful comments. The results reported in this paper were generated using GAUSS 6.0; the GAUSS programs are available at <http://pages.slu.edu/faculty/rapachde/Research.htm>.

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tests; see, for example, Cho (1996), Abraham and Hendershott (1996), and Johnes and Hyclak (1999). Potential determinants of housing prices in this literature include income, interest rates, construction costs, and labor market variables such as the unemployment rate and size of the labor force.²

Following Stock and Watson (1999, 2003, and 2004), we generate simulated out-of-sample forecasts of real housing price growth using an autoregressive distributed lag (ARDL) model framework. More specifically, when forecasting real housing price growth for a given Eighth District state, we estimate 25 individual ARDL forecasting models of real housing price growth, where each ARDL model includes one of the potential predictors. This provides a convenient framework for analyzing the forecasting ability of each of the individual potential predictors of real housing price growth.

The plethora of potential predictors of real housing price growth also leads us to consider combination forecasts. Typically, it is difficult to identify a priori the particular variable (or small set of variables) that is most relevant for forecasting a variable such as real housing price growth, especially because the predictive ability of individual variables can vary markedly over time.³ Combination forecasts provide a way of incorporating information that may be useful for forecasting in environments with a large number of potential predictors, and they have been shown to work well in a number of recent forecasting applications involving GDP growth, inflation, and employment growth; see, for example, Stock and Watson (1999, 2003, and 2004) and Rapach and Strauss (2005 and 2007). We consider a number of different methods for combining the individual ARDL model forecasts from the extant literature and investigate their ability to help generate reliable forecasts of

real housing price growth in the Eighth District states.⁴

Previewing our results, we find that a number of the individual predictors are able to improve on forecasts of real housing price growth relative to an autoregressive (AR) benchmark model, sometimes substantially. These variables include the housing price-to-income ratio, state unemployment rate, and national inflation rate. However, there is no single variable that is able to improve on the AR model forecasts across all of the Eighth District states at all of the forecast horizons considered, and there are instances where a variable that performs very well for one particular state performs poorly for another. Fortunately, we also find that some of the forecast combining methods perform quite well and almost always provide sizable improvements in forecast accuracy relative to the AR benchmark model.

The rest of the paper is organized as follows: The next section outlines the econometric methodology, and the third section presents the empirical results.

ECONOMETRIC METHODOLOGY

Let $\Delta y_t = y_t - y_{t-1}$, where y_t is the log level of real housing prices at time t . Furthermore, let

$$y_{t+h}^h = (1/h) \sum_{j=1}^h \Delta y_{t+j},$$

so that y_{t+h}^h is the (approximate) growth rate of real housing prices from time t to $t+h$; h is the forecast horizon. Let $x_{i,t}$ ($i = 1, \dots, n$) represent one of n potential predictors of real housing price growth. An individual ARDL model based on the predictor $x_{i,t}$ is given by

$$(1) \quad y_{t+h}^h = \alpha + \sum_{j=0}^{q_1-1} \beta_j \Delta y_{t-j} + \sum_{j=0}^{q_2-1} \gamma_j x_{i,t-j} + \varepsilon_{t+h}^h,$$

where ε_{t+h}^h is an error term. Equation (1) can be used to construct a set of recursive (expanding estimation window) simulated out-of-sample forecasts of y_{t+h}^h using information available at time t ,

² We focus on real housing price growth at the state level in this paper primarily because it allows us to examine regional differences in housing price fluctuations while still having a fairly large number of potential predictors available at the state level. Although state-level housing prices are able to capture some important geographic differences in housing price fluctuations, as we mention in the conclusion, we are also planning to investigate forecasts of real housing price growth for individual metropolitan areas in the Eighth District in future research.

³ See Stock and Watson (2003) for evidence of this in the context of forecasting U.S. GDP growth and inflation.

⁴ See Timmermann (2006) for a recent survey of forecast combining methods.

and we denote the forecast of y_{t+h}^h formed at time t for a given predictor $x_{i,t}$ by $\hat{y}_{i,t+h|t}^h$. More specifically, $\hat{y}_{i,t+h|t}^h$ is calculated by plugging Δy_{t-j} ($j = 0, \dots, q_1 - 1$) and $x_{i,t-j}$ ($j = 0, \dots, q_2 - 1$) into (1), with the α , β_j , and γ_j parameters set equal to their ordinary least squares (OLS) estimates based on data available from the start of the sample through period t and ε_{t+h}^h set to its expected value of zero. We select the lag lengths (q_1 and q_2) in (1) using the Schwarz information criterion (SIC) and a minimum value of zero for q_1 and one for q_2 (to ensure that the potential predictor $x_{i,t}$ appears in (2)) and a maximum value of four for q_1 and q_2 .⁵ Dividing the total sample into in-sample and out-of-sample portions of size R and P , respectively, we use this procedure to generate a series of $P - (h - 1)$ recursive simulated out-of-sample forecasts for the ARDL model that includes $x_{i,t}$, which we denote as

$$\left\{ \hat{y}_{i,t+h|t}^h \right\}_{t=R}^{T-h}.^6$$

Note that the lag lengths q_1 and q_2 are selected anew when forming each out-of-sample forecast, so that the lag lengths for the ARDL forecasting model are allowed to vary through time. In our applications in the next section, we consider 25 potential predictors, and so we will have 25 series of h -step-ahead individual ARDL model forecasts of real housing price growth for each of the seven states in the Eighth District.

We also compute recursive simulated out-of-sample forecasts for an AR model, which is given by (1) with the restriction $\gamma_j = 0$ ($j = 0, \dots, q_2 - 1$) imposed. The series of out-of-sample forecasts are generated using a procedure analogous to that for the ARDL forecasting model described above.⁷ Following much of the forecasting literature, the

AR model serves as a benchmark forecasting model.

We consider three types of methods for combining the individual ARDL model forecasts. Some of the combining methods require a holdout period to calculate the weights ($\{w_{i,t}\}_{i=1}^n$) used to combine the individual ARDL model forecasts, and we use the first P_0 observations from the out-of-sample period as the initial holdout period. This leaves us with a total of $P - (h - 1) - P_0$ out-of-sample forecasts available for evaluation.⁸ In our applications in the next section, we evaluate the benchmark AR model, individual ARDL model, and combination forecasts over the 1995:Q1–2006:Q4 out-of-sample period. Importantly, this period includes the bull housing market that has prevailed in many parts of the country over the past decade.

The first type of combining method uses simple schemes: mean, median, and trimmed mean. The mean (median) combination forecast is simply the average (median) of the individual ARDL model forecasts, while the trimmed mean combination forecast takes the average of the individual ARDL model forecasts after dropping the highest and lowest individual ARDL model forecasts. Stock and Watson (1999 and 2003) find that simple combinations of individual ARDL model forecasts consistently outperform an AR benchmark model (although by a fairly limited margin) with respect to forecasting U.S. real GDP growth and inflation.⁹

The second type of combining procedure we employ uses a discount mean square forecast error (DMSFE) criterion over the holdout out-of-sample period to determine the weights used to combine the individual ARDL model forecasts formed at time t ; see Stock and Watson (2004). More specifically, the DMSFE combining method uses the weights

⁵ The SIC and the Akaike information criterion (AIC) are two popular model selection procedures. Note that we obtain similar results when we select the lag lengths in (1) using the AIC.

⁶ Note that the first forecast uses all data available at time R to form a forecast of y_{R+h}^h ; this forecast is denoted by $\hat{y}_{i,R+h|R}^h$. The information set is then updated by one period, and we use all data available at time $R + 1$ to form a forecast of y_{R+1+h}^h ; this second forecast is denoted by $\hat{y}_{i,(R+1)+h|R+1}^h$. We continue in this manner through the end of the out-of-sample period, leaving us with $P - (h - 1)$ recursive simulated out-of-sample forecasts, $\{\hat{y}_{i,t+h|t}^h\}_{t=R}^{T-h}$.

⁷ We select the lag length (q_1) for the AR model using the SIC and a minimum (maximum) value of zero (four) for q_1 .

⁸ Note that we use the first P_0 observations from the out-of-sample period to estimate the combining weights used to generate the first combination forecast available for evaluation. We then use the first $P_0 + 1$ observations from the out-of-sample period to estimate the combining weights used to generate the second combination forecast available for evaluation. We continue in this manner through the end of the available out-of-sample period, leaving us with a series of $P - (h - 1) - P_0$ out-of-sample combination forecasts available for evaluation.

⁹ The simple combining methods obviously do not require a holdout period, as the combining weights are not estimated.

$$w_{i,t} = m_{i,t}^{-1} / \sum_{j=1}^n m_{j,t}^{-1} \quad (i = 1, \dots, n),$$

where

$$m_{i,t} = \sum_{s=R}^{t-h} \theta^{t-h-s} \left(y_{s+h}^h - \hat{y}_{i,s+h|s}^h \right)^2$$

and the parameter θ is a discount factor. When $\theta = 1$, there is no discounting, whereas $\theta < 1$ means that greater importance is attached to the recent forecasting performance of the individual ARDL models in determining the combining weights. In the next section, we consider θ values of 1.0 and 0.9 in our applications.

The final type of combining method we use is the “cluster” approach recently developed by Aiolfi and Timmermann (2006) based on their $C(K, PB)$ algorithm. The initial cluster combination forecast is generated by first grouping the individual ARDL model forecasts over the holdout out-of-sample period,

$$\left\{ \hat{y}_{i,s+h|h}^h \right\}_{s=R}^{R+(P_0-1)-(h-1)} \quad (i = 1, \dots, n),$$

into K equal-sized clusters based on the MSFE, with the first cluster containing the individual ARDL model forecasts with the lowest MSFE values, the second cluster containing the individual ARDL model forecasts with the next lowest MSFE values, and so on. The initial combination forecast is the average of the individual ARDL model forecasts contained in the first cluster. To form the second combination forecast, the MSFE is computed for the individual ARDL model forecasts,

$$\left\{ \hat{y}_{i,s+h|h}^h \right\}_{s=R+1}^{R+(P_0-1)-(h-1)+1} \quad (i = 1, \dots, n),$$

and the individual ARDL model forecasts are again grouped into K clusters based on the MSFE. The second combination forecast is again the average of the individual forecasts in the first cluster. We can proceed in this manner through the end of the available out-of-sample period to construct the complete set of combination forecasts. Following Aiolfi and Timmermann (2006), we consider K values of two and three in our applications in the next section.

EMPIRICAL RESULTS

Data

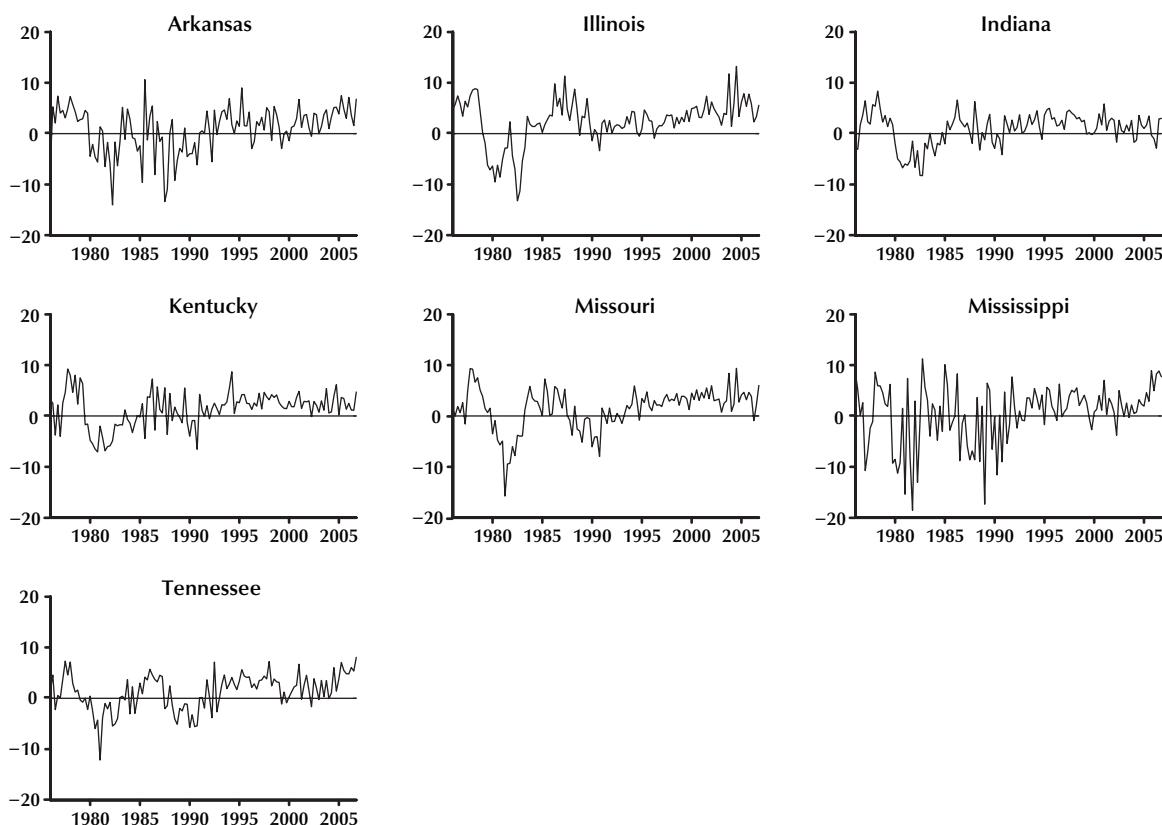
Nominal housing price indices for individual U.S. states starting in 1975:Q1 are available from Freddie Mac. The Conventional Mortgage Home Price Index provides a means for measuring the typical price inflation for houses within the United States using matched transactions on the same property over time to account for quality changes. Freddie Mac uses data from both purchase and refinance-appraisal transactions, and its database consists of over 33 million homes. The available sample for the housing price indices ends in 2006:Q4. We convert the nominal housing price index into real terms using the personal consumption expenditure (PCE) deflator from the Bureau of Economic Analysis (BEA). We then compute annualized growth rates as 400 times the differences in the log levels of real housing prices. The annualized real housing price growth rates are plotted in Figure 1. Note that real housing price growth is predominantly positive over much of our 1995:Q1–2006:Q4 out-of-sample forecast evaluation period, indicating that the individual states of the Eighth District typically experienced fairly strong housing markets over the past decade.¹⁰

As discussed above, we consider 25 potential predictors of real housing price growth for each state. Six of these are state-level variables:

- Ratio of housing price to per capita personal income
- Real per capita personal income
- Population
- Employment
- Labor force
- Unemployment rate

Nominal personal income data are from the BEA and are converted into per capita terms using

¹⁰ The housing price indices exhibit exaggerated saw-tooth patterns in the first part of the sample for a number of the states. This appears to be an artifact of the development and construction of the housing price indices. To minimize the influence of these patterns when estimating the forecasting models, we smooth the real housing price growth observations up to 1984:Q4 by taking a moving average of the current and three previous real housing price observations. Smoothing of the early observations has been applied to the real housing price growth rate series depicted in Figure 1.

Figure 1**Annualized Real Housing Price Growth, 1976:Q1–2006:Q4**

population data from the U.S. Census Bureau and then into real terms using the PCE deflator. The labor market variables are from the Bureau of Labor Statistics (BLS). The housing price-to-income ratio is a popular “valuation ratio” for housing prices that may help to signal whether housing is over- or under-valued. The income and employment variables provide measures of the ability of households to purchase housing and are thus potentially important determinants of housing demand. Significant changes in population can also lead to sizable shifts in housing demand.

We also consider five regional variables as predictors:

- Housing starts
- Building permits

- Homes for sale
- Homes sold
- Housing vacancy rate

These variables, all from the U.S. Census Bureau, are available for each of the four U.S. Census regions.¹¹ These housing market variables may provide signals of trends and supply conditions in housing markets that affect housing prices.

Finally, 14 national variables also serve as predictors:

- Average weekly hours in manufacturing

¹¹ Reflecting their U.S. Census Bureau classification, we use variables from the South region for Arkansas, Kentucky, Mississippi, and Tennessee and variables from the Midwest region for Illinois, Indiana, and Missouri. Note that these variables are not available at the state level for the entire sample period we consider.

- Average weekly initial claims for unemployment insurance
- Manufacturers' new orders for consumer goods and materials (in chained 1982 dollars)
- Vendor performance
- Manufacturers' new orders of nondefense capital goods (in chained 1982 dollars)
- S&P 500 stock price index
- Real M2 money supply (in chained 2000 dollars)
- Term spread (10-year Treasury bond yield minus the federal funds rate)
- Consumer confidence index
- PCE deflator
- Industrial production
- Commercial and industrial loans outstanding (in chained 2000 dollars)
- Consumer installment credit outstanding
- Real effective mortgage rate

The first nine national predictors comprise nine of the ten leading economic indicators from the Conference Board¹²: These indicators potentially measure broad economic trends that can affect the demand for housing. Data on industrial production, commercial and industrial loans outstanding, and consumer installment credit outstanding are all from the Conference Board. These variables include credit measures that also may significantly influence housing prices. The nominal effective mortgage rate is from Freddie Mac, and we subtract the inflation rate based on the PCE deflator to approximate a real effective mortgage rate. The mortgage rate is an important component of the "user cost" of housing and thus a potentially important determinant of housing demand.

All of the predictors are transformed in an effort to render them stationary. This involves taking the first differences of log levels, with the following exceptions: We use levels for the unemployment rate, housing vacancy rate, unemployment claims, vendor performance, term spread, and consumer confidence; we use log levels for

the housing price-to-income ratio; and we use first differences for average weekly hours.

AR Benchmark and Individual ARDL Model Forecasting Results

Table 1 reports forecasting results for the AR benchmark and individual ARDL forecasting models for each state. The table reports the MSFE for the AR benchmark model and the ratio of the individual ARDL model MSFE to the AR benchmark model MSFE. A ratio below unity thus indicates that the individual ARDL model has a lower MSFE than the AR benchmark. Results are reported for forecast horizons of four ($h = 4$) and eight ($h = 8$) quarters.

An important result in Table 1 is that no single predictor has an MSFE ratio that is below unity in all states for both forecast horizons; that is, there is no single predictor that delivers consistently more accurate forecasts than the benchmark AR model across all of the Eighth District states and both forecast horizons. The PCE deflator (inflation rate) produces an MSFE ratio below unity for all seven states at both horizons, with one exception (Indiana at $h = 4$), and many of the MSFE ratios for the inflation rate are well below unity (for example, 0.26 for Kentucky at $h = 8$), indicating substantial reductions in forecast accuracy relative to the AR model. The state housing price-to-income ratio—as mentioned above, a popular valuation ratio for housing—also performs quite well for Arkansas, Indiana, Kentucky, Mississippi, and Tennessee, with MSFE ratios all below unity (often substantially so) at both forecast horizons. However, the MSFE ratios for the state housing price-to-income ratio are well above unity for both horizons for Illinois and above unity for Missouri at the eight-quarter horizon. Other predictors that perform well for a number of Eighth District states are the state unemployment rate and consumer confidence, but there again are situations where the MSFE ratios for these variables are considerably above unity.

Looking at the results in Table 1 on a state-by-state basis, the state housing price-to-income ratio and state unemployment rate stand out for Arkansas. These predictors generate reductions in MSFE relative to the AR benchmark model of up to 31 percent and 54 percent at the four- and eight-

¹² The leading indicator we omit is national building permits, as this is included as a regional predictor.

Table 1**Individual ARDL Model Forecast Results: 1995:Q1–2006:Q4 Out-of-Sample Forecast Evaluation Period**

Predictor	Arkansas		Illinois		Indiana		Kentucky		Missouri		Mississippi		Tennessee	
	<i>h</i> = 4	<i>h</i> = 8	<i>h</i> = 4	<i>h</i> = 8	<i>h</i> = 4	<i>h</i> = 8	<i>h</i> = 4	<i>h</i> = 8	<i>h</i> = 4	<i>h</i> = 8	<i>h</i> = 4	<i>h</i> = 8	<i>h</i> = 4	<i>h</i> = 8
AR MSFE	4.90	5.49	4.66	5.66	2.15	1.93	1.18	2.25	2.93	4.69	9.70	9.44	3.43	4.56
State housing price-to-income ratio	0.70	0.46	1.89	2.74	0.84	0.69	0.67	0.38	0.92	1.13	0.58	0.35	0.76	0.52
State real personal income	1.01	1.02	1.02	1.03	0.95	1.13	0.99	1.01	1.14	1.43	1.02	1.01	1.05	1.06
State population	1.82	1.45	0.88	0.84	0.81	0.50	0.78	0.70	0.90	0.96	1.02	0.75	1.02	1.04
State employment	1.41	1.36	1.07	1.09	1.17	1.31	1.98	1.47	1.38	1.60	1.23	1.18	1.33	1.16
State labor force	1.14	1.08	1.05	0.71	1.13	1.28	1.07	0.98	1.17	1.17	1.08	1.01	1.29	1.16
State unemployment rate	0.69	0.49	1.39	1.89	0.69	0.47	0.67	0.69	1.21	2.05	0.99	0.89	1.15	1.34
Regional housing starts	1.08	0.97	1.18	1.06	1.29	1.13	1.15	1.01	1.24	1.22	0.99	0.94	1.11	0.95
Regional building permits	1.06	0.99	1.07	1.02	1.11	1.01	1.10	0.99	1.12	1.14	1.03	0.95	1.04	1.01
Regional homes for sale	1.36	1.21	1.00	0.97	1.29	1.09	1.33	1.17	1.05	1.05	1.18	1.01	1.22	1.08
Regional homes sold	1.02	1.02	1.00	1.00	1.06	1.00	1.97	0.65	1.00	1.00	1.15	1.02	1.08	0.86
Regional vacancy rate	1.12	1.18	0.82	0.57	1.17	1.23	0.85	0.62	1.11	0.83	1.08	1.10	0.95	0.83
Average weekly hours	1.33	1.10	1.58	1.23	1.20	1.18	1.40	1.20	1.08	1.16	1.16	1.08	1.17	1.11
Unemployment claims	0.95	1.02	1.03	1.02	0.90	0.67	0.97	0.91	0.97	1.04	0.98	0.96	0.96	0.97
New orders–consumer goods	1.14	1.04	1.31	1.13	1.06	1.10	1.17	1.29	1.03	1.12	1.14	1.05	1.08	1.06
Vendor performance	0.90	0.93	0.93	1.01	0.96	0.94	1.16	1.07	1.03	1.09	1.11	0.91	1.05	0.97
New orders–capital goods	1.00	1.00	1.01	1.00	1.13	1.02	1.01	1.01	1.01	1.02	1.03	1.00	1.01	1.00
S&P 500 index	1.05	1.04	1.08	1.10	1.01	1.02	1.05	1.03	1.03	1.03	1.06	1.04	1.01	1.02
Real M2	0.94	0.95	0.98	0.75	1.12	1.04	0.95	0.89	0.77	0.80	0.92	0.90	1.02	0.94
Term spread	0.81	0.82	1.05	1.10	1.25	1.76	2.00	1.96	1.16	1.65	1.30	1.01	1.23	1.29
Consumer confidence	0.87	0.82	1.09	1.16	1.03	1.20	0.75	0.54	0.67	0.44	0.88	0.56	0.94	0.72
PCE deflator (inflation rate)	0.81	0.64	0.83	0.58	1.08	0.96	0.68	0.26	0.53	0.32	0.63	0.43	0.89	0.62
Industrial production	1.05	1.04	1.21	1.11	0.99	0.93	1.05	1.08	1.07	1.13	1.03	0.98	1.08	1.00
Commercial/industry loans	1.28	0.98	1.07	0.92	1.21	1.26	1.08	1.02	1.02	0.99	1.04	1.01	1.16	1.02
Consumer credit outstanding	1.23	1.08	1.06	1.01	0.93	0.99	1.17	1.12	1.33	1.38	1.37	1.22	1.30	1.12
Real effective mortgage rate	0.95	1.01	1.15	1.37	1.03	1.07	1.03	1.05	0.97	1.29	1.11	1.13	1.12	1.19

NOTE: Entries in the AR MSFE row report the MSFE for the AR benchmark model. Entries in the other rows report the ratio of the MSFE for the individual ARDL model that includes the predictor indicated in the first column to the MSFE for the AR benchmark model.

Table 2

Combination Forecast Results: 1995:Q1–2006:Q4 Out-of-Sample Forecast Evaluation Period

Combining method	Arkansas		Illinois		Indiana		Kentucky		Missouri		Mississippi		Tennessee	
	$h = 4$	$h = 8$	$h = 4$	$h = 8$	$h = 4$	$h = 8$	$h = 4$	$h = 8$	$h = 4$	$h = 8$	$h = 4$	$h = 8$	$h = 4$	$h = 8$
Mean	0.96	0.91	0.93	0.82	0.87	0.75	0.86	0.76	0.89	0.95	0.97	0.88	0.98	0.92
Median	0.99	0.99	0.97	0.97	0.93	0.89	0.90	0.91	0.97	1.03	1.00	0.97	1.00	0.99
Trimmed mean	1.03	0.98	1.02	0.94	0.89	0.78	0.98	0.84	0.97	1.02	1.01	0.89	1.18	0.99
DMSFE, $\theta = 1.0$	0.92	0.88	0.93	0.83	0.86	0.69	0.85	0.71	0.90	0.88	0.93	0.84	0.99	0.95
DMSFE, $\theta = 0.9$	0.90	0.82	0.91	0.76	0.88	0.68	0.84	0.69	0.86	0.76	0.89	0.80	0.99	0.93
$C(2, PB)$	0.90	0.85	0.92	0.81	0.88	0.69	0.81	0.61	0.86	0.84	0.92	0.81	0.98	0.86
$C(3, PB)$	0.87	0.76	0.85	0.72	0.84	0.63	0.76	0.52	0.80	0.70	0.86	0.74	1.00	0.79

NOTE: Entries report the ratio of the MSFE for the combining method indicated in the first column to the MSFE for the AR benchmark model.

quarter horizons, respectively. For Illinois, the state population, regional vacancy rate, and inflation rate display the best performance, with reductions in MSFE relative to the AR benchmark of up to 18 percent and 43 percent at the reported horizons. The state housing price-to-income ratio, state population, state unemployment rate, and unemployment claims produce large reductions in MSFE for Indiana, with reductions up to 31 percent and 53 percent at the two horizons. For Kentucky, six predictors are able to generate sizable reductions in MSFE relative to the AR benchmark at both horizons: the state housing price-to-income ratio, state population, state unemployment rate, regional vacancy rate, inflation rate, and consumer confidence. The largest reductions in MSFE are 33 percent and 74 percent at the four- and eight-quarter horizons, respectively. Real M2, consumer confidence, and the inflation rate lead to sizable reductions in MSFE relative to the AR benchmark for Missouri, with reductions of up to 47 percent and 68 percent at the two horizons. Three variables stand out for Mississippi: the state housing price-to-income ratio, consumer confidence, and inflation rate. The state housing price-to-income ratio leads to the largest reductions in MSFE (42 percent and 65 percent) at the two reported horizons. For Tennessee, the state housing price-to-income ratio and inflation rate lead to the largest reductions in MSFE relative to the AR benchmark at both of the reported horizons (up to 24 percent and 48 percent).

Combining Method Forecasting Results

Table 2 reports the combination forecast results in the form of the ratio of the combining method MSFE to the AR benchmark MSFE, so that (as in Table 1) a ratio below unity indicates that the combining method forecast is more accurate than the AR benchmark forecast in terms of MSFE. The results in Table 2 show that the simple combining methods often produce reductions in MSFE relative to the AR benchmark of around 10 percent, and this is in line with the findings of Stock and Watson (1999 and 2003) in the context of U.S. GDP growth and inflation forecasts. The DMSFE combining method forecasts appear to perform somewhat better than the simple combining method forecasts in most cases, with the DMSFE combining method

based on $\theta = 0.9$ leading to reductions in MSFE relative to the AR benchmark of approximately 10 to 15 percent at the four-quarter horizon and approximately 20 to 30 percent at the eight-quarter horizon in most cases. The cluster combining methods exhibit the best overall performance, especially the $C(3, PB)$ method. With one exception (Tennessee at $h = 4$), the MSFE ratios are all well below unity for the $C(3, PB)$ method, with reductions in MSFE of up to 24 percent and 48 percent relative to the benchmark AR model at horizons of four and eight quarters, respectively (both for Kentucky). The $C(3, PB)$ cluster combining method leads to average reductions in MSFE relative to the AR benchmark model across the seven states of approximately 15 percent and 30 percent at horizons of four and eight quarters, respectively. Given that it will be difficult to identify a priori the particular predictors that are most relevant for a given out-of-sample period, the performance of the combining methods—especially the $C(3, PB)$ method—indicates that they provide a useful way of producing relatively accurate forecasts of real housing price growth in the Eighth District states in the presence of many potentially relevant predictors.

CONCLUSION

We examine the ability of a host of economic variables to forecast real housing price growth for the seven individual states in the Federal Reserve's Eighth District. A number of variables, such as the state housing price-to-income ratio, state unemployment rate, consumer confidence, and inflation rate, produce forecasts that often substantially outperform a benchmark AR model in terms of MSFE in individual Eighth District states, but no single variable is able to improve on the AR benchmark for all states at all reported horizons. Given that it will be difficult to identify a priori the particular variable or small set of variables that are best suited for forecasting real housing price growth for a given state and time period, we also analyze the performance of forecast combining methods. We find that combining methods generally offer useful means of incorporating and culling information from a large number of potential predictors

when forecasting real housing price growth in the Eighth District states.

Finally, we briefly discuss two ways that we are extending the research presented in this paper. First, we are currently applying the approaches employed in the present paper to a greater number of individual U.S. states, including larger U.S. states (in terms of population) that have experienced substantial increases in real housing prices over the past decade—states for which there are serious concerns of a housing price “bubble.” We are also preparing to apply the approach used in the present paper to forecasting real housing price growth for individual metropolitan areas in the Eighth District, as households are often interested in forecasts of housing price growth in their more immediate vicinity.

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Educational Attainment and Recovery from Recessions Across Metropolitan Areas

Bryan Bezold

Metropolitan area business cycles vary considerably in both magnitude and duration. Some metro areas recover rapidly from downturns, some take longer, and some never recover. Because recent recessions have involved employment changes at the North American Industrial Classification System (NAICS) supersector level that were both cyclical and structural, part of a metro area's recovery from a recession may include the process of workers adapting to new jobs in other industries. If worker adaptation is part of the recovery process, then metro areas with higher educational levels might be able to recover more quickly from recessions. This hypothesis is tested with multiple regression models of the 1990 and 2001 recessions. There is a significant and negative link between college attainment and the time it took for metropolitan areas to recover from the 2001 recession, but not from the 1990 recession. (JEL A10, J24)

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Metropolitan areas experience economic contractions in much the same way that the broader U.S. economy does. However, because economies of metropolitan statistical areas (MSAs) differ in their demographics and other economic characteristics, they are natural subjects to use to test for relationships between structural economic characteristics and economic performance during business cycles. In this paper I use a panel of the 50 largest MSAs in the United States to test for a relationship between the share of each MSA's population over 25 years of age with a college degree and the time in months it takes for that MSA to recover from a recession. In each case, employment is used to define the beginning and end of a recession and the time interval for recovery. The relationship between college attainment and recovery length is being tested because, as the structure of the U.S. economy changes, the process of recovery from recession may depend on the ability of workers to adapt to new jobs at different firms or in different industries. If more-

educated workers are more adaptable, and more-adaptable workers are better at learning new skills at new jobs, then there may be a relationship between the level of education in an MSA and the time it takes for that MSA to recover from a recession.

During the 2001 recession, as with most recessions, the United States and most major MSAs experienced an overall decline in nonfarm employment, a recovery to the previous peak employment level, and then continued expansion. Nonfarm employment declined from a peak of 132.5 million in February 2001 to a trough of 129.8 million in August 2003. Employment expanded at an average monthly rate of 151,000 between September 2003 and February 2005, when the United States first exceeded its prior peak level of employment. Between March 2005 and January 2007, average monthly job gains accelerated to slightly over 200,000 per month.

At the same time, however, some industries (as defined by North American Industrial

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Classification System [NAICS] supersectors) declined and did not recover. U.S. manufacturing employment, for example, declined from slightly more than 17 million in March 2001 to 14 million in January 2007. Employment in the information sector also appeared to have permanently declined from a pre-recession peak of 3.7 million to 3.0 million in January 2007. This phenomenon was also observable in most MSAs. Approximately 3.7 million workers, or 2.8 percent of total peak employment, appear to have been permanently dislocated from their previous industries.

Compare this with the 1990 recession. Overall, the U.S. experienced an employment peak, trough, and recovery. Nonfarm payroll employment peaked at 109.8 million in June 1990, fell to a trough of 180.2 million in May 1991, and recovered to the previous peak level in February 1993. As with the 2001 recession, manufacturing employment began to decline before overall nonfarm employment began to decline. Manufacturing employment declined by 7.3 percent, or 1.3 million jobs, from a peak of 18.0 million in March 1989 to a trough of 16.7 million in August 1993. Manufacturing-sector employment did not fully recover to its pre-1990 recession peak, but did rise to roughly 98 percent of its peak before beginning to decline again in March 1998.

The structural adjustment that the United States and most major MSAs experienced during the 1990 recession and recovery process was thus smaller than in the 2001 recession. The total number of manufacturing workers permanently displaced—the difference between manufacturing employment at its pre-1990 recession peak and its relative peak in March 1998—was 423,000. That was much smaller than the 3 million workers who were permanently displaced from the manufacturing sector after the 2001 recession.

It is thus the case that the U.S. economy experienced a full recovery from the 2001 recession in terms of employment, but some industries, specifically information and manufacturing, did not. The 1990 recession was also characterized by this phenomenon, but to a much smaller extent, in the manufacturing sector. Because overall nonfarm employment in both cases recovered to and grew past its previous peak, workers in those perma-

nently affected sectors either went to work in new sectors or left the labor force and were replaced by new entrants. This phenomenon likely took place at the firm level as well, with workers dislocated by the closing of firms finding work at different firms either within or outside of that industry.

That would suggest that economies, whether at the national or subnational level, recover from downturns in employment because workers are able to adapt whatever skills they may have to new firms or new industries. Once an economy makes this adjustment, its firms become more productive and it resumes a pre-recession pace of expansion. Note that in the cases of both the 1990 and 2001 recessions, average monthly nonfarm employment gains accelerated after the level of employment reached its pre-recession peak. The implication here is that the business cycle has three phases: *contraction*, during which many firms either go out of business or shed workers; *recovery*, when workers adjusted their skills to new firms or even industries; and *expansion*, when the economy has reorganized and can grow at a slightly higher rate.

If the sorting of workers from old firms to new ones and old industries to new ones is a factor in the recovery of an economy to its prior peak employment level, then it is logical to wonder if the adaptability of workers, their ability to learn new skills so that they can work in different firms or industries, would affect the time it takes for an economy to recover from a contraction.

At this point it is important to note that the National Bureau of Economic Research (NBER), the official chronicler of business cycles in the United States, characterizes recession only in terms of contraction and expansion. There is no distinction, in the NBER view, between recovery and expansion; any period of growth, prior to or after exceeding a pre-recession peak, is considered expansion. This paper's characterization of the business cycle as one with three phases, contraction, recovery, and expansion, represents a view different from the one commonly used by economists.

Many researchers, notably Owyang, Piger, and Wall (2005), have described business cycles at the state level with a two-phase model, expansion and contraction, rather than a three-phase model. Owyang et al. (2007) also have observed that a dif-

ferent set of variables is associated with economic performance during the expansion and contraction phases and that human capital measured by college attainment is correlated with MSA and state performance during growth phases.

Other research is broadly supportive of a correlation between human capital, measured by educational attainment, and measures of MSA growth. Glaeser and Saiz (2003) found a connection between growth and skills measured by college attainment for MSAs that were declining, but not for MSAs that were growing: Having a skilled workforce was more important to MSAs that were not experiencing in-migration than to those that did have higher rates of in-migration. Further, Glaeser and Saiz (2003) also concluded that “rustbelt” MSAs with higher skill levels would be more likely to adjust to structural economic changes due to declining manufacturing employment than MSAs with lower skill levels.

Silvia (2006) observed that the transition of the U.S. economy from a purely domestic labor market to one influenced by both national and international factors would have a number of results, including reduced demand for manufacturing workers but increased demand for college-educated workers. Silvia (2006) also noted that skill accumulation for workers will be a lifelong process in the face of structural economic change.

Because other research confirms correlation between college attainment and economic growth, and also suggests a link between skilled workers and the ability of MSAs to adapt, then one would expect that MSAs with higher skill levels should recover more quickly from recessions that involve structural and not just cyclical economic changes. This paper tests the hypothesis that increased worker adaptability, measured by college attainment levels, is correlated with faster recoveries from recessions. After a contraction in employment, workers that are permanently displaced from their firms or industries will need to be able to adapt to new firms or industries; also, prospective employers must believe that the workers will be able to adapt to new environments for overall MSA employment to recover from a contraction. Better-educated workers should be more able to adjust to new jobs in new industries, so MSAs with a greater

share of educated workers should need less time to re-sort workers into jobs in new firms and industries.

METHODOLOGY

The models in this paper use multiple regression analysis to test for a relationship between (i) the length of time it takes for an MSA economy to recover from its employment trough following a recession and reach a level at or above the pre-recession peak and (ii) the level of college attainment for both the 2001 and 1990 recessions. College attainment from the 1990 and 2000 U.S. Census surveys were used as a proxy for the general level of workers’ adaptability. The length of time in months for an MSA to recover from a post-recession employment trough and reach a level at or above the pre-recession peak was used as the dependent variable. This number was calculated through the inspection of seasonally adjusted nonfarm employment data for each MSA. Once the initial peak, trough, and next peak were identified, then the length of recovery was the number of months between the trough and the next month that nonfarm employment rose permanently above the level of the pre-recession peak. In many cases, the employment data did not have a smooth curve, but a volatile one. In these cases, the employment level occasionally spiked to a level above the pre-recession peak during the recovery period, but then dropped back below it. In those instances, the recovery was not considered complete until seasonally adjusted employment permanently exceeded the pre-recession peak. This is one of several sources of uncertainty in the model.

The independent variables for each MSA in the model were the share of adults over the age of 25 with a college degree, the share of employment in manufacturing and information at that pre-recession peak, and the magnitude (percentage) of each employment decline.

The share of adults with a college degree was the variable being tested; the other independent variables were included as controls. The magnitude of the decline in employment was included because the greater the number of dislocated workers, the

Table 1**Descriptive Statistics for the Sample of 34 MSAs During the 2001 Recession**

Variable	Median	Range	Standard deviation
Percent decline in employment, peak to trough	-0.025	0.053	0.014
Share of employment in manufacturing at pre-recession peak	0.101	0.135	0.035
Share of employment in information at pre-recession peak	0.028	0.044	0.012
Share of adults over 25 with a BA or BS	0.264	0.229	0.047
Recovery length, trough to prior peak level, in months	23.5	35	10.2
	Minimum	Mode	Maximum
Date of pre-recession employment peak	March 2000	December 2000	September 2001
Date of employment trough	October 2001	March 2003	June 2003
Date of recovery to pre-recession peak employment level	August 2002	April 2005	February 2007

Table 2**Descriptive Statistics for the Sample of 44 MSAs During the 1990 Recession**

Variable	Median	Range	Standard deviation
Percent decline in employment, peak to trough	-0.021	0.139	0.027
Share of employment in manufacturing at pre-recession peak	0.135	0.277	0.052
Share of adults over 25 with a BA or BS	0.209	0.263	0.045
Recovery length, trough to prior peak level, in months	16.5	70	17.5
	Minimum	Mode	Maximum
Date of pre-recession employment peak	January 1990	August 1990	September 1991
Date of employment trough	December 1990	April 1991	January 1996
Date of recovery to pre-recession peak employment level	May 1991	January 1992	July 2000

longer it would take to completely sort all of the dislocated workers into new jobs. Because the 2001 recession was concentrated in the manufacturing and information NAICS supersectors, the share of an MSA's employment in those two sectors would likely affect the length of time it took to recover from a recession; more workers in affected sectors would presumably increase the number of workers who have to be sorted into other firms or industries. The inclusion of these two variables on the right-hand side of the equation reflected an assumption that the 2001 recession was an exogenous shock to the manufacturing and information sectors in each MSA.

In the case of the 1990 recession, the share of employment in the information sector was not included because the information sector fully recovered from the 1990 recession and therefore did not produce permanently displaced workers; it was assumed that the decline in manufacturing was the exogenous shock to MSA economies. Table 1 contains descriptive statistics for the model of the 2001 recession variables; Table 2 contains descriptive statistics for the model of the 1990 recession.

More simply put, the control variables are selected to see whether two MSAs that had different college attainment levels but the same magnitude

of contraction, and an equal share of employment in sectors most subject to the exogenous shock, would experience recoveries of different lengths.

The analysis initially began with the 50 largest MSAs in the United States. The eventual model of the 2001 recession, however, is based on just 34 of them: 12 of the 50 largest MSA had not fully recovered from the 2001 recession by January of 2007 and 4 MSAs did not experience any employment contraction during the 2001 recession. Those 16 were excluded from the model.

For the 1990 recession, there were similar limitations. The Los Angeles MSA never recovered from the 1990 recession, and five other MSAs did not experience a significant decline in overall nonfarm employment. A total of six MSAs were thus excluded from the 1990 recession model.

Of the 12 MSAs that had not yet recovered from the 2001 recession, seven had college attainment above the U.S. average (24.4 percent) and five had college attainment below the U.S. average. Similarly, of the four MSAs that did not experience an employment contraction, two had college attainment above the U.S. average and two below. The MSAs that experienced neither recovery nor recession were distributed across the range of college attainment, which raises an initial concern about the proposed link between college attainment and recovery lengths. In the case of the 1990 recession, the only MSA not to fully recover was Los Angeles, which had college attainment below the U.S. average in 1990. Three MSAs with above-average attainment, however—San Francisco, San Jose, and San Diego—had the longest recovery times. So, in both the 1990 and 2001 recession models, there were some clear outliers that could not be included in the model and that did not exhibit the proposed relationship between college attainment and faster recoveries.

RESULTS FOR THE MODELS OF THE 2001 RECESSION

Results of the regression models for the 2001 recession are listed in Tables 3 through 5. Each of the independent variables is significant at the 10 percent but not the 5 percent levels, and the model

explains approximately 30 percent of the variation of the recovery length. The coefficient for college attainment, -60.5 , implies that if the magnitude of the decline in employment and the shares of employment in manufacturing and information are held constant, a one-standard-deviation increase in college attainment, which is 4.7 percentage points, would decrease the length of a recovery by 2.8 months. That is roughly one-quarter of the standard deviation of the recovery length.

Based on the results of the initial model, there is an observed correlation between recovery length and college attainment, but it is not of optimal significance. It is also not a large correlation and is part of a model that leaves most of the variation in recovery length unexplained.

These results leave two possibilities: The first is that there is not a significant relationship between college attainment and recovery time, either because there isn't really a correlation between adaptability and recovery or because college attainment isn't a good measure of adaptability. The second is that such a relationship does exist and would be better observed with some modifications to the original model. A number of modifications were thus attempted.

As mentioned here previously, the monthly employment data used to identify peaks and troughs for each MSA were volatile and the volatility contributed to the possibility that turning points might be misidentified. To correct for this potential error, the monthly data were compressed to quarterly frequency. The same analysis was repeated with the same variables, transformed from months to quarters. The results, however, did not change: After that transformation, the coefficients for three of the four independent variables—college attainment, share of employment in the information sector, and share of employment in the manufacturing sector—were no longer significant at even the 10 percent level. With quarterly rather than monthly data, the difference between each MSA's contraction and recovery became smaller, whereas the difference between each MSA's control variables remained constant. The adjusted R^2 of the model fell from 0.30 with the monthly data to 0.18 with the quarterly data.

Another obvious idea to further test the hypoth-

Table 3**Results of Initial Regression Model of 2001 Recession ($n = 34$)**

Variable	Coefficient	<i>t</i> -statistic
Constant	15.3	1.5
Percent decline in employment (peak to trough)	-217.8	-1.8*
Share of employment in manufacturing at peak	87.1	1.9*
Share of employment in information at peak	276.3	1.8*
College attainment	-60.5	-1.7*
Model statistics		
<i>F</i> -statistic		4.6**
Adjusted R^2		0.30

NOTE: * $p < 0.10$, ** $p < 0.05$.**Table 4****Results of Model of 2001 Recession with Dichotomized College Attainment Based on U.S. Average ($n = 34$)**

Variable	Coefficient	<i>t</i> -statistic
Constant	3.8	0.6
Share of employment in manufacturing at peak	126.2	2.9**
Share of employment in information at peak	365.6	3.0*
College attainment exceeds U.S. average (1 or 0)	-7.9	-2.5**
Model statistics		
<i>F</i> -statistic		6.1**
Adjusted R^2		0.32

NOTE: * $p < 0.10$, ** $p < 0.05$.**Table 5****Results of Model of 2001 Recession with Dichotomized College Attainment Based on Sample Median ($n = 34$)**

Variable	Coefficient	<i>t</i> -statistic
Constant	1.0	0.2
Share of employment in manufacturing at peak	120.2	2.8**
Share of employment in information at peak	419.4	3.2**
College attainment exceeds sample median (1 or 0)	-7.3	-2.3**
Model statistics		
<i>F</i> -statistic		5.6**
Adjusted R^2		0.29

NOTE: * $p < 0.10$, ** $p < 0.05$.

esis is to expand the sample size. Five additional MSAs were added to the sample: Raleigh-Cary, North Carolina; Tucson, Arizona; Tulsa, Oklahoma; Albany-Schenectady-Troy, New York; and Honolulu, Hawaii. These MSAs were included because they were the next-largest U.S. MSAs that experienced both a contraction and recovery. When these five MSAs were added to the model, however, the level of college attainment was not significantly correlated with recovery length. As described here previously, the fact that this model correction did not change the results could mean that the tested relationship between college attainment and recovery length does not exist. It is also possible that the five MSAs added to the sample were not large enough for the reorganizing of workers to be a part of the recovery process. The average peak employment of the five MSAs added to the sample was 413,000, compared with an average of 1.4 million for the other sample of 34 MSAs. Thus, the five MSAs added to the sample may not be large enough to have the perceived job opportunities necessary to convince dislocated workers to remain in the area and look for a new job.

Another possibility is (i) that there is some threshold of adaptability necessary for workers in an MSA to reorganize and (ii) that being much above that threshold is not particularly helpful to the process of economic recovery. To test for that result, the college attainment variable was dichotomized into a dummy variable that reflected college attainment above the U.S. average. The results of this model were slightly better than the original model. With college attainment coded as a 1 if it was above the 2000 U.S. average (24.4 percent), the coefficient was -7.9 , significant at the 5 percent level. In this model, however, the variable reflecting the percent decline in peak-to-trough employment was no longer significant at the 10 percent level and was removed from the model. Given that fact, the results of this model suggest that, after controlling for shares of employment in manufacturing and information, an MSA that had college attainment in the year 2000 that exceeded the U.S. average would recover to its pre-recession peak employment level almost 8 months faster than an MSA with below-average college attainment. Alter-

natively, having college attainment above the U.S. average shortens recovery length in this sample by about three-quarters of one standard deviation.

In our sample, 23 of the 34 MSAs (about two-thirds) had college attainment that exceeded the U.S. average. It is also generally true that MSAs tend to have higher college attainment than rural areas do, so comparing MSAs with the U.S. average may not be appropriate. The model was run a final time with the dummy recoded to reflect 1 if that MSA had college attainment greater than the sample median. In the case of the 2001 recession model with 34 MSAs, the variable for college attainment above the sample median was significant at the 5 percent level, as were the manufacturing and information sector employment controls.

RESULTS FOR THE MODELS OF THE 1990 RECESSION

For the 1990 recession, the same methodology was applied, except that the share of employment in the information sector was not used as a control variable. The results of these regressions are in Tables 6 through 8. For the initial model, the level of college attainment was not significantly correlated with shorter recovery times. The model was repeated with a dichotomized variable reflecting college attainment above the U.S. average in 1990 or above the sample mean (both of which were coded as 1). Neither of the dichotomized variables was significantly correlated. The share of employment in manufacturing was also not significantly correlated with recovery from the 1990 recession.

CONCLUSIONS

These results suggest that, after controlling for the magnitude of peak-to-trough decline in employment in manufacturing and information, there is a negative relationship between some measures of college attainment and the length of time measured in months that it takes for a large MSA to recover from a post-recession employment trough to its previous peak employment level for the 2001 recession. This is not the case for the 1990 recession. The level of significance of the relationship between

Table 6**Results of Initial Model of 1990 Recession ($n = 44$)**

Variable	Coefficient	<i>t</i> -statistic
Constant	20.5	1.89*
Percent decline in employment (peak to trough)	-508.28	-6.98**
Share of employment in manufacturing at peak	-48.23	-1.29
College attainment	-34.32	-0.817
Model statistics		
<i>F</i> -statistic		17.21**
Adjusted R^2		0.53

NOTE: * $p < 0.10$, ** $p < 0.05$.**Table 7****Results of Model of 1990 Recession with Dichotomized College Attainment Based on U.S. Average ($n = 44$)**

Variable	Coefficient	<i>t</i> -statistic
Constant	8.82	2.65**
Percent decline in employment (peak to trough)	-470.17	-7.05**
College attainment exceeds U.S. average (1 or 0)	-3.01	-0.814
Model statistics		
<i>F</i> -statistic		25.85**
Adjusted R^2		0.53

NOTE: * $p < 0.10$, ** $p < 0.05$.**Table 8****Results of Model of 1990 Recession with Dichotomized College Attainment Based on Sample Mean ($n = 44$)**

Variable	Coefficient	<i>t</i> -statistic
Constant	8.26	2.56**
Percent decline in employment (peak to trough)	-467.22	-6.99**
College attainment exceeds sample median (1 or 0)	-2.10	-0.57
Model statistics		
<i>F</i> -statistic		24.49**
Adjusted R^2		0.52

NOTE: * $p < 0.10$, ** $p < 0.05$.

the level of college attainment and recovery length is not optimal, but the relationship reaches the 5 percent level of significance when college attainment is dichotomized into a dummy variable reflecting above-average college attainment. The model results do not change when smaller MSAs are added to the sample or when the data are compressed from monthly frequency to quarterly frequency.

There are a number of reasons to view these results with some skepticism. The first is that the relationship is significant when observing the 2001 recession, but not the 1990 recession. There are a few things worth noting about the model for the 1990 recession in spite of the fact that there is not a significant relationship between recovery times and college attainments. One is that the sizes of the coefficients for the college attainment variables are all smaller in the 1990 model than in the 2001 model. So, even if the relationship between college attainment and recovery time was significant in the model of the 1990 recession, it would still be weaker than that observed in the model of the 2001 recession. Another interesting characteristic of the 1990 model, again setting aside the question of significance, is that even with a smaller number of right-hand-side variables, the R^2 is much higher for the models of the 1990 recession than the models for the 2001 recession. In fact, a simple equation in which recovery length after the 1990 recession is associated with only a constant term and an MSA's percent decline in employment explains more than half of the variation in recovery time. These differences suggest that the 1990 and 2001 recessions were distinct from one another.

Another reason for skepticism is that that 12 of the 50 largest MSAs experienced a contraction but have not yet recovered from the 2001 recession; and some of these, most notably Boston, San Francisco, and San Diego, have relatively high college attainment. It is also true that some areas with high college attainment—such as San Diego, San Francisco, and San Jose—were among the slowest to recover from the 1990 recession. On the other hand, some areas with low college attainment—such as Detroit and Cleveland—still had not recovered from the 2001 recession by the beginning of 2007. The inclusion of those MSAs might

have improved the relationship between college attainment and recovery length.

It is also true that the independent variable in this model, college attainment, may not be the best proxy for worker adaptability. The fact that adding more observations to the sample did not improve the results is another source of uncertainty. Further research, such as an examination of these same MSAs during previous contractions and recoveries, or perhaps with a more refined measure of worker adaptability than simple college attainment, is thus necessary.

The fact that the relationship between college attainment and recovery length was significant for the 2001 recession but not for the 1990 recession could alternatively be seen to support, rather than contradict, the proposed relationship between college attainment as a measure of worker adaptability and faster recovery from recessions. The period of weak employment growth following the 1990 recession has commonly been referred to as a “jobless recovery” that differed from past recessions. The recovery from the 2001 recession was similar in that there was also a weak employment recovery, but different in that the apparently permanent decline in manufacturing suggests that a structural, and not just cyclical, change took place in the U.S. economy after the 2001 recession. After the 2001 recession, a larger number of workers needed to adapt themselves to new industries and firms, so it was more important for MSAs to have more adaptable and skilled workers to recover from the 2001 recession as compared with the 1990 recession. The fact that the relationship between educational attainment and recovery was stronger for the 2001 recession than for the 1990 recession provides some empirical support for the proposition that the 1990 and 2001 recessions were different from one another.

This finding is also consistent with previous research that has established a correlation between skills and growth and the ability of MSAs to adjust to structural change (Glaeser and Saiz, 2003). That, in turn, suggests that education and adaptability are more important to economic recovery when recessions have a larger component of structural change as opposed to a larger component of cyclical change. If observers such as Silvia (2006) are correct,

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and globalization will drive both continued structural changes in the U.S. economy and increased demand for educated workers, then future economic recoveries may be more influenced by educational attainment than those in the past.

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Transferable Tax Credits in Missouri: An Analytical Review

Paul Rothstein and Nathan Wineinger

In 2005, Missouri had 53 legally authorized tax credit programs. In this paper, the authors assemble basic information on all of these programs and further analyze the six largest (by tax credits issued) that include freely transferable credits. Their analysis focuses on the institutional features of these programs, the kinds of market failures or disparities they may address, and whether the design of each program is consistent with its economic rationale. The authors also consider whether the evaluation of each program by the state is consistent with its economic rationale. They conclude with a brief discussion of the transactions prices for the credits on which they have data and whether making the tax credits refundable as well as transferable could reduce the transactions costs associated with these programs. (JEL D61, H71, R58)

Federal Reserve Bank of St. Louis *Regional Economic Development*, 2007, 3(2), pp. 53-74.

In 2005, the state of Missouri had 53 legally authorized tax credit programs. At least 32 (and at most 38) actually issued credits in that year. The value of the credits issued was at least \$357 million dollars. This is a large number of programs, and the amount of tax revenue forgone is significant. The revenue is only a modest share of total state general revenue, however, about 5 percent.

An interesting feature of many Missouri tax credits is that they are to some degree transferable. Transferability allows an entity that has more tax credits than tax liability to sell what he or she cannot use. It therefore makes the credit useful to entities that have little or no state tax liability, so tax policy becomes a closer substitute for expenditure policy. Transferability also allows entities that receive multiyear credits for capital projects to sell the credits and obtain the financing they

need. On the other hand, a \$1 tax credit does not sell for \$1, but the credit costs the taxpayers of Missouri that amount when it is redeemed. Transferability therefore adds an extra dimension of costs and benefits to a tax credit.

Of the 53 tax credit programs mentioned above, 30 have credits that were officially designated as transferable (57 percent); and of the 32 programs we know actually issued credits in 2005, 17 issued transferable credits (53 percent). Transferability does not necessarily mean that one can sell the credits on e-Bay to the highest bidder, however. The state classifies tax credits as transferable or not, but the degree of transferability can be determined only by reading the authorizing legislation. Because it would not be practical to examine all of these programs, we focus mostly on the six largest programs (by value of credits issued in 2005) that issued what we consider to be “freely” transferable credits.

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The central question in which we are interested is whether each program is good public policy. We take this question to mean, in the broadest possible terms, is there something inefficient or unfair about the outcomes that would result if the program did not exist? We provide a general discussion of this question for each of the six largest tax credit programs (by number of credits issued) that have freely transferable credits. In doing this, we draw on current research in local public-sector economics and basic economic principles. Given the difficulty of the question and the limited amount of information available about these programs, however, we decided not to overly simplify matters just to provide “yes” or “no” answers.

We begin our analysis by identifying and describing the six largest programs. We then examine the way these programs are evaluated by the Missouri Department of Economic Development (DED), which has the formal responsibility for reviewing them. A necessary condition for good public policy is strong and regular administrative review. It is therefore appropriate to consider how these reviews help analyze the policies themselves. We also consider three recent reviews of the programs that were not done by DED.

We then turn to our basic question. If there is something inefficient about the outcomes that would occur or if growth would be slower if a program did not exist, then we should be able to identify a market failure that the program addresses. If there is something unfair about the outcomes that would occur if a program did not exist, then we should be able to identify the disparities or inequities that the program addresses. Thus, our basic question leads us to ask whether the program in question addresses some kind of market failure or corrects disparities or inequities. Furthermore, the answers to these questions provide some insight into how the program should be structured, how its key parameters should be chosen, and what variables should be measured to evaluate it. One can quantify the impact of a program in any number of ways (jobs created, services delivered, output produced, etc.). One cannot draw meaningful conclusions from these numbers unless the rationale for the program is clear.

In our conversations with various officials, we found general dissatisfaction with the fact that DED evaluates every program as if its purpose were economic development. This is DED’s job, however, so the criticism is not really of DED but its mandate. In doing what is expected of them, they ignore the distinctions between correcting market failures, reducing disparities, and promoting economic development. These are different goals, they imply different structural features for the programs, and they require the measurement of somewhat different variables for proper program evaluation. In many cases, DED’s approach forces a stark mismatch between their analysis and the analysis suggested by economic theory.

An additional matter for concern is simply how little analysis is actually being done. DED tends to produce lists of raw information about the impact of each program. In particular, they make no attempt to produce a single, bottom-line number of all the *tangible* benefits and costs for each program. By tangible program benefits and costs, we mean simply those impacts that can be plausibly converted into dollars and cents. Failing to quantify these impacts (to the greatest extent possible) is an enormous problem. There are always important *intangible* benefits and costs, as well—the highly subjective aspects of programs that preserve state history, reduce poverty, and promote opportunity, and which may also interfere with property rights or reduce incentives to work. Concrete information about tangible benefits and costs is essential for having a rational debate over these intangible benefits and costs.

The next sections provide preliminary information about the programs, discuss the program evaluations done by DED and others, present our analysis of the programs, and then consider briefly whether making the tax credits refundable in addition to transferable would improve their cost effectiveness.

AN OVERVIEW OF MISSOURI TAX CREDIT PROGRAMS

We begin our analysis of Missouri transferable tax credit programs by placing them in the larger

context of all Missouri tax credit programs and the size of Missouri's government. First, tax credit programs are a popular policy tool in Missouri and most tax credits are in fact transferable. The credits cause the state to forgo a significant amount of revenue in absolute terms. They cause just a modest loss as a share of all general revenue, though.

Lists of the tax credit programs in any year are available from two sources. The better-known is form MO-TC, which is issued by the Missouri Department of Revenue (DOR). This form lists the tax credits that DOR has some role in administering (44 in all).

A second list of tax credits appears as part of the budget instructions issued to Missouri's governmental departments by the Office of Administration. This list includes tax credits that DOR has no role in administering, but it also includes other kinds of tax preferences.¹

By using these lists and making inquiries at the relevant government agencies, we developed a spreadsheet with 53 tax credit programs for 2005. (See the appendix.) We have complete information for almost every program, but there are a few key omissions.

We regard the value of tax credits issued under a particular program in a given year as a good measure of the "importance" of the program in that year. This number reflects economic demand for the credits, which is the quantity (in dollars) that people want to acquire on existing terms.² We also say that a program is "active" in a given year if it issued any credits at all.

A brief glance at the appendix shows that, in 2005, many programs were inactive.³ Thus, the total number of programs is not really a good indicator of the aggregate importance of tax credits in Missouri. A more careful review of the data gives the following basic results:

¹ The list is available at www.oa.mo.gov/bp/budget.htm ("Attachment 8").

² Strictly speaking, this is true only if the amount actually issued is strictly less than the amount that *could have been issued* in that year. This was generally, but not always, the case.

³ Zeros in the spreadsheet are the actual values. Missing data is indicated by "N/A."

- Between 32 and 38 tax credit programs were active in 2005. We cannot state the exact number because of the lack of data for six programs.
- The value of credits issued by the 32 active programs for which we have data was about \$357 million dollars.
- Of these 32 programs, 17 issued credits designated as "transferable."⁴
- The value of the credits issued by these 17 programs was about \$266 million dollars. This is 74 percent of the total value of the credits issued by the 32 active programs for which we have data.⁵

On the one hand, \$357 million is a significant sum. On the other, in 2005, the Missouri state government reported about \$6.933 billion in general revenue.⁶ If the revenues forgone from the 32 programs could have been collected without changing any other figures, general revenue would have been about 5 percent higher. Gathering this revenue would not have increased Missouri's ranking of 42nd among U.S. states in terms of tax revenue per capita.⁷

MISSOURI TRANSFERABLE TAX CREDIT PROGRAMS

In this section, we explain our selection of the six transferable tax credit programs, which we examine in detail. We find that all of these programs are primarily administered by the DED and appear on form MO-TC.

⁴ This does not mean the same thing in all cases, however. Two important programs, the Low Income Housing Tax Credit Program and the Certified Capital Companies Program, issue transferable credits that are not "freely" transferable. We will discuss this further later in the paper.

⁵ If we exclude credits issued under the Low Income Housing Tax Credits Program and the Certified Capital Companies Program, we still find that 47 percent of all credits issued are transferable.

⁶ This is revenue apart from the earnings of utilities and certain other operations.

⁷ The state ranking is for 2004, the most recent year for which the data is available; see The Tax Foundation, www.taxfoundation.org/. These figures do not include credits issued by the six programs for which we do not have data.

Table 1**Tax Credit Programs Issuing Over \$5 Million in Credits (FY 2005)**

Tax credit program	Transferable	Amount issued
Missouri Low Income Housing Tax Credit	Yes	\$83,477,412
Historic Preservation Tax Credit Program	Yes	80,213,374
Enterprise Zone Tax Benefit Program	No	39,066,023
Infrastructure Tax Credit Program	Yes	28,964,274
Brownfield Redevelopment Program (remediation)	Yes	14,808,297
Certified Capital Companies Program (CAPCO)	Yes	14,000,000
Neighborhood Assistance Tax Credit Program	No	11,263,385
Missouri Health Insurance Pool	No	10,015,203
Affordable Housing Assistance Tax Credit Program	Yes	9,133,829
New and Expanded Business Facility Credit	Yes	8,779,797
Missouri Business Use Incentives for Large-Scale Development (BUILD)	No	8,419,707
Examination Fee Tax Credits	No	7,576,530
Missouri Property and Casualty Guaranty Association	No	7,227,710
Neighborhood Preservation Tax Credit	Yes	6,784,310

NOTE: Bold typeface indicates the six programs with freely transferable credits.

Table 1 comes from data in the appendix. We sorted the data by the amount of tax credits issued and extracted those programs issuing more than \$5 million in credits. This gives us 14 programs.

Of the 14, eight are designated as “transferable.” This does not mean the same thing in all cases, however. In particular, two of the eight programs are subject to special restrictions. For example, the Low Income Housing Tax Credit Program follows federal rules. These require an entity using the credit to have an ownership interest in a housing project. Thus, it is not enough just to have Missouri tax liability. One cannot simply auction the credits to the highest bidder.

Similarly, the Certified Capital Companies Program follows rules specified by the DED: Rule 4 CSR 80-7.040(G) states that tax credits may be sold only to insurance companies. Again, one cannot simply sell the credits to the highest bidder.

In contrast, the statutes for the remaining six tax credits define relatively free markets for those credits. These six transferable tax credit programs are indicated in bold in Table 1, and they are the focus of our analysis.

BRIEF DESCRIPTIONS OF THE SIX PROGRAMS⁸

In this section we briefly describe the six programs: We give a short statement of (i) what each credit is for, (ii) whether the credit is awarded at the discretion of the DED or is an entitlement to any entity that meets the statutory criteria, (iii) the taxes against which it can be applied, (iv) whether there are carry-back and carry-forward provisions, (v) and any special statutory language about transferability.

Historic Preservation Tax Credit Program

- The credit is given for 25 percent of the qualifying expenses incurred in the rehabilitation of an approved historic structure. The total costs of the rehabilitation must be more than half of the acquisition cost of the property.
- The credit is an entitlement.

⁸ This information comes from DED (2005 and 2006) and the relevant statutes.

- The credits can be applied to the following taxes: income (excluding withholding), bank, insurance premium, and other financial institution.
- There is a carry-back of 3 years and a carry-forward of 10 years.⁹
- By statute the credits cannot be issued to nonprofit entities, but they can buy and sell them.¹⁰

Infrastructure Tax Credit Program

- The credit is equal to 50 percent of a contribution made to local governments or state agencies to finance the development of publicly owned essential public purpose infrastructure such as water, sewer, gas, electrical systems, streets, bridges, rail spurs, storm water drainage, and other projects.
- The credit is discretionary.
- The credits can be applied to the following taxes: income (excluding withholding), corporate franchise, bank, and insurance premium.
- There is a carry-forward of 5 years.
- By statute, the credits must transact at between 75 and 100 percent per dollar of credit. There is also an explicit stipulation that the seller of the credits must report the payment received from the buyer as taxable income and that the buyer must recognize the difference between the face value and his payment to the seller as taxable income.

Brownfield Redevelopment Tax Credit Program (Remediation)

- The tax credit is worth up to 100 percent of the costs of cleaning contaminated commercial or industrial sites that have been underutilized for at least 3 years. The project must

retain 25 jobs or create 10 new jobs; if the property is privately owned, a city or county government must endorse the project; and all projects must be accepted into the state's Voluntary Cleanup Program.

- The credit is discretionary.
- The credits can be applied to the following taxes: income (excluding withholding), corporate franchise, bank, insurance premium, and other financial institution.
- There is a carry-forward of 20 years.

Affordable Housing Assistance Tax Credit Program

- The credit is equal to 55 percent of a contribution made to a nonprofit housing organization. The contribution must be used for the building, procurement, rehabilitation, and in some cases basic operating expenses of a housing organization that provides certain types of housing, either affordable (targeted toward persons below 50 percent of median income) or market rate (targeted toward "rebuilding communities" as defined by statute).
- The credit is discretionary.
- The credits can be applied to the following taxes: income, corporate franchise, bank, insurance premium, other financial institution, and express company.
- There is a carry-forward of 10 years.

New and Expanded Business Facility Tax Credit Program

- Tax credits are awarded during a 10-year window based on capital invested in new facilities and the creation of new jobs. Facilities must belong to certain industries, including manufacturing, research and development, and computer-related services. The credit amount varies depending on whether the facility is owned by an existing Missouri company or a new company and whether the facility is in a distressed area or not. The program is being phased out, but

⁹ A carry-back of three years allows a taxpayer whose tax credits exceed his current tax liability to use the excess to offset tax liability from the three previous years. This presumably generates a refund from the state if the taxpayer is not in arrears.

¹⁰ We confirmed this last point with the DED.

credits could potentially be issued through 2014.¹¹

- The credit is an entitlement.
- The credits can be applied to the following taxes: income (excluding withholding), insurance premium, and insurance company retaliatory.
- There is no carry-forward for the recipient (but see the next bullet point).
- Regarding transferability, the statutory language is similar to that for the infrastructure tax credit program. The credits must transact at between 75 percent and 100 percent per dollar of credit. There is an explicit stipulation that the seller of the credits must report the payment received from the buyer as taxable income, and the buyer must recognize the difference between the face value and his payment as taxable income.

Neighborhood Preservation Tax Credit Program

- This tax credit is worth a minimum of 15 percent and maximum of 35 percent of eligible expenses for new construction or rehabilitation of owner-occupied homes incurred in communities with median household incomes that are low for their metropolitan statistical area.
- The credit is an entitlement.
- The credits can be applied to the following taxes: income (excluding withholding), corporate franchise, bank, insurance premium, and other financial institution.
- There is a carry-back of 3 years and a carry-forward of 5 years.
- There is an explicit statement that the credit cannot be claimed in addition to any other state tax credits.

¹¹ Only facilities that applied for the credit on or before December 16, 2004, and began operations on or before that date are eligible. In each year in the 10-year window in which at least \$100,000 in new capital is invested (or \$1,000,000 in replacement facilities) and two new jobs are created (25 for office jobs), an existing Missouri company receives a credit of \$100 (\$150 in distressed areas) per new job and a new Missouri company a credit of \$75 (\$125 in distressed areas) per new job.

THE SCOPE OF THE DED'S PROGRAM EVALUATIONS

The tax credit analysis form issued by the Missouri Office of Administration states the following:

Per 33.282.2 RSMo, each department authorized to offer deductions, exemptions, credits or other tax preferences shall submit the estimated amount of such tax expenditures for the fiscal year beginning July 1st of the following year and a cost/benefit analysis of such tax expenditures for the preceding fiscal year.

Pursuant to this, the DED performs an annual analysis of the tax credits that it administers.

Table 2 compiles DED data on *fiscal* costs and benefits for our six programs for 3 consecutive years. In other words, all of the reported costs and benefits, whether direct, indirect, current-year, or long-run, are simply *state tax revenues* that are lost or gained as a result of the programs.

Four features of the data are worth noting:

- The data on fiscal costs and benefits in the 2005 report is more complete than that in the previous two reports.
- The direct cost, total cost, and tax credits redeemed for each program are generally all equal. In other words, the DED measures program costs by the tax credits redeemed. This may be generally reasonable, but over the long run economic development credits (such as the infrastructure and business facility credits) create additional fiscal costs, for example, through demand for additional government services.
- Using FY 2005 data, DED forecasts fiscal net losses in the long run (from the credits granted in 2005) for the tax credit programs for historic preservation, affordable housing, and neighborhood preservation. These programs also generate net losses in the short run.
- Two additional programs, for infrastructure and brownfield redevelopment, generate net losses in the short run (but net benefits

Table 2**Fiscal (Tax Revenue) Costs and Benefits from Each Program**

Tax credit program FY 2003	Issued	Redeemed (also direct cost)	Total cost	Direct benefit	Total benefit	Total net benefit (2003)	Benefit-cost ratio (5-year)
Historic Preservation	89,214,177	42,979,369	42,979,369	NA	25,324,223	-17,655,146	1.25 to 1
Infrastructure	11,227,302	10,250,949	10,250,949	NA	395,877	-9,855,072	0.04 to 1
Brownfield Redevelopment (remediation)	15,481,014	6,817,545	6,817,545	NA	18,972,677	12,155,132	5.65 to 1
Affordable Housing Assistance	6,223,933	7,811,713	7,811,713	NA	1,904,063	-5,907,650	0.49 to 1
New and Expanded Business Facility	9,168,145	7,890,982	7,890,982	NA	38,187,629	30,296,647	7.95 to 1
Neighborhood Preservation	5,085,754	3,975,948	3,975,948	NA	1,365,838	-2,610,110	0.68 to 1
Tax credit program FY 2004	Issued	Redeemed (also direct cost)	Total cost	Direct benefit	Total benefit	Total net benefit (2004)	Benefit-cost ratio (5-year)
Historic Preservation	75,692,322	66,089,980*	67,408,896	8,822,146	15,291,920	-52,116,976	NA
Infrastructure	39,401,435	10,020,578	5,841,779**	22,250,124	37,739,094	31,897,315	NA
Brownfield Redevelopment (remediation)	4,250,346	16,101,975*	16,021,091**	1,181,802	1,849,955	-14,171,136	NA
Affordable Housing Assistance	10,378,534	7,554,503	7,793,500	793,546	1,553,279	-6,240,221	NA
New and Expanded Business Facility	8,702,349	7,826,417*	5,812,636**	10,214,799	16,213,525	10,400,889	NA
Neighborhood Preservation	4,440,206	4,001,293*	4,216,773	491,053	960,679	-3,256,094	NA
Tax credit program FY 2005	Issued	Redeemed (also direct cost)	Total cost	Direct benefit	Total benefit	Total net benefit (2005)	Benefit-cost ratio (12-year)
Historic Preservation	80,213,374	74,532,355	74,532,355	5,267,125	7,524,464	-67,007,891	0.66 to 1
Infrastructure	28,964,274	25,953,799	25,953,799	10,286,639	14,695,198	-11,258,601	5.21 to 1
Brownfield Redevelopment (remediation)	14,808,297	10,627,870	10,627,870	2,639,434	3,770,620	-6,857,250	2.89 to 1
Affordable Housing Assistance	9,133,829	7,702,860	7,702,860	1,073,787	1,533,982	-6,168,878	0.32 to 1***
New and Expanded Business Facility	8,779,797	4,546,330	4,546,330	7,914,995	11,307,136	6,760,806	24.05 to 1
Neighborhood Preservation Tax	6,784,310	8,461,503	8,461,503	698,739	998,198	-7,463,305	0.19 to 1***

NOTE: *Redeemed is slightly less than direct cost; **reports negative indirect costs; ***5-year.

Table 3**Reported Impact of \$1 of Redeemed FY 2005 Tax Credits on Personal Income (over 5 or 12 years)**

Tax credit program	New personal income
Historic preservation**	\$11.68
Infrastructure**	137.01
Brownfield (remediation)**	64.18
Affordable housing*	5.59
Business facility**	499.70
Neighborhood preservation*	3.32

NOTE: *Indicates 5 years; **indicates 12 years.

in the long run). Only the business facility credit generates net benefits in both the short and long run.

Regarding tangible nonfiscal costs and benefits, DED produces a range of information on the impact of each program in the short and long run. For illustration, Table 3 presents the long-run increase in personal income for every dollar of redeemed credits in 2005.¹²

From an economic perspective, there are two basic problems with the way DED evaluates the tax credit programs. First, DED regards each program as if its purpose were economic development (i.e., to create faster growth or more jobs than would occur otherwise). This is not true, however, because some of these programs are more likely to correct market failures or reduce economic disparities than promote development. These different goals imply different structural features for the programs and require the measurement of somewhat different variables for proper program evaluation. We discuss these points in greater detail in the section on program design and evaluation. In many cases, DED's focus on development forces a stark mismatch between its analysis and the analysis suggested by economic theory.

¹² This is clearly the total effect over the given time period and not the average annual effect over the time period. We do not know whether DED uses a discount rate in computing the total effect.

A second problem comes from DED's tendency to produce lists of raw information, like that in Table 3. Although this information should certainly be reported, lists of facts about impact are not a substitute for a single, bottom-line number of all the *tangible* benefits and costs for each program. By tangible program benefits and costs, we mean simply those impacts that can be plausibly converted into dollars and cents. Public policies often have important *intangible* benefits and costs. These highly subjective items are key components of policies that preserve state history, reduce poverty, and promote opportunity, but may also interfere with property rights or reduce the incentive to work. Concrete information about tangible benefits and costs is essential for having an informed debate over intangible benefits and costs. Economic analysis cannot remove the subjective element in program evaluation. It can, however, narrow it substantially. Lists of raw data do not do this.¹³

OTHER EVALUATIONS OF THE PROGRAMS AND OF DED

We found three recent evaluations of the Missouri tax credit programs besides those done by DED. We present a brief discussion of each.

The State Auditor's Report

In February 2001, the Missouri state auditor issued a report entitled, "Review of the State Tax Credits Administered by the Department of Economic Development" (Office of the State Auditor of Missouri, Claire McCaskill, 2001). For our purposes, the report makes three points worth noting.

First, the report is very critical of data collection at DED. The accuracy of the collected data is one concern, but the report focuses more sharply on omissions in data collection:

Key data such as number of actual jobs created per project, average wages, total investment, industry sectors affected, street addresses for the projects and other relevant information are not

¹³ For an excellent example of one way to produce a single measure of all tangible costs and benefits, see Bartik (2005).

captured in a centralized management information system and in some cases are not captured at all. (p. 2)

Data is not maintained or monitored for 16 of 33 tax credit programs. These 16 programs are formula-based tax credits, which are granted if the project meets the eligibility requirements set out in the authorizing statute. Department of Economic Development management stated that it is not the responsibility of the agency to monitor the economic impact that formula-based tax credits have on the state because they have no discretion over whether projects qualifying for the tax credit receive the tax credit. (p. 7)

Second, the report is very critical of “cost-benefit analysis.” It is not entirely consistent in its use of this term, but the intent is clear:

A former economist for the Department of Economic Development, who was the former Manager and Senior Economist for Office of Research and Policy Analysis, said that he has read a lot of the economic literature and attended numerous national conferences and has come to the conclusion that no one knows how to perform a useful cost-benefit analysis of tax credit programs. (p. 4-5)

This comment, while not entirely without foundation, is presented as a definitive statement about a fundamental limit of economic analysis. We think it more accurately reflects something else. One cannot perform a meaningful cost-benefit analysis of tax credit programs by treating all of them as if they were economic development programs. Some programs address market failures and others address disparities and inequities. Only some are supposed to promote economic development. One can use cost-benefit analysis in all cases, but one must measure different variables depending on the purpose of the program. Ignoring these differences and reviewing non-development credits as if they were development credits is an incoherent exercise. It should not be surprising that no one knows how to do it.

The auditor concludes by calling for an “impact analysis” of each program. She had her staff analyze four of the smaller tax credit programs. In each case she used DED’s regional forecasting

model to consider the impact of the tax credits issued on state revenues, employment, wages, and gross state product. To make the simulation internally consistent, she assumed that government spending would fall by the amount of the tax credits redeemed. She also sent surveys to recipients of the tax credits, asking if the credits were essential to their decision to make their investments.¹⁴

The impact analysis conducted by the auditor was a step in the right direction in 2001. It is now conducted by DED for all its tax credit programs, and the results are presented in its annual report.¹⁵

Don Phares’s Report

Don Phares (2003) of the University of Missouri at St. Louis produced a report for the Department of Revenue entitled, “Examining Missouri’s Tax System: Tax Expenditures—A First Step.”¹⁶

The term “tax expenditures” in the title is very general. It encompasses all exceptions to general tax rules that result in less tax liability for some entity. Tax credits are one kind of tax expenditure.

Professor Phares echoes the auditor’s call for more data collection, noting the progress DED made in evaluating the programs under its discretion; he adds, however, that “proper evaluation would allow the extent to which [the credits] meet their intended purpose to be addressed” (p. 13). This refrain is likely to be repeated into the indefinite future, until such time as (i) it is recognized that the intended purpose may be to address some kind of market failure or to correct disparities and inequities and not merely to promote economic development, (ii) key program parameters are

¹⁴ Asking the recipients of the tax credits if the credits were essential to their decisions is a highly problematic exercise. The recipients have their own agendas, and they may answer these questions in pursuit of those agendas. This may not entail giving a thoughtful or candid answer to a direct question. One of the purposes of social science and nonexperimental statistics is to provide methods for learning about the causes of choices without relying on answers to these kinds of questions. Furthermore, while the auditor is certainly right that the only way to answer the question with “absolute certainty” in each case is to know the subjective thoughts of the project managers (p. 19), a “statistical certainty” is often enough for policy purposes.

¹⁵ We were told that DED does try to determine for the discretionary programs whether the credits are essential to the investment decisions.

¹⁶ The report contains references to other evaluations of Missouri tax credits that we do not discuss here.

Table 4**Recommendations of the Incentives Review Committee**

Tax credit program	Recommendation
Historic preservation	Maintain
Infrastructure ¹⁷	Maintain
Brownfield (remediation)	Maintain ¹⁸
Affordable housing	Maintain
Business facility	(Not evaluated) ¹⁹
Neighborhood preservation	Improve

chosen in ways that are consistent with each program's rationale, and (iii) each program is evaluated in ways that are consistent with its rationale.

Incentives Review Committee Report

The most recent report on tax credit programs in Missouri was undertaken by the Incentives Review Committee of the Missouri Department of Economic Development (2005), pursuant to a request by Governor Matt Blunt. It has the efficient title, "Report on Missouri Incentives Programs."

This report is excellent in two respects. First, it pays careful attention to the different purposes of each program. Second, it recommends evaluation criteria that bear some connection to these purposes. This makes an interesting contrast with the auditor's report on the issue of (broad) cost-benefit analysis. Indeed, its two pages of criteria for program evaluation really go beyond cost-benefit analysis and include objectives such as transparency and low transactions costs (although it uses different language). The committee then provides a brief evaluation of each program and a recommendation to "improve," "combine," "delete," or "maintain" the program.

Unfortunately, it is not clear how rigorously the committee used these criteria in developing

their evaluations and recommendations. The report gives only a brief discussion of each program and provides little explanation for its conclusions. Furthermore, implementing these criteria would have required extraordinary amounts of money, time, data, and expertise. Even with those, the analysts would have needed to conjecture about missing information and poorly understood behavioral responses. This would have necessitated a sensitivity analysis to determine how the conclusions depended on the assumptions. If the authors did these things, they do not mention them in the report.

We report in Table 4 the recommendations in the report for our six programs.

The only recommendation for change is for the neighborhood preservation credit. The authors note that

[t]he program is based on a first-come allocation and the demand is significantly more than the annual allocation. As such, the distribution of funding has been on a lottery basis, which does not provide for a concentrated redevelopment impact. Also, some areas in the city-wide distressed areas are not lower income. (p. 40)

Their recommendation for improvement is to

[e]nact legislation to award funds on a competitive basis, requiring a comprehensive neighborhood redevelopment plan. (p. 40)

PROGRAM DESIGN AND PROGRAM EVALUATION

Are Missouri's tax credit programs good public policy? We take this question to mean, in the broadest possible terms, is there something inefficient or unfair about the outcomes that would result if the program did not exist? We provide a general discussion of this question for each of the six largest tax credit programs (by number of credits issued) that have freely transferable credits. In doing this, we draw on current research in local public-sector economics and basic economic principles. Given the difficulty of the question and the limited amount of information available about these programs,

¹⁷ This is listed in the report as the "MDFB Contribution Credit."

¹⁸ The summary table at the front of the report recommends "combine," but in the discussion of the program the recommendation is "maintain." The former appears to be an editing error.

¹⁹ This program is being phased out, as noted in the section that provides brief descriptions of these programs.

however, we decided not to overly simplify matters just to provide “yes” or “no” answers.

Although our analysis is qualitative and not quantitative, we must still keep a specific thought experiment in mind to evaluate the programs consistently. Following standard practice in the evaluation of tax policy, the initial assumption is that the tax credit program does not exist and the state budget is balanced. The tax credit is then introduced. This creates a shortfall in revenue that must be met either by a reduction in spending or an increase in other taxes: We generally consider both cases. These changes taken together have equity and efficiency implications.

Historic Preservation Tax Credit Program

Recall our basic question in the context of this program. This tax credit causes Missouri to have more historic structures than market forces alone would provide. Is there something inefficient or unfair about this?

The main reason that the market may fail here is that historic structures provide benefits to more people than just the owners of the structures. For example, the structures may enhance local property values or generate local tourism. These benefit many non-owners. In the formal language of economics, the market for historic structures does not capture the “willingness to pay” of all the beneficiaries, who receive a “positive externality.” The result is that too few structures are preserved. This simple point has useful implications for program design and evaluation.

First, an efficient program must have a carefully chosen subsidy rate. This rate should induce additional preservation activity up to the point where the total additional benefits from this activity (higher property values, tourism, etc.) exactly balance the total additional cost. These costs would include the “true” cost of the subsidy itself. This could well be more than the dollar value of the subsidy, both because raising revenue is costly and because any state services forgone to fund the subsidy may be worth more than their simple dollar value. We have no way to determine whether the current 25 percent subsidy rate is proper according to these economic criteria.²⁰

Second, even if the policy were well designed, it would never pass a cost-benefit test that sums up only fiscal costs and benefits (i.e., state tax revenues that are lost or gained). This is true at the current subsidy rate and should also be true at the proper subsidy rate, given the highly indirect links between historic preservation activities and state tax revenues. The policy should, however, pass a cost-benefit test that sums up all tangible costs and benefits. As noted above, these benefits would include the willingness to pay of all the beneficiaries of the program. Also as noted above, a bottom-line estimate of all the tangible net benefits would allow citizens and legislators to debate, in a structured (albeit subjective) way, the intangible aspects of the program.

Finally, we note that the program is an entitlement. Entitlement tax credits, in contrast to discretionary credits, are often criticized because they probably give more money for activities that would have been undertaken anyway.²¹ To the extent this occurs, the program is redistributing income from one group of taxpayers (those who fund the subsidy or lose government benefits) to another (those who engage in preservation activities). This may not be entirely bad, however. If the subsidy is funded by higher taxes and some of those taxpayers receive positive externalities from historic structures, then they are now simply paying for something that they previously enjoyed for free.

More generally, one should not overreact to the incidental income transfers that will always be part of simple market solutions to market failures. The alternative is to make the tax credit discretionary, but this would certainly lead to higher administrative costs. There is a trade-off between incidental redistribution and administrative costs that should not be forgotten and which may not be small.

Infrastructure Tax Credit Program

This program allows local communities to have more and better public infrastructure than they would otherwise have. Again we ask, Is there

²⁰ Note that these criteria have nothing to do with economic development.

²¹ Entitlement credits also tend to be reviewed less carefully. This is a separate issue that is emphasized in Bartik (2005).

something inefficient or unfair about the amount of infrastructure in different communities that market forces alone would provide?

Regarding efficiency, there is a large literature in economics on the question of whether there is a “race to the bottom” in the funding of public infrastructure. The idea is that jurisdictions (communities, states, and even countries) compete with each other for investment and workers by cutting taxes. The question is whether taxes can be cut so far that even basic infrastructure that all residents desire will not be provided. If so, then an infrastructure tax credit program may enhance efficiency by allowing communities to finance the proper amounts of infrastructure despite the race to the bottom.

Whether or not a race to the bottom occurs depends on a number of factors. These include whether communities have the appropriate tax instruments at their disposal, whether there is a large or small number of communities, who owns the land and other spatially fixed inputs to production, the objectives of the local government, and the time frame of the analysis (short run or long run). We think it is fair to say that, except for the very long run, the consensus in the literature is that in the real world there is quite likely to be a race to the bottom in tax cuts and therefore in the funding of public infrastructure.²²

Given that a race to the bottom tends to exist, the recommendations of economic theory for program design and evaluation are similar to the recommendations for the historic preservation program. The program should subsidize local spending with a carefully chosen subsidy rate. This rate should be selected so that each jurisdiction, acting in a decentralized way, chooses the proper quantity of infrastructure. It can be shown that this essentially requires a subsidy rate equal to the tax revenue each region fears it would lose if it increased its own tax rate (from the rate it would choose without the tax credit program). With this subsidy, the quantity of infrastructure would be such that any further increase in infrastructure would generate

only as much consumption as would be foregone to pay for that increase.

Recall that the actual program does not subsidize the local tax rate; rather, it funds \$1 of infrastructure through a 50 cent donation from private citizens and (presumably) a 50 cent reduction in state services. Because the structure of this program is so far removed from the basic economic incentives that an efficient program would take into account, it is difficult to evaluate. Given that a market failure exists, the program may well be better than nothing, but that is a low bar to surmount.

Finally, we note that, as with the historic preservation program, even a well-designed infrastructure credit program would never pass a cost-benefit test that sums up only fiscal costs and benefits. There would be little or no connection between the fiscal cost of the proper subsidy and any extra revenues the state would receive from any extra infrastructure attributable to the program. The policy should, however, pass a cost-benefit test that sums up all tangible costs and benefits.

Brownfield Redevelopment Tax Credit Program (Remediation)

This program causes Missouri to have fewer commercial/industrial sites with hazardous substances than market forces alone would allow. Is there something inefficient or unfair about the latter? After all, if land in a certain area becomes scarce enough, then eventually even brownfields will find buyers.

The problem with brownfields, of course, is the problem of negative externalities. Brownfields are ugly, they present various hazards (for example, to ground water), and they deter development somewhat beyond their immediate boundaries. The externalities presumably differ wildly depending on the type of hazardous waste involved and its proximity to different communities. This line of thought leads to the same kind of conclusions as have been drawn for the previous two programs, with one major exception. The huge variation in external damages at different locations provides an economic rationale for making the program discretionary, which it is.

Unfortunately, if this is the right perspective on this program, then another feature of its design

²² The literature is large, but the key papers on which this conclusion is based are by Zodrow and Mieszkowski (1986), Wildasin (1989), and Myers (1990).

presents a paradox. The program charges *taxpayers* 100 percent of the costs of cleanup, but only when a third party, a commercial developer, is interested in the site. This is very odd. If a brownfield is creating large enough negative externalities that citizens are willing to pay 100 percent of the costs to clean it up, then one should expect them to raise the funds and do so. The broad-based taxes they would generally use are not ideal for this purpose, but they are practical and they work. We therefore expect most brownfields to exist where citizens' willingness to pay is less than the cost of cleanup. This makes it efficient to wait until a third party—the developer—has a willingness to pay to make up the difference. However, because the developer does not pay anything for the cleanup, it is unlikely that his willingness to pay *does* make up the difference. The developer's interest is simply an expressed desire to have something when other people pay for it. If citizens' and the developer's total willingness to pay is less than the actual cost of the cleanup, then the cleanup is inefficient. It is also arguably unfair to have the taxpayers pay the full cost.

Affordable Housing Assistance Tax Credit Program

This program is obviously intended to be redistributive. One must recognize this fact to properly evaluate the program. An efficiency issue is also present, however. We discuss this first.

Affordable housing policy in one state always raises the question of whether it may lead people from other states to move to the more generous state. This is a variation on the race to the bottom discussed under the infrastructure program. Unfortunately, although state action can help overcome the problems of fiscal competition among local communities, federal action would be required to help overcome the problems of fiscal competition among the states. The movement of low-income residents in response to differences in benefits across states has been studied for many years by all kinds of social scientists. For the purposes of the analysis here, we assume that these movements are small. The proper evaluation of this program by DED would make use of this literature.

In contrast with the historic preservation program, this program's focus on redistribution makes more central the issue of whether the program creates housing that would not have been created otherwise. In other words, it is important to know if the program merely "crowds out" private spending on the construction of affordable housing. If the program is ineffective in this way and funded by higher taxes, then there is an income transfer from taxpayers to developers and the poor are most likely neither harmed nor helped. If the program is ineffective and funded by reduced state spending in other areas, then the poor may well be worse off.

It is surely unlikely that an affordable housing program crowds out for-profit private-sector spending. It is a fair question, however, whether it crowds out not-for-profit or philanthropic spending on affordable housing. If it does, then it is difficult to see how the poor could be helped, and any reductions in other programs to fund this program could be harmful. Again, there is a literature in economics on this issue, and the proper evaluation of this program by DED would make use of it.

No purely redistributive program would pass a cost-benefit test of either fiscal costs and benefits or tangible costs and benefits. Tangible costs and benefits would exactly balance if funds could be raised costlessly and services delivered without waste; but neither is true. Thus, tangible costs will always exceed benefits. Again, this makes it important to have a single, bottom-line measure of the tangible net costs of the program. Presenting this information on, say, a per-beneficiary basis might allow citizens and legislators to debate, in a structured way, whether the intangible benefits of housing assistance are sufficient to offset the costs.

New and Expanded Business Facility Tax Credit Program

At long last, we come to an economic development program. In other words, this program does not correct a market failure or attempt to redistribute income to assist the poor. It is an attempt to create growth that market forces alone would not provide.²³

²³ "Missed development opportunities" may result from missing capital markets or missing insurance markets. These market failures are qualitatively different from the externalities discussed above, however.

DED's methods of analysis are directed toward addressing this question. Even here, however, it is possible to take the analysis much further than DED does. A proper evaluation of economic development programs would have the following steps, of which the DED does only the first.

1. For all programs, determine the long-run fiscal benefits and costs.
2. For all programs, determine the other tangible long-run benefits and costs. Roughly, these benefits would include the extra earnings of residents due to improvements in local labor markets and increases in property values, while costs would include any extra public services or infrastructure required.
3. Combine steps 1 and 2 to compute a single, bottom-line measure of the tangible net benefits or net costs of each program.
4. Perform sensitivity analysis to remedy the problems of missing information and poorly understood behavioral responses, which affect steps 1 and 2. For step 1, there is uncertainty over how much activity would take place if not for the credits and uncertainty over the multiplier effects used to compute long-run fiscal benefits. For step 2, the benefits and costs of the labor market effects, for example, are sensitive to whether the new jobs are going to people who were formerly unemployed or not.²⁴

The business facility credit raises tax revenue in the short and long run. The only issue, then, is whether the costs of additional public services that come with development could offset the large gains reported by the state. This seems highly unlikely.

Neighborhood Preservation Tax Credit Program

The efficiency rationale for this program is very similar to the rationale for the historic preservation program. Preserving neighborhoods has benefits to people besides those who buy, sell, and improve homes in those neighborhoods. We refer

the reader to the discussion of the historic preservation program for the basic analysis.

Finally, recall the recommendation of the Incentives Review Committee for this program (see the section on other evaluations of the programs and of the DED). They argue that redevelopment should be concentrated and the subsidy given to activities that are part of a redevelopment plan. This is correct if the external benefits of neighborhood preservation are highly dependent on concentrated activity. This seems likely. No similar recommendation was made for the historic preservation program, but this is a sound position with regard to efficiency if even somewhat isolated historic structures have external value.

SHOULD THE TRANSFERABLE CREDITS ALSO BE REFUNDABLE?

We conclude by considering a reform that would be applicable to all but the business facility tax credit. None of the other five credits is refundable. That is to say, once an entity has offset all of its tax liability it cannot use the remainder to receive a refund from the state. The only way an entity with little or no tax liability (like a nonprofit organization) can benefit from the tax credits is by selling them. In contrast, the business facility credit is refundable and transferable.²⁵

A potential problem with credits that are just transferable is straightforward: A \$1 tax credit does not sell for \$1, but the credit will cost the taxpayers of Missouri that amount when it is redeemed. Money that was supposed to support public programs ends up as profit to the buyer of the credits. In contrast, if the tax credits were *also* refundable, then every tax dollar spent on the tax credit would go toward the intended activity.

²⁴ This is emphasized in Bartik (2005).

²⁵ The refundability and transferability of the business facility credit are somewhat constrained, however. Missouri Revised Statutes, Chapter 135, Section 135.110 states, "[T]o the extent such credits exceed the taxpayer's Missouri tax on taxable business income, [they] shall constitute an overpayment of taxes and in such case, be refunded to the taxpayer provided such refunds are used by the taxpayer to purchase specified facility items." If the credits are sold, the selling price must be at least 75 percent of the face value. This seemed like a minor constraint, however, which is why we consider the credit to be freely transferable.

Table 5**Transactions Prices for Tax Credits**

Program	Observations	Average sale price per dollar	Standard deviation	Average transaction
Historic preservation	3,624	90 cents	5 cents	\$178,622
Brownfield (remediation)	816	91 cents	6 cents	137, 442
Neighborhood preservation	1,322	87 cents	9 cents	28,658

To illustrate, we recently obtained data on all transactions from 2002-06 for the historic preservation, neighborhood preservation, and brownfield (remediation) credits.²⁶ As Table 5 shows, they all sell for about 10 cents (per dollar) below face value.

Many factors contribute to the discount on the tax credits. For arm's length transactions, the purchaser of the credit would take into account the competitive return on other uses of her capital. This in turn would depend on how long she expects her capital to be tied up in the investment, the riskiness of the investment, and the true net-of-tax return. As many people with whom we spoke emphasized, the tax consequences of transacting and using the credits is particularly important in evaluating the discount. For example, the profit from purchasing tax credits at a discount and then using them is itself taxable, and the use of the credits also causes a taxpayer who itemizes and pays ordinary income tax (as opposed to alternative minimum tax) to lose some of her federal deduction for state taxes paid. Whether or not these factors could explain the discount, especially for short-term investments, is the subject of ongoing research.

Refundability, especially when coupled with transferability, is a reform that merits further exploration. It is not without its critics, however. Refundability is of no value to agents who need immediate liquidity. For them, transferability is essential. This is most likely for people using the credits as part of the financing for large capital projects. Also, refundability requires an extra

degree of cooperation from the government. The state is relatively passive in allowing a taxpayer to sell a credit and take a deduction. The state must act in sending a refund. At least during a recession, the holder of a tax credit who has no tax liability may still want to sell it to someone who has tax liability, even with a discount, if he believes the state may delay paying the refund.²⁷ At the very least, these points make it clear that refundability should be considered in conjunction with transferability and not as a substitute for it.

CONCLUSIONS

One theme we have emphasized throughout the analysis is that, before one considers the specific goals of a program, one must understand why a program is needed at all. Is there something inefficient or unfair about the outcomes that would result if the program did not exist? Specific goals that exist without a careful analysis of this basic question are likely to be arbitrary and inconsistent.

We pose this basic question for each of the six largest programs (by value of credits issued in 2005) that issued "freely" transferable credits and see where it leads.

More precisely, we ask whether the program addresses a market failure, corrects disparities or inequities, or promotes economic development. We then see how these questions relate to program design and evaluation.

²⁶ Transactions prices for the affordable housing credit are not available; there seems to have been only one transaction of the business facility credit (which is also refundable); and data on the infrastructure tax credit is still being prepared for us.

²⁷ It has also been suggested to us that refundable tax credit payments count toward the annual constitutional spending limits in Missouri (the Hancock Amendment) and that recent rulings by the IRS may eliminate income recognition for transferable credits. Evaluating these claims is outside the scope of our analysis here.

This brings us to our second theme. It is a thankless (and flawed) task to evaluate every program as if its purpose were economic development. Different goals imply different structural features for the programs. They also require the measurement of somewhat different variables for proper evaluation. To evaluate a program that corrects an externality, one must gather some information about that externality. To evaluate a program that corrects disparities or inequities, one must talk explicitly about who gains from the program and who loses from the state spending that will be reduced because of the tax revenue forgone as a result of the program.

Third, we emphasize the need for analysis. Lists of raw data about the impact of a policy are not the same thing as evaluation. A proper evaluation develops a single, bottom-line number of all tangible net benefits or costs. This is the only way to set up a rational and informed debate over the subjective or intangible benefits and costs of a program.

In closing, it seems to us that proper program evaluation simply cannot be done right now in Missouri. The Department of Economic Development has great expertise but fundamentally works for whoever occupies the governor's office. This may explain their narrow focus, uniform approach, and tendency to report data instead of conclusions. The state auditor has the necessary independence but lacks the expertise. Outside academics have the expertise but lack the specialized knowledge that accrues to people who evaluate public programs for a living. The state will have many, perhaps even more, tax credit programs into the foreseeable future. It ought to consider creating an organization, perhaps akin to the Congressional Budget Office, with the independence, expertise, and accumulated knowledge that leads to the very best program evaluation.

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APPENDIX

All Tax Programs, Sorted by Amount Issued, FY 2005

Alpha code	Name	Authorization, RSMo.	Transferable	Refundable
LHC	Missouri Low Income Housing	135.350 to 135.363	Yes	No
HPC	Historic Preservation TCP	253.545 to 253.561	Yes	No
EZC	Enterprise Zone	135.200 to 135.270, 135.429	No	Yes
IDC	Infrastructure TCP	100.286(6)	Yes	No
RTC	Brownfield Redevelopment Program (remediation)	447.700 to 447.718	Yes	No
	Certified Capital Companies (CAPCO) Program	135.500 to 135.529	Yes	No
NAC	Neighborhood Assistance	32.100 to 32.125	No	No
	Missouri Health Insurance Pool	376.975	No	No
AHC	Affordable Housing Assistance TCP	32.105 to 32.125	Yes	No
BFC	New and Expanded Business Facility Credit	135.100 to 135.150, 135.258	Yes	Yes
BUC	BUILD (Missouri Business Use Incentives for Large-Scale Development)	100.700 to 100.850	No	Yes
	Examination Fee Tax Credits (exam)	148.400	No	No
	Missouri Property and Casualty Guaranty Association	375.774	No	No
RCN	Neighborhood Preservation Tax Credit	135.475 to 135.487	Yes	No
YOC	Youth Opportunities	135.460 and 620.1100 to 620.1103	No	No
NEC	New Enterprise Creation	620.635 to 620.653	Yes	No
NGC	New Generation Cooperative Incentive	348.430	Yes	No
TDC	Transportation Development	135.545	Yes	No
DPC	Development Tax Credit	32.110 to 32.125	Yes	No
APU	Agricultural Product Utilization Contributor	348.430	Yes	No
RCC	Rebuilding Communities	135.535	Yes	No
BJI	Brownfield "Jobs and Investment"	447.700 to 447.718	No	At DED discretion
MHC	Maternity Home	135.600	No	No
BEC	Bond Enhancement/Bond Guarantee	100.297	Yes	No
DVC	Shelter for Victims of Domestic Violence	135.550	No	No
SBI	Small Business Incubator	620.495	Yes	No
WGC	Wine and Grape Production	135.700	No	No
CPC	Charcoal Producers	135.313	Yes	No
SBG	Small Business Guaranty Fees/Loan Guarantee Fee	135.766	No	No
	Examination Fee Tax Credits (valuation)	148.400	No	No
	Examination Fee Tax Credits (registration)	148.400	No	No
FDA	Family Development Account	208.750 to 208.775	No	No
DTC	Brownfield (demolition)	447.700 to 447.718	No	No
CBC	Community Bank Investment/Community Development Corporation	135.400 to 135.430	Yes	No
DRC	Development Reserve	100.25	Yes	No
DFH	Dry Fire Hydrant	320.093	Yes	No
EFC	Export Finance	100.25	Yes	No
FPC	Film Production	135.750	Yes	No
MQJ	Missouri Quality Jobs	620.1875 to 620.1890	Yes	Yes
SCC	Missouri Business Modernization and Technology	348.300 to 348.318	Yes	No
	Missouri Life and Health Guaranty Association	376.745	No	No
NEZ	New Enhanced Enterprise Zone	135.1050 to 135.1075	Yes	Yes
REC	Qualified Research Expense/Research	620.1039	No	No
SDT	Skills Development Credit	N/A	Yes	No
ISB	Small Business Investment/Capital	135.400 to 135.429	Yes	No
SMC	Sponsorship and Mentoring Program	135.348	No	No
SCT	Shared Care	660.055	No	No
BFT	Bank Franchise Tax	148.064	No	N/A
BTC	Bank Tax Credit for S Corporation Shareholders	143.471	Yes	No
	Cellulose Casings	260.285	No	No
DAC	Disabled Access	135.490	No	No
WEC	Processed Wood Energy	135.300	Yes	No
ATC	Special Needs Adoption	135.325	Yes	No

APPENDIX, cont'd**All Tax Programs, Sorted by Amount Issued, FY 2005**

Name	Carry forward	Carry back	Multi-year
Missouri Low Income Housing	5	3	10
Historic Preservation TCP	10	3	
Enterprise Zone	0	0	
Infrastructure TCP	5	0	
Brownfield Redevelopment Program (remediation)	20	0	
Certified Capital Companies (CAPCO) Program	Until used	0	
Neighborhood Assistance	5	0	
Missouri Health Insurance Pool	Until used (excess over tax liability)	No	
Affordable Housing Assistance TCP	10	0	
New and Expanded Business Facility Credit	10	0	
BUILD (Missouri Business Use Incentives for Large-Scale Development)	0	0	
Examination Fee Tax Credits (exam)	5	0	
Missouri Property and Casualty Guaranty Association	No	No	3
Neighborhood Preservation Tax Credit	5	3	
Youth Opportunities	5	0	
New Enterprise Creation	10	0	
New Generation Cooperative Incentive	5	3	
Transportation Development	10	3	
Development Tax Credit	5	0	
Agricultural Product Utilization Contributor	5	3	
Rebuilding Communities	5	3	
Brownfield "Jobs and Investment"	0	0	
Maternity Home	4	0	
Bond Enhancement/Bond Guarantee	10	0	
Shelter for Victims of Domestic Violence	4	0	
Small Business Incubator	5	0	
Wine and Grape Production	0	0	
Charcoal Producers	7	0	
Small Business Guaranty Fees/Loan Guarantee Fee	0	0	
Examination Fee Tax Credits (valuation)	0	0	
Examination Fee Tax Credits (registration)	0	0	
Family Development Account	0	0	
Brownfield (demolition)	20	0	
Community Bank Investment/Community Development Corporation	10	0	
Development Reserve	5	0	
Dry Fire Hydrant	7	0	
Export Finance	5	0	
Film Production	5	0	
Missouri Quality Jobs	0	0	
Missouri Business Modernization and Technology	10	0	
Missouri Life and Health Guaranty Association	No	No	5
New Enhanced Enterprise Zone	0	0	
Qualified Research Expense/Research	5	0	
Skills Development Credit	5	0	
Small Business Investment/Capital	10	3 (Distressed)	
Sponsorship and Mentoring Program	4	0	
Shared Care	0	0	
Bank Franchise Tax	0	0	N/A
Bank Tax Credit for S Corporation Shareholders	4	0	
Cellulose Casings	0	0	
Disabled Access	Unlimited	0	
Processed Wood Energy	4	0	
Special Needs Adoption	4	0	

APPENDIX, cont'd**All Tax Programs, Sorted by Amount Issued, FY 2005**

Name	Cap type	Cap amount	Federal deductions
Missouri Low Income Housing	Annual (100% of federal LIHTC)		Yes
Historic Preservation TCP	None		Yes
Enterprise Zone	None		No
Infrastructure TCP	Annual, flexible	10,000,000	No
Brownfield Redevelopment Program (remediation)	None		No
Certified Capital Companies (CAPCO) Program	10-year cumulative		None
Neighborhood Assistance	Annual	18,000,000	No
Missouri Health Insurance Pool	Total of pool		None
Affordable Housing Assistance TCP	Annual	11,000,000	Yes
New and Expanded Business Facility Credit	None		No
BUILD (Missouri Business Use Incentives for Large-Scale Development)	Annual	15,000,000	No
Examination Fee Tax Credits (exam)	Total of pool		None
Missouri Property and Casualty Guaranty Association	Total of pool		None
Neighborhood Preservation Tax Credit	Annual	16,000,000	No
Youth Opportunities	Annual	6,000,000	No
New Enterprise Creation	Cumulative	20,000,000	No
New Generation Cooperative Incentive	Annual	6,000,000	No
Transportation Development	Annual	10,000,000	No
Development Tax Credit	Annual	6,000,000	No
Agricultural Product Utilization Contributor	Annual	6,000,000	No
Rebuilding Communities	Annual	8,000,000	No
Brownfield "Jobs and Investment"	None		No
Maternity Home	Annual	2,000,000	N/A
Bond Enhancement/Bond Guarantee	Cumulative	50,000,000	No
Shelter for Victims of Domestic Violence	Annual	2,000,000	None
Small Business Incubator	Annual	500,000	No
Wine and Grape Production	None		No
Charcoal Producers	None	0	N/A
Small Business Guaranty Fees/Loan Guarantee Fee	None		No
Examination Fee Tax Credits (valuation)	Total of pool		None
Examination Fee Tax Credits (registration)	Total of pool		None
Family Development Account	Annual	4,000,000	No
Brownfield (demolition)	None		No
Community Bank Investment/Community Development Corporation	Cumulative	6,000,000	No
Development Reserve	None	None	No
Dry Fire Hydrant	Annual	500,000	No
Export Finance	None	None	No
Film Production	Annual	1,500,000	No
Missouri Quality Jobs	Annual	12,000,000	No
Missouri Business Modernization and Technology	Cumulative	9,000,000	No
Missouri Life and Health Guaranty Association	Total of pool		None
New Enhanced Enterprise Zone	Annual	4,000,000	No
Qualified Research Expense/Research	Annual	10,000,000	No
Skills Development Credit	Annual	6,000,000	N/A
Small Business Investment/Capital	Cumulative	13,000,000	No
Sponsorship and Mentoring Program	Appropriation	0	None
Shared Care	None		N/A
Bank Franchise Tax	None		No
Bank Tax Credit for S Corporation Shareholders	None		No
Cellulose Casings	Appropriation		No
Disabled Access	None		Yes
Processed Wood Energy	None		No
Special Needs Adoption	Annual		Yes

APPENDIX, cont'd**All Tax Programs, Sorted by Amount Issued, FY 2005**

Name	Fiscal year 2005			
	Authorized	Issued	Redeemed	Total outstanding
Missouri Low Income Housing	183,106,160	83,477,412	65,392,601	156,095,405
Historic Preservation TCP	116,566,180	80,213,374	74,532,355	61,343,552
Enterprise Zone	39,066,023	39,066,023	25,294,754	0
Infrastructure TCP	10,398,000	28,964,274	25,953,799	37,308,093
Brownfield Redevelopment Program (remediation)	15,515,319	14,808,297	10,627,870	4,180,427
Certified Capital Companies (CAPCO) Program	14,000,000	14,000,000	13,429,309	45,440,744
Neighborhood Assistance	16,000,000	11,263,385	9,286,880	14,000,000
Missouri Health Insurance Pool	10,015,203	10,015,203	6,121,053	9,066,945
Affordable Housing Assistance TCP	11,000,000	9,133,829	7,702,860	15,000,000
New and Expanded Business Facility Credit	8,779,797	8,779,797	4,546,330	3,085,774
BUILD (Missouri Business Use Incentives for Large-Scale Development)	7,842,167	8,419,707	3,770,557	4,649,150
Examination Fee Tax Credits (exam)	7,576,530	7,576,530	2,650,135	5,703,974
Missouri Property and Casualty Guaranty Association	7,227,710	7,227,710	5,965,556	1,998,707
Neighborhood Preservation Tax Credit	13,609,190	6,784,310	8,641,503	6,824,880
Youth Opportunities	6,438,159	4,476,005	3,211,185	5,000,000
New Enterprise Creation	0	4,212,752	2,504,561	7,155,490
New Generation Cooperative Incentive	6,000,000	3,915,000	3,334,935	6,749,210
Transportation Development	6,682,249	3,226,568	3,545,219	7,000,000
Development Tax Credit	5,591,000	2,866,000	2,487,152	6,762,264
Agricultural Product Utilization Contributor	6,000,000	2,081,343	1,639,540	4,593,008
Rebuilding Communities	6,970,463	1,736,701	1,694,006	1,955,245
Brownfield "Jobs and Investment"	406,273	1,646,927	1,726,687	0
Maternity Home	953,987	953,987	743,635	N/A
Bond Enhancement/Bond Guarantee	870,275	870,275	594,034	276,241
Shelter for Victims of Domestic Violence	2,000,000	648,618	515,034	1,251,032
Small Business Incubator	500,000	361,913	246,807	384,983
Wine and Grape Production	313,683	313,683	179,323	0
Charcoal Producers	146,606	146,606	70,151	575,597
Small Business Guaranty Fees/Loan Guarantee Fee	103,591	103,591	11,224	0
Examination Fee Tax Credits (valuation)	35,000	35,000	12,000	23,000
Examination Fee Tax Credits (registration)	24,430	24,430	24,430	0
Family Development Account	780,000	7,625	12,875	4,000
Brownfield (demolition)	0	0	0	0
Community Bank Investment/Community Development Corporation	0	0	2,021,628	1,250,000
Development Reserve	0	0	0	0
Dry Fire Hydrant	0	0	17,228	65,000
Export Finance	0	0	0	0
Film Production	1,500,000	0	322,079	752,705
Missouri Quality Jobs	0	0	0	0
Missouri Business Modernization and Technology	0	0	164,894	337,341
Missouri Life and Health Guaranty Association	0	0	0	0
New Enhanced Enterprise Zone	0	0	0	0
Qualified Research Expense/Research	0	0	1,626,864	5,823,761
Skills Development Credit	0	0	0	0
Small Business Investment/Capital	0	0	109,050	969,475
Sponsorship and Mentoring Program	854,443		0	0
Shared Care	N/A	N/A		0
Bank Franchise Tax	N/A	N/A	2,543,523	0
Bank Tax Credit for S Corporation Shareholders	N/A	N/A	941,460	N/A
Cellulose Casings	N/A	N/A	382,540	0
Disabled Access	N/A	N/A	56,761	N/A
Processed Wood Energy	3,348,890	N/A	3,700,285	N/A
Special Needs Adoption	N/A	N/A	2,578,354	N/A

APPENDIX, cont'd**All Tax Programs, Sorted by Amount Issued, FY 2005**

Name	Special status
Missouri Low Income Housing	
Historic Preservation TCP	
Enterprise Zone	Phasing out
Infrastructure TCP	
Brownfield Redevelopment Program (remediation)	
Certified Capital Companies (CAPCO) Program	Cap reached
Neighborhood Assistance	
Missouri Health Insurance Pool	
Affordable Housing Assistance TCP	
New and Expanded Business Facility Credit	Phased out
BUILD (Missouri Business Use Incentives for Large-Scale Development)	
Examination Fee Tax Credits (exam)	
Missouri Property and Casualty Guaranty Association	
Neighborhood Preservation Tax Credit	
Youth Opportunities	
New Enterprise Creation	Cap reached
New Generation Cooperative Incentive	Cap is sum of both DOA tax credits
Transportation Development	Expired
Development Tax Credit	6,000,000 cap only for FY 2005-07
Agricultural Product Utilization Contributor	Cap is sum of both DOA tax credits
Rebuilding Communities	
Brownfield "Jobs and Investment"	
Maternity Home	
Bond Enhancement/Bond Guarantee	Cap remaining 48,812,870
Shelter for Victims of Domestic Violence	Moved to DSS
Small Business Incubator	
Wine and Grape Production	
Charcoal Producers	Expired
Small Business Guaranty Fees/Loan Guarantee Fee	
Examination Fee Tax Credits (valuation)	
Examination Fee Tax Credits (registration)	
Family Development Account	
Brownfield (demolition)	
Community Bank Investment/Community Development Corporation	Cap reached
Development Reserve	Issued from account, no accounts opened
Dry Fire Hydrant	Expired
Export Finance	Issued from account, no accounts opened
Film Production	
Missouri Quality Jobs	Starts FY 2006, and cap set at 7,000,000
Missouri Business Modernization and Technology	Cap reached
Missouri Life and Health Guaranty Association	None since 1998
New Enhanced Enterprise Zone	Starts FY 2006
Qualified Research Expense/Research	Expired
Skills Development Credit	Repealed after no one used it
Small Business Investment/Capital	Cap reached
Sponsorship and Mentoring Program	Not funded
Shared Care	
Bank Franchise Tax	
Bank Tax Credit for S Corporation Shareholders	
Cellulose Casings	
Disabled Access	
Processed Wood Energy	
Special Needs Adoption	Outstanding N/A, DNR authorizes, Department of Revenue redeems no cross check

APPENDIX, cont'd**All Tax Programs, Sorted by Amount Issued, FY 2005**

Name	Missouri agency
Missouri Low Income Housing	Housing Development Commission
Historic Preservation TCP	Department of Economic Development
Enterprise Zone	Department of Economic Development
Infrastructure TCP	Development Finance Board
Brownfield Redevelopment Program (remediation)	Department of Economic Development
Certified Capital Companies (CAPCO) Program	Department of Economic Development
Neighborhood Assistance	Department of Economic Development
Missouri Health Insurance Pool	Department of Insurance
Affordable Housing Assistance TCP	Missouri Housing Development Commission
New and Expanded Business Facility Credit	Department of Economic Development
BUILD (Missouri Business Use Incentives for Large-Scale Development)	Development Finance Board
Examination Fee Tax Credits (exam)	Department of Insurance
Missouri Property and Casualty Guaranty Association	Department of Insurance
Neighborhood Preservation Tax Credit	Department of Economic Development
Youth Opportunities	Department of Economic Development
New Enterprise Creation	Department of Economic Development
New Generation Cooperative Incentive	Agricultural and Small Business Development Authority
Transportation Development	Department of Economic Development
Development Tax Credit	Department of Economic Development
Agricultural Product Utilization Contributor	Agricultural and Small Business Development Authority
Rebuilding Communities	Department of Economic Development
Brownfield "Jobs and Investment"	Department of Economic Development
Maternity Home	Department of Social Services
Bond Enhancement/Bond Guarantee	Department of Economic Development
Shelter for Victims of Domestic Violence	Department of Public Safety
Small Business Incubator	Department of Economic Development
Wine and Grape Production	Department of Economic Development
Charcoal Producers	Department of Natural Resources
Small Business Guaranty Fees/Loan Guarantee Fee	Department of Economic Development
Examination Fee Tax Credits (valuation)	Department of Insurance
Examination Fee Tax Credits (registration)	Department of Insurance
Family Development Account	Department of Economic Development
Brownfield (demolition)	Department of Economic Development
Community Bank Investment/Community Development Corporation	Department of Economic Development
Development Reserve	Development Finance Board
Dry Fire Hydrant	Department of Economic Development
Export Finance	Development Finance Board
Film Production	Department of Economic Development
Missouri Quality Jobs	Department of Economic Development
Missouri Business Modernization and Technology	Department of Economic Development
Missouri Life and Health Guaranty Association	Department of Insurance
New Enhanced Enterprise Zone	Department of Economic Development
Qualified Research Expense/Research	Department of Economic Development
Skills Development Credit	Department of Economic Development
Small Business Investment/Capital	Department of Economic Development
Sponsorship and Mentoring Program	Department of Elementary and Secondary Education
Shared Care	Department of Health, Division of Senior Services
Bank Franchise Tax	Department of Revenue
Bank Tax Credit for S Corporation Shareholders	Department of Revenue
Cellulose Casings	Department of Revenue
Disabled Access	Department of Revenue
Processed Wood Energy	Department of Natural Resources
Special Needs Adoption	Department of Revenue



How Well Are the States of the Eighth Federal Reserve District Prepared for the Next Recession?

Gary A. Wagner and Erick M. Elder

Economic downturns often force state policymakers to enact sizable tax increases or spending cuts to close budget shortfalls. In this paper the authors make use of a Markov-switching regression model to empirically describe the expansions and contractions in the states of the Eighth Federal Reserve District. They use the estimated parameters from the switching regressions to form probability distributions of the revenue shortfalls states are likely to encounter in future slowdowns. This allows them to estimate the probability that each state's projected fiscal-year-end balances will be sufficient to offset the fiscal stress from a recession. (JEL E6, H7)

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Economic downturns often force state policymakers into difficult financial positions because of the procyclical nature of tax bases and the countercyclical nature of government spending. Because of the fiscal institutions that exist in many states (such as balanced budget rules and borrowing restrictions), policymakers' options for mitigating periods of fiscal stress are effectively limited to the use of reserve balances, spending reductions, and tax increases.

In this paper we follow Wagner and Elder (2006) and use a Markov-switching regression model to empirically describe the expansions and contractions in states of the Eighth Federal Reserve District.¹ Using the estimated parameters, we form probability distributions of the revenue shortfalls states are likely to encounter during the next downturn. Based on fiscal-year-end projections for 2007,

we then estimate the probability that each state's reserve balances will be sufficient to offset the fiscal stress from a recession. In other words, we estimate the probability that each state in the Eighth Federal Reserve District will be able to avoid spending reductions or tax increases if a recession were to begin in 2007.

In the following sections of the paper, we review previous research, outline our empirical methodology and findings, and offer concluding remarks.

STATE FISCAL CRISES AND "OPTIMAL" RAINY DAY FUNDS

An Overview of State Fiscal Crises and Policy Options

Although many factors contribute to periods of state fiscal pressure, the cyclical variability of revenue streams is generally considered to be the

¹ The Eighth District states are Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee.

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primary cause of fiscal crises (Holcombe and Sobel, 1997; Crain, 2003). Most state tax bases, including the primary bases of retail sales and wage and salary income, tend to be strongly procyclical. This means that revenue growth from these sources expands more rapidly than a state's economy during expansions and contracts more severely during downturns. Given the difficulty of forecasting recessions, state policymakers often find themselves in situations in which revenue is insufficient to match expenditure demands.

Policymakers normally rely on spending reductions, tax increases, and reserve balances accumulated during periods of revenue growth (or savings) to help mitigate unexpected budget shortfalls. Although the use of savings has expanded in recent decades, with nearly all states having a formal "rainy day" or budget stabilization fund to institutionalize the process, spending reductions and tax increases constitute the majority of state fiscal adjustments made during recessions. Following the 2001 national recession, for instance, the National Association of State Budget Officers (NASBO) reported that states increased taxes by nearly \$18 billion during fiscal years 2002 through 2004 and also reduced budgeted spending by nearly \$30 billion over the same period.² Moreover, states used more than \$9 billion in reserve balances during this period to help close budget gaps, which is considerably more than the \$1 billion in savings tapped during the 1990-91 downturn (Holcombe and Sobel, 1997).

States in the Eighth Federal Reserve District were not immune to the difficult times associated with the 2001 recession. Table 1 reports the tax and spending adjustments for each state in the Eighth District for fiscal years 2002 through 2004.

Eighth District states increased taxes by nearly \$3.3 billion from 2002 through 2004, with all of the increases occurring in fiscal years 2003 and 2004. Three states—Illinois, Indiana, and Tennessee—accounted for more than 95 percent of the tax

increases in the District. Arkansas, Kentucky, and Missouri made modest tax adjustments, while Mississippi was the only state in the District to avoid tax increases during the slowdown.

On the expenditure side, Illinois, Indiana, and Missouri were responsible for more than 80 percent of the District's after-budget adjustments. Most of these spending cuts occurred in 2002 and 2003, with only Illinois and Indiana making changes in 2004. Tennessee had the smallest expenditure adjustments during the recession, with \$64 million in cuts in 2003.

Across the nation, states relied more heavily on spending adjustments than tax increases (roughly 60-40) during the 2001 downturn. In the Eighth District, however, only Arkansas, Illinois, and Indiana had a mix of tax increases and spending reductions that approximated the adjustments in the rest of the country. Kentucky, Mississippi, and Missouri relied almost exclusively on spending cuts, whereas Tennessee relied almost entirely on tax increases.

"Optimal" Rainy Day Funds

To assess how "prepared" states may be in future recessions, it is necessary to quantify the fiscal stress that states are likely to experience during a downturn. Previous studies have addressed this issue from the point of view of an "optimal" rainy day fund: If a state typically experiences fiscal stress equal to, say, 12 percent of the budget during a downturn, then savings equal to this amount would be sufficient to eliminate the need for spending cuts and tax increases throughout the slowdown.³

Early attempts to estimate the fiscal stress that states experience, such as Pollock and Suyderhoud (1986), Sobel and Holcombe (1996), and Navin and Navin (1997), did so by examining the cumulative deviation in the series of interest (either revenues or revenues plus expenditures) from a

² Given that the spending figures reported by NASBO do not account for spending reductions that occurred at the time state budgets were initially adopted, the aggregate reduction in state spending due to the recession is potentially much larger than \$30 billion. For a more detailed analysis of the 2001 recession on state fiscal health, see Garrett and Wagner (2004).

³ The use of savings to insure against unexpected budget shortfalls has several advantages over the use of spending cuts and tax increases. First, expenditure reductions and tax increases are unpopular among voters and therefore may be politically costly for policymakers. Second, the use of savings is an expansionary policy, whereas expenditure reductions and tax increases are contractionary policies. See Wagner and Elder (2005) for an overview on the effectiveness of state rainy day funds and reserve balances.

Table 1**Fiscal Adjustments of Eighth District States Due to 2001 Recession (in millions of current dollars)**

	2002	2003	2004	Total
Tax adjustments				
Arkansas	-2.3	0	109.3	107
Illinois	0	370	828	1,198
Indiana	-5.9	1,002	2	998.1
Kentucky	0	0	8	8
Mississippi	0	0	0	0
Missouri	-24.5	72.5	0	48
Tennessee	0	933.2	0	933.2
Eighth District total	-32.7	2,377.7	947.3	3,292.3
Total all states	303.8	8,018	9,550	17,871.8
Spending adjustments (made after budget enactment)				
Arkansas	171	73	0	244
Illinois	500	202	1,320	2,022
Indiana	468.7	345.7	60	874.4
Kentucky	231.5	90.1	0	321.6
Mississippi	150.6	47.8	0	198.4
Missouri	750	304.7	0	1,054.7
Tennessee	0	64	0	64
Eighth District total	2,271.8	11,27.3	1,380	4,779.1
Total all states	13,668	11,752	3,488	28,908

SOURCE: Various issues of *Fiscal Survey of the States*, National Association of State Budget Officers.

linear trend. For example, Sobel and Holcombe (1996) summed the cumulative shortfalls in expenditures and revenues from their respective trends from 1989 to 1992 and found that the average state would have needed reserves equal to 30 percent of expenditures to maintain trend expenditures and revenues during the 1990-91 recession. Examining individual states over a longer period, Pollock and Suyderhoud (1986) and Navin and Navin (1997) find that savings equal to 11 percent and 13 percent of the budgets in Indiana and Ohio, respectively, would be sufficient to offset a normal downturn.

Although Pollock and Suyderhoud (1986), Sobel and Holcombe (1996), and Navin and Navin (1997) provide only point estimates of state fiscal

stress, it is possible to form probability distributions of state expansions and contractions using a linear-trend approach. This would allow one not only to estimate a distribution of shortfalls that states are likely to experience, conditional on past recessions, but also to calculate how much states would need to save during expansions to insure against those possible shortfalls that a state may experience. However, using a linear-trend approach to form these distributions has a serious shortcoming because the parameters from a linear-trend model are chosen to minimize the deviation from trend rather than to best describe the distribution of expansions and contractions in the data. In other words, if expansions are defined as periods above

trend and contractions are defined as periods below trend, then there is no reason to believe that the expansions and contractions identified from a linear-trend model will correspond to actual business cycles.⁴

A recent paper by Wagner and Elder (2006) attempts to overcome this limitation by identifying state economic cycles using a Markov-switching regression model. The model explicitly assumes that a data series can be characterized by a series of distinct regimes (such as expansions and contractions), and recent work by Li, Lin, and Hsiu-hua (2005) suggests that the model performs very well in accurately identifying business cycle turning points. Estimation involves jointly determining the parameter values describing each regime that best fit the observed data. These parameters include an estimate of the mean growth rate of each regime, as well as the probabilities that a given observation came from either an expansion or contraction regime, which are known as transition probabilities.

Wagner and Elder (2006) demonstrate how the estimated parameters from a Markov-switching regression model may be used to construct empirical probability distributions of state expansions and contractions. Forming these distributions for each state, Wagner and Elder (2006) find that the typical state's expected revenue shortfall is between 2.9 and 3.5 percent of revenue when the shortfall is measured relative to zero revenue growth, and between 13 and 16 percent of revenue when the shortfall is measured relative to the average rate of revenue growth during expansions. In addition, forming distributions of complete cycles that are based on the uncertainty in expansions and contractions, Wagner and Elder find that the average state should save between 0.5 and 2.5 percent of revenue during each expansion period to accumulate reserve balances sufficient to weather the next downturn without the need for tax increases or spending cuts.

⁴ A related paper by Cornia and Nelson (2003) uses value-at-risk (VaR) to model the maximum budget shortfall that a state can expect to experience over a fixed time period. However, because VaR cannot model a data series as being generated by two (or more) probability distributions, such as expansions and contractions, it is impossible to form distributions of savings rates using VaR.

MARKOV-SWITCHING MODEL AND EIGHTH DISTRICT STATE BUSINESS CYCLES

Markov-Switching Model

The basic idea underlying regime-switching models is that many data series appear to be generated from multiple, distinct data-generating processes. As Hamilton (1994) notes, structural breaks or regime changes in a data series may be triggered by a variety of factors, including economic downturns, policy changes, and financial crises. If the regime changes are assumed to be predictable and known a priori, then they may simply be modeled using dummy variables. A more practical assumption is that the occurrence of such regime changes is unknown.

Econometric models featuring regime changes were first studied by Quandt (1958). Goldfeld and Quandt (1973) extended Quandt's simple switching model by allowing the data series to be generated by multiple regime switches that were governed by a Markov process so that the timing of the switches became dependent on the current regime in effect.

Although regime-switching regressions have a long history, they were not widely employed as a means of modeling business cycle movements until Hamilton (1989) extended Goldfeld and Quandt's model to include serially dependent data. Hamilton's model was a two-regime autoregression applied to the growth rate in real U.S. gross national product under the assumption that the regimes exogenously switched according to an unobserved Markov process. He found that not only did the model best fit the data when it identified distinct expansion and contraction regimes, but also that the changes between regimes closely matched the NBER recession turning points.

Although Markov-switching models have been widely used to examine aggregate data, they have only recently been applied to U.S. states. Owyang, Piger, and Wall (2005a) were the first to make use of the model and explored the extent to which state-level business cycles track the aggregate economy. Using Crone's (2002) monthly coincident index of state-level labor-market activity, they find

that, while state cycles generally follow the aggregate economy, individual states may shift into an expansion or contraction before the national economy shifts, continue in an expansion as the national economy contracts, and experience a downturn that is not associated with an aggregate downturn. Moreover, Owyang, Piger, and Wall (2005a) find that expansion growth rates depend positively on the state's education and age composition, whereas recession growth rates depend on the state's industry mix.

Because state revenue data are published only annually and also include discretionary changes to both tax rates and tax bases, they are poorly suited for isolating state-level business cycle movements. As a result, we follow both Owyang, Piger, and Wall (2005a) and Wagner and Elder (2006) by using Crone's (2002) monthly coincident index as our measure of state-level economic activity over the period 1979:09–2007:01. As Owyang, Piger, and Wall (2005a) note, an advantage of Crone's (2002) index is that, unlike many state-level data series, it exhibits distinct business cycle movements at a high frequency. On the other hand, because the index is constructed from only labor market variables, it is not as broad a measure of economic activity as gross domestic or gross state product.

Denoting a state's monthly growth rate in the coincident index at time t as $\dot{y}_t$, the two-regime Markov-switching model may be expressed as

$$\begin{aligned} \dot{y}_t &= \mu_{S_t} + \varepsilon_t, \\ \varepsilon_t &\sim N(0, \sigma_\varepsilon^2), \\ \mu_{S_t} &= \mu_0 + \mu_1 S_t, \quad \mu_1 > 0, \end{aligned} \quad (1)$$

where μ denotes the mean growth rate and ε_t is the error term at time t assumed to be normally distributed with variance σ_ε^2 . The growth rate in (1) is assumed to switch exogenously between two regimes, and the switches are governed by an unobserved regime variable, $S_t = \{0, 1\}$. When $S_t = 0$, which we refer to as the low-growth regime, $\dot{y}_t$ follows a stationary AR(0) process and is assumed to be generated by a normal distribution with a mean of μ_0 . When S_t switches from 0 to 1, which we call the high-growth regime, $\dot{y}_t$ is presumed to

have been generated from a normal distribution with a mean equal to $\mu_0 + \mu_1$. In short, the data-generating process for $\dot{y}_t$ is a mixture of two normal distributions having the same variance but potentially different means.

Although S_t is unobserved, its behavior is restricted to evolve according to a first-order, two-state Markov chain with the following transition matrix:

$$\begin{aligned} \mathbf{P} &= \begin{bmatrix} P(S_t = 0 | S_{t-1} = 0) & P(S_t = 1 | S_{t-1} = 0) \\ P(S_t = 0 | S_{t-1} = 1) & P(S_t = 1 | S_{t-1} = 1) \end{bmatrix} \\ (2) \quad &= \begin{bmatrix} P_{LL} & 1 - P_{LL} \\ 1 - P_{HH} & P_{HH} \end{bmatrix}, \end{aligned}$$

where P_{ij} is the transition probability of $S_t = i$, given that $S_{t-1} = j$. Hence, P_{HH} is the probability that economic activity is in the high-growth regime in period t , conditional on having been in the high-growth regime in period $t-1$. Placing restrictions on the behavior of S_t allows one to estimate the probability that economic activity is in an expansion (or contraction) regime in each time period, despite the fact that the underlying regime is assumed to be latent and unobservable.⁵

Markov-Switching Parameter Estimates for Eighth District States

The parameter estimates from each Eighth District state's Markov-switching regression are presented in Table 2. The expected duration of each regime, which is discussed in more detail below, is also presented.

Given that we are updating the specification used by Owyang, Piger, and Wall (2005a) and Wagner and Elder (2006) with more available data,

⁵ We also follow Owyang, Piger, and Wall (2005a) and estimate the models using the Bayesian Gibbs-sampling approach developed by Kim and Nelson (1998). Our prior distributions were set equal to the priors of Owyang, Piger, and Wall (2005a), and the joint posterior distributions were simulated using 10,000 replications with an additional 2,000 burn-in replications. The mean parameters (μ_0 and μ_1) are assumed to be normally distributed with means of 1 and -1, respectively, and a covariance matrix that is equal to the identity matrix. The transition probabilities, P_{HH} and P_{LL} , have prior beta distributions given by $\beta(9, 1)$ and $\beta(8, 2)$, implying means of 0.9 and 0.8, respectively. For a more detailed description of the estimation procedure, see Kim and Nelson (1998) and Owyang, Piger, and Wall (2005a). We acknowledge use of the computer routines described in Kim and Nelson (1999).

Table 2
Markov-Switching Parameter Estimates

	$\hat{\mu}_0 + \hat{\mu}_1$	$\hat{\mu}_0$	$\hat{P}_{HH}$	$\hat{P}_{LL}$	$E[t_H]$	$E[t_L]$	$E[t_H] + E[t_L]$
Arkansas	0.334*	-0.082*	0.982	0.940	55.55	16.71	72.27
Illinois	0.362*	-0.239*	0.978	0.950	45.72	20.08	65.80
Indiana	0.337*	-0.386*	0.981	0.910	54.90	11.22	66.12
Kentucky	0.350*	-0.194*	0.980	0.936	51.82	15.72	67.54
Mississippi	0.341*	-0.075	0.975	0.930	41.19	14.45	55.65
Missouri	0.362*	-0.216*	0.980	0.941	50.48	17.12	67.61
Tennessee	0.389*	-0.057	0.979	0.936	49.40	15.79	65.20
Median	0.351	-0.194	0.980	0.937	50.48	15.79	66.28

NOTE: The reported parameters are the means of the posterior distributions; *denotes that the 90 percent highest posterior density interval does not contain zero; and $E[t_H]$ and $E[t_L]$ denote the expected duration of expansions and contractions, respectively.

our parameter estimates are very similar to the parameter estimates of these studies. The median expansion and contraction (monthly) growth rates across the Eighth District states are 0.351 and -0.194, respectively. However, as shown in the first column of Table 2, expansion growth rates range from a high of 0.389 in Tennessee to a low of 0.334 in Arkansas; recession growth rates, shown in column 2, vary from a low of -0.386 in Indiana to a high of -0.057 in Tennessee. There is considerably more variation in the average recession growth rates across the District than in the average expansion growth rates. In fact, three states in the District, Arkansas, Mississippi, and Tennessee, have average recession growth rates less than -0.10, whereas three states have recession growth rates in excess (more negative) of -0.20.⁶

The estimated transition probabilities for each state, P_{HH} and P_{LL} , demonstrate the persistence in each regime. Given an expansion in period $t-1$, our estimates indicate that the median state in the District has a 0.980 probability of expanding in period t . Similarly, the probability is 0.937 that a contraction in period $t-1$ will be followed by a

contraction in period t . As Hamilton (1994) shows, the expected duration of regime j may be computed as $E[t_j] = (1 - P_{jj})^{-1}$ for $j = H, L$. (These figures are reported for each state in Table 2.) Although cycle durations vary noticeably, the median Eighth District state can expect to experience 50 months of expansion (denoted $E[t_H]$ in Table 2), followed by nearly 16 months of contraction (denoted $E[t_L]$ in Table 2), resulting in an expected business cycle of 66 months. The state with the longest expected expansion in the District, Arkansas, will on average experience continuous growth for one year longer than the state with the shortest expected expansion, Mississippi. Similarly, Illinois has the longest expected contraction in the District, at just over 20 months, which is 9 months longer than Indiana's shortest expected contraction.⁷ Overall, the Markov-switching model identifies nearly 77 percent of the observations as expansions, suggesting that the normal regime for all states in the District is one of growth.

⁶ See Owyang, Piger, and Wall (2005b) for a much more detailed analysis of the expansion growth rates, contraction growth rates, and regime turning points in Eighth District states.

⁷ Although we do not report the estimated probability that a state is in an expansion at a given point in time (S_t), it is generally very clear whether a state is currently in an expansion or contraction regime. Owyang, Piger, and Wall (2005b) examine these probabilities in detail for Eighth District states, and the interested reader is referred to their paper.

EMPIRICAL DISTRIBUTIONS OF STATE SHORTFALLS AND SAVINGS RULES

Probability Distributions of State Revenue Shortfalls

The estimated parameters of the Markov-switching regressions provide measures of the duration and amplitude of state economic cycles. In this section of the paper we follow Wagner and Elder (2006) and use these parameters to form probability distributions of state revenue shortfalls.

Although states may experience fiscal pressure on both the expenditure and revenue sides of the budget, Kusko and Rubin (1993) note that revenue streams are far more sensitive to business cycle movements than expenditures. We therefore focus only on state revenue, implying that our estimates should be interpreted as the minimum fiscal stress that states are likely to experience during a downturn.

In addition, given that state tax bases tend to be more volatile than economic activity, we define φ as the elasticity of a state's total revenue growth with respect to the growth in the state's economy. Each state's high- and low-regime growth rates in revenue may therefore be expressed as $g_H = \varphi(\hat{\mu}_0 + \hat{\mu}_1)$ and $g_L = \varphi\hat{\mu}_0$, respectively. The use of an elasticity allows us to alter the degree of revenue variability that is due to a state's particular tax mix. In short, we assume that changes in state-level revenue growth mimic changes in the state's economic activity (i.e., revenue growth has the same transition probabilities as overall economic activity), but permit revenue to be more volatile than overall economic activity. To explore the sensitivity of our estimates, we use three reasonable revenue elasticities (1.2, 1.5, and 1.8) for each state.

Given that P_{LL} is the probability that a contraction in period $t-1$ will be followed by a contraction in period t , the probability that a downturn will persist exactly t_L periods is given by

$$P_L(t_L) = P_{LL}^{t_L-1} - P_{LL}^{t_L}.$$

Therefore, if one computes (i) each state's revenue shortfall for a contraction lasting $t_L = 1, 2, \dots, \infty$ periods and (ii) the probability that a recession of

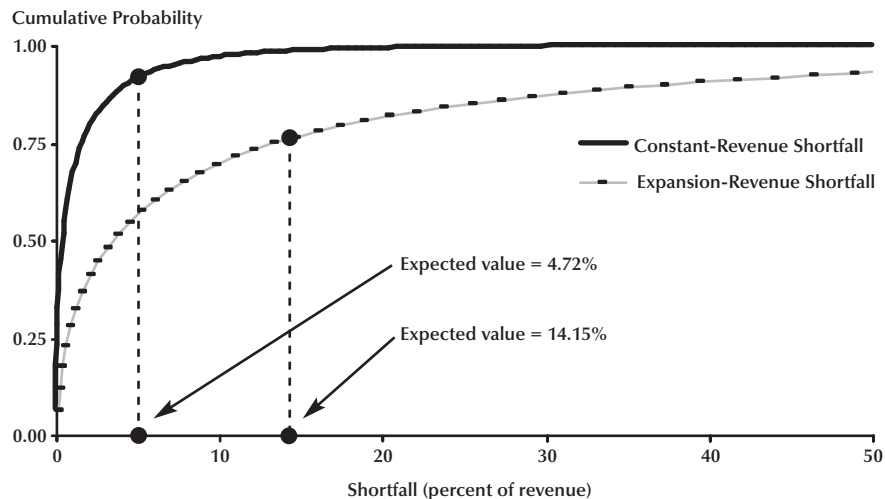
exactly that length will occur, the values may then be used to form a cumulative probability distribution. The distributions may then be used to determine how much states need to save to achieve a given level of certainty. In addition, for a given level of savings, the distributions can also be used to estimate the probability that this level of savings will be sufficient in a future downturn.

To calculate the shortfalls, we set revenue growth at a monthly rate of g_H during each expansion period and at a rate of g_L during each contraction period. Shortfalls are measured relative to an amplitude parameter, γ , that is nothing more than the target monthly growth rate in revenue during each recession period. Although γ may take on any value, we calculate shortfalls using both $\gamma = 0$ and $\gamma = g_H$. Setting $\gamma = g_H$ measures the shortfall relative to the average expansion growth rate in revenue, whereas setting $\gamma = 0$ measures the shortfall relative to zero revenue growth. In other words, $\gamma = g_H$ will generate the level of savings required to maintain the average expansion growth rate in revenue throughout a downturn, while $\gamma = 0$ yields the level of savings needed to sustain a constant level of revenue (or zero growth rate) throughout a slowdown.

If an expansion lasts t_H periods, then the state's level of revenue will be equal to $R_0(1 + g_H)^{t_H}$, where g_H is the (per-period) expansion growth rate in revenue and R_0 is the initial level of revenue. Assuming a contraction begins and the (per-period) growth rate in revenue switches to g_L , the level of revenue will then be equal to $R_0(1 + g_H)^{t_H}(1 + g_L)$ after the first low-growth period and the total revenue shortfall will be equal to $R_0(1 + g_H)^{t_H}[(1 + \gamma) - (1 + g_L)]$. Relative to revenue in the previous expansion period, which effectively measures the shortfall as a percentage of revenue, the shortfall may be written as $(1 + \gamma) - (1 + g_L)$. Hence, for a recession lasting t_L periods, the total revenue shortfall expressed as a share of revenue will be

$$(3) \quad \zeta(t_L) = \sum_{i=1}^{t_L} (1 + \gamma)^i - \sum_{i=1}^{t_L} (1 + g_L)^i.$$

For each state in the Eighth District, we assume that a recession may persist for a maximum of 30 years and construct shortfall distributions using

Figure 1**Cumulative Density Functions of Revenue Shortfalls****(Elasticity = 1.2, $g_H = 0.351$, $g_L = -0.194$, $P_{HH} = 0.980$, and $P_{LL} = 0.937$)**

both $\gamma = 0$ and $\gamma = g_H$, which we refer to as a “constant-revenue shortfall” and “expansion-revenue shortfall,” respectively. Figure 1 illustrates sample cumulative density functions for both shortfalls using the median parameter estimates in Table 2 and a revenue elasticity of 1.2.

The expected value of the constant-revenue shortfall is 4.72 percent of revenue, whereas the mean of the expansion-revenue shortfall is 14.15 percent. The expected shortfall values are reported for each District state in Table 3 using revenue elasticities of 1.2, 1.5, and 1.8.⁸

Depending on the revenue elasticity, the median state in the Eighth District can expect to encounter a constant-revenue shortfall of between 4.6 and 6.8 percent of revenue during a given recession. Because the magnitude of a constant-revenue shortfall is a function of both the state’s average recession growth and the expected duration of a recession, the expected constant-revenue

shortfall in Illinois is much larger than the shortfall for any other state in the Eighth District. In contrast, the moderate recession growth rates in Arkansas, Mississippi, and Tennessee imply that these states could maintain a constant level of revenue during a typical downturn with reserve balances of approximately 3 percent of the budget.

The expansion-revenue shortfall estimates, which depend on the duration of a recession plus the difference between the average expansion and average recession growth rates, are noticeably larger than this 3 percent for every state in the District. In fact, the expansion-revenue shortfalls exceed 10 percent of the state’s revenue for every elasticity value in five of the District’s seven states and exceed this threshold in all seven states if the elasticity is 1.5 or larger. With an elasticity of 1.5, for example, the typical state in the Eighth District can expect a budget shortfall between 15 and 17 percent of revenue during a “normal” downturn, but the estimates range from a high of nearly 32 percent in Illinois to a low of just over 11 percent in Indiana and Mississippi.

Although the expansion-revenue shortfall estimates are quite large, it is important to recall

⁸ The shortfall distributions were constructed by varying the number of periods (length of recessions) and restricting revenue to grow at its estimated average rate each period, g_L . Wagner and Elder (2006) explored an alternative approach by varying both the length of recessions and per-period growth rate in revenue. They find that both approaches produced similar results.

Table 3**Expected Revenue Shortfalls for Eighth District States (percentage of revenue)**

	Constant-revenue shortfall ($\gamma = 0$)			Expansion-revenue shortfall ($\gamma = g_H$)		
	Revenue elasticity			Revenue elasticity		
	1.2	1.5	1.8	1.2	1.5	1.8
Arkansas	2.26	2.81	3.36	12.24	15.50	18.86
Illinois	9.14	11.28	13.37	25.09	31.68	38.43
Indiana	4.64	5.74	6.81	9.07	11.33	13.60
Kentucky	4.64	5.75	6.84	13.89	17.51	21.19
Mississippi	1.56	1.95	2.33	9.12	11.54	14.02
Missouri	6.08	7.52	8.94	17.50	22.08	26.76
Tennessee	1.43	1.78	2.13	11.86	15.07	18.38
Mean	4.25	5.26	6.25	14.11	17.82	21.61
Median	4.64	5.74	6.81	12.24	15.50	18.86
Maximum	9.14	11.28	13.37	25.09	31.68	38.43
Minimum	1.43	1.78	2.13	9.07	11.33	13.60

Table 4**Projected Fiscal Standing of Eighth District States**

	Projected FY 2007-end balance (share of revenue)	Probability FY 2007 balance is sufficient	
		Constant-revenue shortfall	Expansion-revenue shortfall
Arkansas	5.33	0.853	0.552
Illinois	3.34	0.512	0.336
Indiana	6.10	0.756	0.645
Kentucky	7.85	0.808	0.603
Mississippi	4.62	0.894	0.581
Missouri	8.55	0.767	0.573
Tennessee	4.77	0.958	0.652
Mean	5.79	0.793	0.563
Median	5.33	0.808	0.581
Maximum	8.55	0.958	0.652
Minimum	3.34	0.512	0.336

NOTE: FY is fiscal year. Projected FY 2007 balances were obtained from individual state budgets.

that measuring shortfalls relative to expansions provides a useful upper bound for analyzing state fiscal stress. If policymakers were to save according to their state's expansion-revenue shortfalls, then, on average, the state would be able to avoid *all* expenditure reductions and tax increases for the duration of a slowdown.

An alternative perspective is to use each state's shortfall distributions to determine the probability that the state's current level of savings is sufficient to offset a given shortfall. We do this for each state using the state's fiscal-year-end projections for 2007. The results are provided below in Table 4.

We looked at Eighth District states' fiscal year 2007 projections and found that the average state will have reserve balances in excess of 5 percent. Moreover, the probability that any state's savings is sufficient to fully offset a downturn is, for the most part, quite high. For example, our estimates indicate that the probability is roughly 0.80 that District states will be able to maintain a constant level of revenue for the duration of a recession without relying on tax increases or spending reductions. The estimates range from a high of over 95 percent in Tennessee to a low of just over 50 percent in Illinois. In terms of hedging an expansion-revenue shortfall, we find that there is nearly a 60 percent chance that District states will be able to continue the average expansion growth rate in revenue during a slowdown without the use of other fiscal adjustments. In fact, all of the District states except Illinois have at least a 55 percent chance of escaping major fiscal adjustments relative to baseline conditions should a slowdown begin in 2007.

Probability Distributions of State Savings Rates

Because the parameters from the Markov-switching regressions describe the distribution of both expansions and contractions, Wagner and Elder (2006) estimate savings rates that are based on all of the possible expansion-contraction combinations that may occur in a given state. In this section of the paper we show how these savings rates are obtained, which essentially provide a benchmark for policymakers interested in insuring against fiscal shocks.

Assuming that policymakers save a fraction of revenue (s) during each period of an expansion, revenue will be equal to $R_0(1 + g_H)$ and savings will be $R_0s(1 + g_H)$ and at the end of one period. Following t_H periods of expansion, the state's accumulated savings, compounding at a rate r , will be given by

$$(4) \quad R_0s \sum_{j=1}^{t_H} (1+r)^{t_H-j+1} (1+g_H)^j.$$

If revenue growth switches from an expansion to a contraction, then the revenue shortfall in the first low-growth period will be the difference between actual revenue, $R_0(1 + g_H)^{t_H} (1 + g_L)$, and the target level of revenue, $R_0(1 + g_H)^{t_H} (1 + \gamma)(1 - s)$, where γ denotes the amplitude parameter specifying the target revenue growth rate during contractions.

Prohibiting states from saving during contraction periods, the revenue shortfall in just the first contraction period will be equal to

$$R_0 \left[(1 + g_H)^{t_H} (1 + \gamma)(1 - s) - (1 + g_H)^{t_H} (1 + g_L) \right].$$

For a recession lasting t_L periods, the state's cumulative revenue shortfall may be written as

$$(5) \quad R_0 (1 + g_H)^{t_H} \left[(1 - s) \sum_{i=1}^{t_L} (1 + \gamma)^i - \sum_{i=1}^{t_L} (1 + g_L)^i \right].$$

Because equation (5) is the state's revenue shortfall from a downturn lasting t_L periods and equation (4) is the state's savings from an expansion lasting t_H periods, setting equations (4) and (5) equal to one another and solving for s yields the fraction of current revenue the state must save during each of the t_H expansion periods to accumulate savings equal to the revenue shortfall. This savings rate is given by

$$(6) \quad s(t_H, t_L) = \frac{(1 + g_H)^{t_H} \left[\sum_{i=1}^{t_L} \left[(1 + \gamma)^i - (1 + g_L)^i \right] \right]}{\sum_{j=1}^{t_H} (1 + r)^{t_H-j+1} (1 + g_H)^j + (1 + g_H)^{t_H} \sum_{i=1}^{t_L} (1 + \gamma)^i}.$$

The savings rate given by equation (6) applies to a specific expansion length and a specific con-

Table 5**Expected Savings Rates for Eighth District States (percentage of revenue)**

	Constant-revenue shortfall ($\gamma = 0$)			Expansion-revenue shortfall ($\gamma = g_H$)		
	Revenue elasticity			Revenue elasticity		
	1.2	1.5	1.8	1.2	1.5	1.8
Arkansas	0.39	0.49	0.59	2.12	2.71	3.33
Illinois	1.52	1.89	2.27	4.28	5.51	6.80
Indiana	1.03	1.29	1.55	2.08	2.65	3.23
Kentucky	0.86	1.08	1.30	2.61	3.35	4.11
Mississippi	0.33	0.41	0.50	1.92	2.45	3.00
Missouri	1.08	1.35	1.63	3.17	4.07	5.01
Tennessee	0.27	0.34	0.41	2.22	2.84	3.49
Mean	0.78	0.98	1.18	2.63	3.37	4.14
Median	0.86	1.08	1.30	2.22	2.84	3.49
Maximum	1.52	1.89	2.27	4.28	5.51	6.80
Minimum	0.27	0.34	0.41	1.92	2.45	3.00

traction length. If we assume that the length of expansions (t_H) and the length of recessions (t_L) are independent, then the probability that an expansion persisting t_H periods will be followed by a recession lasting t_L periods can be computed as $P_H(t_H) \times P_L(t_L)$, where

$$P_j(t_j) = P_{jj}^{t_j-1} - P_{jj}^{t_j} \text{ for } j = H, L.$$

Assuming that both expansions and recessions last for a maximum of 30 years (or 360 months), we form savings rate distributions from the 129,600 possible expansion-contraction combinations. The expected savings rate for constant-revenue shortfalls ($\gamma = 0$) and expansion-revenue shortfalls ($\gamma = g_H$) are presented in Table 5 using revenue elasticities of 1.2, 1.5, and 1.8.

The savings rates show the fraction of total revenue that a state must save during each expansion period in order to accumulate sufficient savings to offset a “normal” fiscal cycle. Assuming a revenue elasticity of 1.5 for instance, if the median state in the Eighth District saved 1.08 percent of revenue each expansion period, then the state would be able to maintain a constant level of revenue during a typical downturn and would have

zero reserve balances when the downturn ends. If the objective is to maintain the average expansion rate of revenue growth throughout a recession, then the median state would need savings equal to 2.84 percent during each expansion period.⁹ For a given target growth rate in revenue (γ), the closer policymakers are to achieving the state’s expected savings rate, the more likely it is that the state will be able to avoid expenditure reductions and tax increases in the next recession.

CONCLUSION

Slowdowns in economic activity place tremendous strain on state budgets and frequently force policymakers to enact sizable spending cuts and tax increases to close budget shortfalls. Following Wagner and Elder (2006), this paper uses a basic Markov-switching regression model to form empirical distributions of the monthly revenue cycles in

⁹ The Markov-switching model assumes that the underlying regime is not observable. However, a reasonable approach to implementing a savings rule in practice would be to rely on the estimated probability that a state is in an expansion at a given point in time, $P(S_t = 1)$. The simplest possible rule for the state to follow would be to assume that the economy is expanding (and therefore save) if $P(S_t = 1) > 0.5$ and save nothing otherwise.

Eighth District states. We then estimate the revenue shortfalls that District states are likely to experience in a future recession using multiple fiscal objectives.

We find, for instance, that the typical state in the District needs reserve balances equal to 4 to 6 percent of revenue to maintain a constant level of revenue during the next recession without relying on spending cuts and tax increases. If the goal is to preserve the average expansion growth rate in revenue during a slowdown, while simultaneously avoiding spending or tax adjustments, then the average state would need to have savings equal to 15 to 17 percent of revenue before the start of the next recession. Based on fiscal-year-end projections for 2007, we find that all of the Eighth District states except Illinois have a greater than 50 percent chance of avoiding major fiscal adjustments should a slowdown begin in 2007.

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The Economic Impact of Broadband Deployment in Kentucky

David Shideler, Narine Badasyan, and Laura Taylor

Significant resources are being invested by government and the private sector in broadband infrastructure to increase broadband deployment and use. With a unique dataset of broadband availability (sorted by county), the authors assess whether broadband infrastructure has affected the industrial competitiveness of Kentucky counties. Their results suggest that broadband availability increases employment growth in some industries but not others. (JEL H54, R11)

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As the “knowledge economy” continues to transform our society, broadband internet access is an essential component of infrastructure for economic development. Broadband deployment and use is expected to offer benefits to businesses and consumers as well as the public sector. Potential benefits of broadband usage to businesses include productivity gains through e-commerce, integrated supply chains, improved management (Williamson et al., 2006), and increased productivity through telecommuting. There are substantial foreseeable benefits of residential broadband use, including improved efficiency of retailing, reductions in commuting, increased variety of home entertainment, greater availability of health care, and improved access to educational opportunities. In addition, broadband facilitates the delivery of e-government services and applications, bringing the potential to significantly enhance government communication with its constituents. Similarly, broadband enables online community applications, which provide additional opportunities for individuals to contribute to society, especially the disabled. Crandall and Jackson (2001) projected

that these benefits would lead to a \$500 billion increase in U.S. gross domestic product by 2006.

In response to these perceived benefits of broadband, Kentucky embarked on “Prescription for Innovation”—a unique broadband deployment and adoption plan that leverages state, federal, and private investment to ensure statewide broadband availability and significantly improve technology adoption. ConnectKentucky, a public-private partnership, has the charge of realizing the four strategic goals of Prescription for Innovation:

- full broadband deployment by the end of 2007;
- increased use of computers and the Internet;
- the creation of a meaningful online presence for every local community;
- the development of e-community leadership teams to form business plans and identify applications for business, local government, education, health care, libraries, agriculture, tourism, and local nongovernmental organizations.

To date, ConnectKentucky has achieved and

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exceeded expectations by realizing a deployment rate of 94 percent of Kentucky households, with deployment planned to cover the remaining 6 percent by the end of 2007; a 73 percent increase in the use of broadband in the home since 2004; and a 20 percent increase in household computer ownership since 2004.

ConnectKentucky has become a model for broadband deployment and adoption for other states throughout the nation because of these successes; moreover, a national nonprofit organization, Connected Nation, Inc., has been created to replicate its model in other states.

Empirical evidence *ex post* of broadband investments by governments and the private sector is sparse. Quantifying many of the benefits described above requires extensive data collection, which is costly and time consuming. Therefore, the existing evidence has focused on economic impacts, measured in terms of employment growth or efficiency gains from broadband adoption. For example, Lehr et al. (2005) estimate the impacts of broadband availability on a number of economic indicators such as employment growth, wages, proportion of establishments in information technology (IT), and rental rates between 1998 and 2002. The study concludes that the communities in which broadband became available by 1999 experienced more rapid growth in employment, the number of businesses overall, and the number of businesses in IT-intensive sectors. Lehr et al. also observed higher market rates for rental housing in the communities with broadband availability. In another study, Crandall, Lehr, and Litan (2007), finds similar results, though the scope of analysis is limited to only employment and output.

The present study focuses exclusively on the economic impact that broadband deployment has had in Kentucky's local communities. Although most of the early studies relied upon projections of forward linkages, this study will look at observed changes in economic activity related to broadband deployment, as did Lehr et al. (2005) and Crandall, Lehr, and Litan (2007). A major difference between the previous studies and the present one is in our measure of broadband availability. The previous studies use data from Federal Communication Commission (FCC) Form 477 to measure broadband

data availability. In the case of Lehr et al. (2005), Form 477 data identifies the number of broadband providers with at least one subscriber in each zip code. Crandall, Lehr, and Litan (2007) use the state-level Form 477 data, which provides the number of lines available (i.e., the number of subscribers) in each state. Our measure utilizes county-level data aggregated from ConnectKentucky's GIS database of broadband service as measured at the point of service. That is, ConnectKentucky uses proprietary infrastructure data from broadband providers to determine in which geographic areas broadband service is offered. Measuring broadband availability this way is superior to the previous measures because it provides a more accurate assessment of where broadband is available; the zip code data exaggerates broadband availability,¹ while the state-level data is too geographically aggregated to identify variances in broadband coverage.

Following in the spirit of Lehr et al. (2005), this study uses an economic growth framework to determine the impact of broadband deployment on economic activity in Kentucky's counties. The next section describes our data and methodology in more detail and is followed by our estimation results. We conclude with a discussion of extensions and policy implications of this work.

DATA AND METHODOLOGY

Identifying the impact of infrastructure poses several challenges that make the analysis different from that for other economic impacts. First, a typical economic impact analysis identifies the employment creation and related economic benefits associated with the expansion in the local economy. Infrastructure itself does not create sustained employment, only temporary employment associated with construction or maintenance. Second, standard economic impact analyses are based on backward linkages. In a traditional impact analysis, accounting for the backward linkages among firms

¹ The U.S. Government Accountability Office reported that the FCC Form 477 zip code data overstates broadband availability because an entire zip code is reported as having broadband if at least one subscriber is located there; this is a poor measure of availability, particularly in rural areas where zip codes tend to be large geographic areas.

is what allows researchers to identify how growth in one industry will lead to growth in others. However, it is often difficult to predict how specific types of infrastructure will be utilized by industries, particularly previously unavailable infrastructure like broadband. Since there is no prior history of the use of broadband in a locale, there is no way to predict which firms will or will not utilize the infrastructure and how use of the infrastructure will affect the firms' production processes. Additionally, the presence of the new infrastructure may also make the region attractive to new firms that will relocate to take advantage of it. Given these difficulties, economists often estimate the economic impacts of infrastructure using a modified growth model. (See Rupasinga, Goetz, and Freshwater, 2000, and Lehr et al., 2005, for additional applications of this model.)

The growth model is a methodology to predict a region's growth over time. Simply stated, this model predicts the economic growth of a region during one period based upon the level of economic activity of some previous period plus any compounded growth that would be expected to occur between the two periods. Mathematically, this process can be expressed as

$$Y_t = AY_{t-i}^\alpha e^{ri},$$

where Y represents the economic level at time t , A is a constant, α is a scaling parameter, and e^{ri} is the formula for compounded growth at rate r for i periods. The critical element of this approach is determining the right expected growth rate, r , between the two periods. Because of the importance of this step, the growth rate, r , is often determined statistically using multivariate regression analysis. By transforming this growth equation using natural logarithms, assuming that A and α equal 1 (which are standard assumptions when empirically testing growth models), and defining time periods in such a way as to make $i = 1$, equation (1) is derived:

$$(1) \quad \ln(Y_t/Y_{t-1}) = r = r^* + X\beta + \varepsilon.$$

This equation simply states that the economic growth rate is a function of the optimal growth rate, r^* (which is constant), some explanatory

variables (X), and an error term, ε (which has a log-normal distribution). It is reasonable to assume that the observed rate of economic growth will differ from the optimum growth rate in any given period simply because of unanticipated shocks to the economy. This is the same theoretical model used in Lehr et al. (2005). If one takes Y to represent industrial output, instead of aggregate economic activity, this framework can also be used to analyze the effect of broadband infrastructure on specific industries, where the change in industrial output is estimated by various input factors and a random error term.

Empirically, measuring growth and identifying explanatory variables poses some challenges. Because output is not measured at the local level (like gross domestic or state product), researchers often use employment, wages, or number of establishments data as a proxy for the size of the local economy. Given our desire to look at total economic impacts and industrial impacts from broadband, we use the U.S. Census Bureau's county business patterns data series for 2003, 2004, and 2005 as our economic data because it provides both total and sectoral employment at the two-digit North American Industrial Classification System (NAICS) level. This dataset contains private, non-agriculture production employment data measured as of the week of March 12 annually. Using this data, we compute the employment growth rates of the periods 2003-04 and 2004-05 for each of the two-digit NAICS codes. A combination of zero employment levels in rural counties and suppressed data due to Census disclosure rules led to missing values in the data and reduced the number of observations available for analysis in some industries. Table 1 provides summary statistics and the number of observations for the employment growth rates.

Additional data concerns stemmed from the very diverse nature of counties in Kentucky. For example, in 2004, total employment across counties ranged from 131 employees to over 400,000 employees; the average county employment was 12,681, while the median county employment was only 3,554. This wide distribution of values becomes even more of a concern because our analysis uses growth rates, such that a small increase in employment, say 25 employees, could

Table 1A**Summary Statistics**

Dependent variable	Employment growth (2004-05)	N	Minimum	Maximum	Mean	Standard deviation
emp00_45	Total employment growth	120	-0.27	0.17	0.01	0.05
emp11_45	Employment growth in forestry, fishing, and hunting	26	-1.00	1.33	-0.16	0.69
emp21_45	Employment growth in mining	34	-1.00	1.48	0.00	0.57
emp22_45	Employment growth in utilities	21	-1.00	0.33	-0.15	0.37
emp23_45	Employment growth in construction	112	-1.00	0.72	-0.03	0.37
emp31_33_45	Employment growth in manufacturing	103	-1.00	1.59	-0.02	0.26
emp42_45	Employment growth in wholesale trade	100	-1.00	2.67	-0.08	0.46
emp44_45_45	Employment growth in retail trade	119	-0.22	0.27	0.01	0.08
emp48_49_45	Employment growth in transportation and warehousing	94	-1.00	3.90	-0.06	0.65
emp51_45	Employment growth in information	88	-1.00	0.92	-0.44	0.52
emp52_45	Employment growth in finance and insurance	112	-1.00	1.22	0.02	0.32
emp53_45	Employment growth in real estate and rental and leasing	97	-1.00	1.38	-0.10	0.45
emp54_45	Employment growth in professional, scientific, and technical services	111	-1.00	0.73	-0.24	0.47
emp55_45	Employment growth in management of companies and enterprises	30	-1.00	1.57	0.04	0.54
emp56_45	Employment growth in administrative and support and waste management and remediation services	87	-1.00	2.68	0.01	0.73
emp61_45	Employment growth in educational services	39	-1.00	0.66	-0.29	0.53
emp62_45	Employment growth in health care and social assistance	118	-1.00	0.85	0.01	0.15
emp71_45	Employment growth in arts, entertainment, and recreation	62	-1.00	1.08	-0.17	0.44
emp72_45	Employment growth in accommodation and food services	111	-1.00	1.28	-0.03	0.34
emp81_45	Employment growth in other services	116	-1.00	0.58	-0.09	0.25
emp99_45	Employment growth in unclassified	22	-1.00	2.00	-0.64	0.82

Table 1B

Independent variable	Employment growth (2003-04)	N	Minimum	Maximum	Mean	Standard deviation
emp00_34	Total employment growth	120	-0.23	0.40	0.01	0.07
emp11_34	Employment growth in forestry, fishing, and hunting	120	-1.00	1.50	-0.19	0.21
emp21_34	Employment growth in mining	120	-1.00	1.14	-0.04	0.25
emp22_34	Employment growth in utilities	120	-1.00	0.03	-0.15	0.12
emp23_34	Employment growth in construction	120	-1.00	1.03	0.03	0.29
emp31_33_34	Employment growth in manufacturing	120	-1.00	1.42	0.01	0.21
emp42_34	Employment growth in wholesale trade	120	-1.00	1.00	-0.03	0.27
emp44_45_34	Employment growth in retail trade	120	-0.35	1.06	0.01	0.13
emp48_49_34	Employment growth in transportation and warehousing	120	-1.00	1.00	-0.03	0.37
emp51_34	Employment growth in information	120	-1.00	2.15	-0.08	0.31
emp52_34	Employment growth in finance and insurance	120	-1.00	1.05	0.00	0.20
emp53_34	Employment growth in real estate and rental and leasing	120	-1.00	2.90	0.01	0.45
emp54_34	Employment growth in professional, scientific, and technical services	120	-1.00	5.46	0.04	0.57
emp55_34	Employment growth in management of companies and enterprises	120	-1.00	0.94	0.00	0.16
emp56_34	Employment growth in administrative and support and waste management and remediation services	120	-1.00	4.25	-0.04	0.50
emp61_34	Employment growth in educational services	120	-1.00	0.58	-0.03	0.18
emp62_34	Employment growth in health care and social assistance	120	-0.51	0.56	0.00	0.12
emp71_34	Employment growth in arts, entertainment, and recreation	120	-1.00	0.67	-0.08	0.31
emp72_34	Employment growth in accommodation and food services	120	-1.00	0.58	0.01	0.21
emp81_34	Employment growth in other services	120	-1.00	0.46	-0.02	0.21
emp99_34	Employment growth in unclassified	120	-1.00	3.67	-0.28	0.45
Other						
sat104	Percent of county area with broadband service as of January 1, 2004	120	0.01	1.00	0.50	0.30
sat1042	sat104 squared	120	0.00	1.00	0.34	0.35
hwyaccess	Miles of limited-access roads	120	0.00	303.50	26.06	39.97
bached00	Percent of persons 25+ with at least a bachelors degree	120	0.05	0.36	0.12	0.06
unemp03	Unemployment rate, 2003	120	0.04	0.12	0.07	0.02
rural	Rural dummy variable (1 = rural county)	120	0.00	1.00	0.58	0.50

lead to a 19 percent increase in employment in the county with the least employment or a 0.00006 percent increase in the county with the highest employment. To ensure that no one observation heavily influenced the values in our results, we identified influential observations using “studentized” residuals in the analysis of each industry. Influential observations were those for which the residual value exceeded 2 in absolute value; these counties were excluded from the analysis of that industry to ensure that the results were representative of counties across Kentucky.² Several industries showed signs of heteroskedasticity, according to White’s general test. Generalized least-squares procedures were used to correct for the heteroskedastic error term for the following industries: wholesale trade; transportation and warehousing; information; real estate and rental and leasing; and professional, scientific, and technical services.³

Data for our independent variables came from several sources. To measure broadband availability, we computed the area of a county for which broadband service is available using ConnectKentucky’s GIS inventory of Kentucky’s broadband deployment and service availability. The GIS inventory provides a comprehensive view of broadband technologies, representing digital subscriber lines (DSL), cable modem service, and fixed wireless networks, measured at the point of service availability (i.e., at the location of infrastructure placement). Coverage areas were aggregated to the county level by Census block groups, and then the ratio of the coverage area to total area of the county was computed. This saturation rate was our measure of broadband infrastructure as of January 2004.

Early studies of the economic impacts of broadband, based on forward-looking models, suggest a range of potential benefits of broadband to businesses. This includes reduced costs and increased productivity of the workforce as well as prospects of expansion and growth, as businesses will no longer be constrained in their local market. Because

there is no history of the use of broadband in a locale, the overall expected impact of broadband on employment growth can be twofold. On one hand, broadband can lead to job losses, but higher wages, through increased labor productivity. On the other hand, it can lead to job creation as a result of longer-term productivity increases and/or as businesses expand their markets and venture into regional and international markets. The overall effect will depend on the type of industry as well as the length and scope of broadband adoption by a particular business.

The saturation rate squared is also included to study the returns to scale of broadband deployment. For instance, diminishing returns, captured by a negative coefficient of saturation squared, would indicate that, as broadband deployment nears its maximum (100 percent coverage of area), its marginal effect on employment growth diminishes. In other words, if the county is nearing 100 percent served, adding an additional unit of broadband infrastructure to unserved portions of that county would provide smaller additional benefit in terms of job growth. This phenomenon could be related to the increasing necessity of broadband within the economy; as broadband service within a county becomes ubiquitous, it becomes expected infrastructure, and thus other economic variables become those factors that influence variations in job growth. It is worth noting, however, that this study does not account for multiple layers of broadband service; that is, we have focused solely on job growth as it relates to broadband deployment at a given point in time. This paper does not consider the possibility that competition among broadband service providers may also affect job growth, and consideration of this idea is left for future research.

Our control variables were generated from standard, secondary sources. Educational attainment, measured as the percent of the population 25 years and older with at least a college degree in 2000, was provided by the Kentucky State Data Center. Educational attainment is a proxy for human capital stock; one expects that higher educational attainment within a county will lead to more economic activity due to the availability of more productive human capital. The level of nontechnological infrastructure was measured as the number of miles of limited-access highway

² Excluding outliers explains why the number of observations reported in Table 1 might differ from the number of observations (*n*) reported in the results tables.

³ Because ordinary least-squares estimators are still unbiased under heteroskedasticity, generalized least-squares techniques correct the standard errors of the parameter estimates, but they do not affect the value of the estimates.

miles; these data were computed using the major-roads shapefile from the Kentucky Transportation Cabinet, available through the Kentucky Geography Network. From the attribute table, we summed the length of interstates and parkways in miles, reported as DMI_LEN_MI, for DRAWCODE value 5 (interstates and parkways) in each county, denoted by CO_NUMBER. One would also expect a positive relationship between highway access and economic activity, since more accessibility should reduce transportation and distribution costs to firms. Other control variables include a rural region dummy variable to control for differences between urban and rural places (such as population density); ConnectKentucky has a four-category classification system (1 = rural, 2 = small metropolitan, 3 = suburban, and 4 = metropolitan)⁴ that was adopted for this project. This variable takes a value of 1 for counties designated rural, and 0 otherwise. The county unemployment rate in 2003, as reported in the Local Area Unemployment Statistics series from the U.S. Bureau of Labor Statistics, was included as a proxy for the amount of available labor in the county. If this variable were positively correlated with employment growth, it suggests that the industry is labor intensive so that more available labor (typically less skilled labor) leads to more employment. If this variable is negatively correlated with employment growth, it suggests that the industry is not labor intensive and/or it is able to recruit its labor from outside of the county. Lastly, a lagged version of the dependent variable was included to capture any other unique characteristics about the county and/or the industry within the county.

To determine the impact that broadband infrastructure has had on Kentucky's local economies, we used multivariate regression. In our analysis, we regress the employment growth for 2004-05 for each of the 21 two-digit industrial codes as a function of broadband saturation, saturation squared, highway access, percentage of the population over 25 with a college degree, employment growth between 2003 and 2004, the unemployment rate in 2003, and the rural dummy variable.

⁴ ConnectKentucky developed this system to more accurately reflect the regional differences across Kentucky that are not evident when one uses the U.S. Department of Agriculture's rural-urban continuum.

RESULTS

This section presents regression analysis of the impact of broadband deployment on employment growth in 20 industrial sectors (using two-digit NAICS codes and excluding public administration) and total employment growth in Kentucky. The results are presented in Tables 2 through 22.

To thoroughly understand the role of broadband in economic development, we conducted our analysis using a series of models, similar to the structure used by Lehr et al. (2005). That is to say, we present the results of four models for each industry to see how the influence of saturation and its square changes as additional controls are introduced into the model. Our first model, then, contains only saturation and saturation squared as explanatory variables. Our second model adds the lagged employment-growth variable. The third model contains all control variables except saturation and saturation squared. The final model, the most complex, contains all of our independent variables. We also report *F*-statistics to determine the overall significance of the models.

The results of greatest interest relate to the significance and magnitude of the broadband variables. The broadband deployment variable has a positive and significant impact on total employment (Table 2) as well as employment growth in the following industries: mining (Table 4), construction (Table 6), information (Table 11), and administrative, support, and waste management and remediation services (Table 16). The square of broadband deployment is negative and significant in all of the above industries, suggesting diminishing returns, as explained above. Broadband's contribution to total employment growth ranges from 0.14 to 5.32 percent.⁵

⁵ The ranges presented are calculated across the various models for each industry and across the range of saturation values. The lower bound of the range corresponds to the parameter estimates of the simplest model, for which the broadband parameter(s) are significant, multiplied by the minimum amount of broadband saturation of the observations used for that industry's regression. The upper bound of the range corresponds to the parameter estimates of the most complex model, for which the broadband parameter(s) are significant, multiplied by the mean amount of broadband saturation of the observations used for that industry's regression. Because of the diminishing returns to scale, the maximum saturation rate yields lower employment growth than the mean.

Table 2
Regression Results for Total Employment

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.0163 (−1.339)	−0.0161 (−1.322)	0.0202 (0.787)	−0.0091 (−0.335)
sat104	0.1503*** (2.893)	0.1499*** (2.878)		0.1727*** (3.042)
sat1042	−0.1162*** (−2.574)	−0.1158*** (−2.559)		−0.1340*** (−2.738)
emp00_34		−0.0329 (−0.603)	−0.0410 (−0.702)	−0.0373 (−0.662)
hwyaccess			0.000071 (0.662)	0.000055 (0.529)
batched00			−0.0047 (−0.053)	−0.0694 (−0.781)
unemp03			−0.0463 (−0.163)	−0.1353 (−0.484)
rural			0.0024 (0.256)	0.0069 (0.740)
R^2	0.079	0.082	0.008	0.096
Adjusted R^2	0.062	0.057	−0.038	0.036
F -statistic	4.76***	3.28**	0.17	1.61
n	114	114	114	114

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 3
Regression Results for Forestry, Fishing, and Hunting

	Model 1	Model 2	Model 3	Model 4
Intercept	-0.2613 (-0.574)	-0.2414 (-0.517)	0.9713 (1.004)	0.6373 (0.543)
sat104	1.2113 (0.589)	1.1012 (0.520)		0.2237 (0.097)
sat1042	-1.4430 (-0.792)	-1.3875 (-0.745)		-0.4898 (-0.241)
emp11_34		-0.1636 (-0.387)	-0.2846 (-0.681)	-0.3323 (-0.749)
hwyaccess			-0.003825 (-1.572)	-0.003697 (-1.419)
batched00			-0.0666 (-0.023)	1.0385 (0.295)
unemp03			-12.1320 (-1.252)	-9.5106 (-0.832)
rural			-0.2611 (-0.699)	-0.1630 (-0.373)
R^2	0.057	0.063	0.252	0.267
Adjusted R^2	-0.025	-0.065	0.064	-0.018
F -statistic	0.69	0.49	1.34	0.94
n	26	26	26	26

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 4
Regression Results for Mining

	Model 1	Model 2	Model 3	Model 4
Intercept	-1.1524*** (-2.704)	-1.1251** (-2.563)	1.4845** (2.434)	0.2549 (0.348)
sat104	4.2753*** (2.744)	4.1584** (2.579)		4.0498** (2.603)
sat1042	-3.2672** (-2.595)	-3.1826** (-2.451)		-3.2633** (-2.599)
emp21_34		0.0885 (0.376)	0.4037 (1.689)	0.3089 (1.378)
hwyaccess			0.001596 (1.063)	0.002309 (1.614)
batched00			-1.8336 (-1.187)	-1.8579 (-1.264)
unemp03			-18.6839*** (-2.785)	-17.1996*** (-2.787)
rural			0.1482 (0.733)	0.2808 (1.430)
R^2	0.217	0.221	0.313	0.471
Adjusted R^2	0.161	0.134	0.176	0.310
F -statistic	3.88**	2.55*	2.28*	2.92**
n	31	31	31	31

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 5**Regression Results for Utilities**

	Model 1	Model 2	Model 3	Model 4
Intercept	0.2007 (0.513)	0.1284 (0.334)	0.0478 (0.068)	1.4081* (1.832)
sat104	-1.5917 (-1.066)	-1.0432 (-0.692)		-4.3522*** (-3.083)
sat1042	1.4710 (1.115)	1.1594 (0.889)		4.1867*** (3.113)
emp22_34		1.7583 (1.389)	2.2656 (1.574)	1.2979 (0.972)
hwyaccess			-0.000802 (-0.569)	-0.003194* (-1.901)
batched00			1.4976 (0.711)	-0.0028 (-0.002)
unemp03			-2.3573 (-0.277)	-2.3171 (-0.312)
rural			-0.2484 (-0.988)	-0.7213** (-2.770)
R^2	0.068	0.168	0.408	0.675
Adjusted R^2	-0.041	0.013	0.197	0.485
F -statistic	0.62	1.08	1.93	3.56**
n	20	20	20	20

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 6
Regression Results for Construction

	Model 1	Model 2	Model 3	Model 4
Intercept	-0.0449 (-0.621)	-0.0114 (-0.148)	0.4658*** (3.310)	0.3001** (1.989)
sat104	0.6704** (2.198)	0.5592* (1.766)		0.7974** (2.447)
sat1042	-0.6827** (-2.575)	-0.5877** (-2.139)		-0.7267** (-2.606)
emp23_34		-0.1343 (-1.266)	-0.1758* (-1.711)	-0.1089 (-1.049)
hwyaccess			0.000146 (0.274)	0.000167 (0.319)
batched00			-1.2414*** (-2.730)	-1.3336*** (-2.820)
unemp03			-3.4686** (-2.190)	-3.3877** (-2.121)
rural			-0.0144 (-0.302)	0.0061 (0.130)
R^2	0.081	0.096	0.118	0.180
Adjusted R^2	0.062	0.068	0.071	0.118
F -statistic	4.28**	3.40**	2.51**	2.88***
n	100	100	100	100

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 7**Regression Results for Manufacturing**

	Model 1	Model 2	Model 3	Model 4
Intercept	0.0098 (0.238)	0.0181 (0.430)	-0.0100 (-0.118)	-0.0047 (-0.052)
sat104	-0.0380 (-0.214)	-0.0622 (-0.347)		-0.0397 (-0.207)
sat1042	0.0226 (0.144)	0.0375 (0.238)		0.0269 (0.162)
emp31_33_34		-0.0605 (-1.022)	-0.0546 (-0.926)	-0.0577 (-0.949)
hwyaccess			0.000203 (-0.639)	0.000191 (-0.584)
batched00			-0.0821 (-0.305)	-0.0611 (-0.216)
unemp03			0.4527 (0.475)	0.4918 (0.505)
rural			-0.0094 (-0.329)	-0.0097 (-0.331)
R^2	0.001	0.012	0.023	0.023
Adjusted R^2	-0.020	-0.019	-0.030	-0.052
F -statistic	0.06	0.39	0.43	0.31
n	99	99	99	99

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 8
Regression Results for Wholesale Trade

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.1101 (−0.925)	−0.0762 (−0.641)	0.2908 (1.261)	0.3092 (1.260)
sat104	0.3479 (0.683)	0.2222 (0.438)		−0.3899 (−0.710)
sat1042	−0.4463 (−0.993)	−0.3627 (−0.814)		0.0898 (0.180)
emp42_34		0.3139* (1.885)	0.3328** (2.149)	0.4010* (1.960)
hwyaccess			0.001039 (1.242)	0.001308 (1.140)
batched00			0.2426 (0.325)	0.7408 (1.240)
unemp03			−6.2595** (−2.530)	−5.0516* (−1.820)
rural			−0.0094 (−0.116)	−0.0219 (−0.290)
R^2	0.027	0.063	0.190	0.244
Adjusted R^2	0.006	0.032	0.144	0.183
F -statistic	1.27	2.05	4.17***	4.02***
n	95	95	95	95

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 9**Regression Results for Retail Trade**

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.0219 (−1.142)	−0.0224 (−1.175)	−0.0837** (−2.054)	−0.0830* (−1.841)
sat104	0.0422 (0.508)	0.0532 (0.642)		0.0555 (0.626)
sat1042	0.0110 (0.151)	−0.0004 (−0.006)		−0.0039 (−0.050)
emp44_45_34		−0.1004 (−1.467)	−0.1120 (−1.546)	−0.0857 (−1.198)
hwyaccess			−0.000229 (−1.434)	−0.000274* (−1.740)
batched00			0.2481* (1.815)	0.1455 (1.042)
unemp03			1.0414** (2.278)	0.8562* (1.879)
rural			−0.0132 (−0.953)	−0.0159 (−1.138)
R^2	0.072	0.090	0.089	0.144
Adjusted R^2	0.055	0.064	0.046	0.087
F -statistic	4.20**	3.55**	2.06*	2.50**
n	112	112	112	112

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 10**Regression Results for Transportation and Warehousing**

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.3130* (−1.926)	−0.3259** (−2.029)	0.0308 (0.092)	−0.0835 (−0.210)
sat104	0.8014 (1.141)	0.9295 (1.334)		0.6747 (0.590)
sat1042	−0.6466 (−1.022)	−0.7395 (−1.180)		−0.6035 (−0.640)
emp48_49_34		−0.3339* (−1.812)	−0.3050* (−1.675)	−0.3205 (−1.410)
hwyaccess			0.001524 (1.211)	0.001621 (1.240)
batched00			−0.0999 (−0.088)	−0.2570 (−0.250)
unemp03			−1.8209 (−0.501)	−2.0990 (−0.500)
rural			−0.0893 (−0.772)	−0.0673 (−0.460)
R^2	0.016	0.051	0.083	0.093
Adjusted R^2	−0.006	0.019	0.030	0.017
F -statistic	0.71	1.58	1.56	1.22
n	92	92	92	92

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 11
Regression Results for Information

	Model 1	Model 2	Model 3	Model 4
Intercept	-1.3904*** (-7.608)	-1.3975*** (-7.705)	-1.0817*** (-3.303)	-1.5642*** (-4.150)
sat104	3.5404*** (4.710)	3.6109*** (4.832)		2.7246*** (4.340)
sat1042	-2.6044*** (-3.994)	-2.6591*** (-4.103)		-2.0416*** (-3.570)
emp51_34		0.2389 (1.510)	0.2120 (1.291)	0.2453** (2.110)
hwyaccess			0.000673 (0.538)	0.000492 (0.630)
batched00			3.6844*** (3.355)	2.6651** (2.250)
unemp03			3.6022 (1.017)	1.9360 (0.510)
rural			-0.1838 (-1.480)	-0.1321 (-1.180)
R^2	0.266	0.286	0.291	0.420
Adjusted R^2	0.248	0.260	0.246	0.367
F -statistic	14.67***	10.70***	6.42***	7.87***
n	84	84	84	84

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 12**Regression Results for Finance and Insurance**

	Model 1	Model 2	Model 3	Model 4
Intercept	0.0882* (1.916)	0.0884* (1.936)	0.1452 (1.505)	0.1593 (1.553)
sat104	-0.1579 (-0.790)	-0.1555 (-0.784)		-0.1089 (-0.510)
sat1042	0.0672 (0.377)	0.0694 (0.392)		0.0359 (0.192)
emp52_34		-0.1429 (-1.645)	-0.1546* (-1.711)	-0.1455 (-1.604)
hwyaccess			0.000072 (0.191)	0.000142 (0.372)
bached00			-0.3995 (-1.252)	-0.2823 (-0.849)
unemp03			-0.9763 (-0.912)	-0.8134 (-0.754)
rural			0.0055 (0.158)	0.0059 (0.166)
R^2	0.032	0.058	0.050	0.068
Adjusted R^2	0.013	0.030	0.001	0.000
F -statistic	1.68	2.04	1.01	0.99
n	103	103	103	103

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 13**Regression Results for Real Estate and Rental and Leasing**

	Model 1	Model 2	Model 3	Model 4
Intercept	-0.3452** (-2.361)	-0.2765* (-1.878)	-0.9924*** (-3.622)	-1.1343*** (-2.790)
sat104	1.1267* (1.805)	0.9297 (1.500)		0.8904 (1.220)
sat1042	-0.8476 (-1.525)	-0.6935 (-1.260)		-0.7373 (-1.220)
emp53_34		-0.2013** (-2.084)	-0.2511*** (-2.679)	-0.2359** (-2.620)
hwyaccess			0.000231 (0.233)	0.000314 (0.330)
batched00			2.4956*** (2.869)	2.2130** (2.370)
unemp03			8.4204*** (2.716)	7.7797* (1.980)
rural			0.1264 (1.375)	0.1536 (1.340)
R^2	0.046	0.091	0.190	0.210
Adjusted R^2	0.024	0.060	0.142	0.143
F -statistic	2.11	2.91**	3.99***	3.14***
n	91	91	91	91

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 14**Regression Results for Professional, Scientific, and Technical Services**

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.4827*** (−3.043)	−0.5022*** (−3.095)	−0.9608*** (−3.444)	−0.9995*** (−2.940)
sat104	0.9555 (1.423)	1.0098 (1.487)		0.0960 (0.120)
sat1042	−0.7463 (−1.283)	−0.7798 (−1.331)		−0.1670 (−0.240)
emp54_34		0.0487 (0.610)	0.0158 (0.215)	0.0107 (0.050)
hwyaccess			0.002047* (1.814)	0.002136 (1.070)
batched00			2.5142*** (2.660)	2.6492*** (2.820)
unemp03			5.7840* (1.865)	6.1294* (1.830)
rural			−0.1020 (−1.011)	−0.0926 (−0.790)
R^2	0.021	0.024	0.180	0.184
Adjusted R^2	0.002	−0.004	0.140	0.127
F -statistic	1.12	0.87	4.51***	3.24***
n	109	109	109	109

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 15**Regression Results for Management of Companies and Enterprises**

	Model 1	Model 2	Model 3	Model 4
Intercept	1.0839** (2.426)	0.9459** (2.135)	2.5492*** (3.864)	2.6532*** (3.922)
sat104	-3.2493* (-2.043)	-2.7434* (-1.737)		-1.1233 (-0.756)
sat1042	2.2258* (1.735)	1.8210 (1.430)		0.4818 (0.403)
emp55_34		-0.5545 (-1.553)	-0.2124 (-0.645)	-0.1776 (-0.555)
hwyaccess			0.000936 (0.766)	0.001203 (0.945)
bached00			-3.4965** (-2.503)	-2.5110* (-1.725)
unemp03			-32.8718*** (-4.087)	-29.6529*** (-3.568)
rural			0.6480*** (2.855)	0.5375** (2.177)
R^2	0.204	0.279	0.517	0.590
Adjusted R^2	0.138	0.186	0.402	0.439
F -statistic	3.07*	2.97*	4.49***	3.91***
n	27	27	27	27

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 16**Regression Results for Administrative, Support, and Waste Management and Remediation Services**

	Model 1	Model 2	Model 3	Model 4
Intercept	-0.8048*** (-3.749)	-0.8225*** (-3.879)	-0.9155* (-1.938)	-1.4892*** (-3.088)
sat104	3.3569*** (3.648)	3.5039*** (3.843)		3.0858*** (3.095)
sat1042	-2.8518*** (-3.492)	-2.9873*** (-3.690)		-2.7935*** (-3.220)
emp56_34		-0.2026* (-1.771)	-0.1189 (-0.956)	-0.1433 (-1.208)
hwyaccess			0.001013 (0.655)	0.001463 (0.987)
batched00			2.6551* (1.912)	2.3009 (1.642)
unemp03			8.0518 (1.449)	6.8384 (1.272)
rural			-0.1362 (-0.883)	0.0212 (0.137)
R^2	0.145	0.178	0.124	0.232
Adjusted R^2	0.123	0.146	0.066	0.159
F -statistic	6.69***	5.62***	2.15*	3.19***
n	82	82	82	82

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 17**Regression Results for Educational Services**

	Model 1	Model 2	Model 3	Model 4
Intercept	-1.2298** (-2.429)	-1.2218** (-2.375)	-0.3593 (-0.457)	-1.7970 (-1.397)
sat104	3.4602* (1.895)	3.4229* (1.843)		3.4027 (1.452)
sat1042	-2.6005* (-1.822)	-2.5801* (-1.780)		-2.7168 (-1.479)
emp61_34		0.1311 (0.236)	0.1183 (0.193)	0.3076 (0.484)
hwyaccess			0.001346 (0.732)	0.001518 (0.791)
bached00			1.7215 (0.885)	2.4842 (1.236)
unemp03			-4.1990 (-0.457)	2.1853 (0.211)
rural			0.1120 (0.410)	0.2258 (0.745)
R^2	0.095	0.096	0.126	0.186
Adjusted R^2	0.043	0.017	-0.011	-0.005
F -statistic	1.84	1.21	0.92	0.98
n	38	38	38	38

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 18**Regression Results for Health Care and Social Assistance**

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.0031 (−0.158)	−0.0058 (−0.299)	−0.0375 (−0.981)	−0.0447 (−1.066)
sat104	0.0021 (0.025)	0.0107 (0.128)		0.0987 (1.103)
sat1042	0.0364 (0.496)	0.0298 (0.408)		−0.0476 (−0.614)
emp62_34		0.0775 (1.517)	0.0830 (1.619)	0.0963* (1.889)
hwyaccess			0.000108 (0.673)	0.000081 (0.509)
bached00			0.1040 (0.776)	0.0091 (0.066)
unemp03			0.1593 (0.379)	−0.0564 (−0.133)
rural			0.0366** (2.594)	0.0379*** (2.635)
R^2	0.044	0.064	0.087	0.131
Adjusted R^2	0.027	0.039	0.045	0.075
F -statistic	2.60*	2.52*	2.07*	2.31**
n	115	115	115	115

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 19**Regression Results for Arts, Entertainment, and Recreation**

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.5365*** (−2.994)	−0.5341*** (−3.042)	−0.7935** (−2.538)	−0.9087*** (−2.713)
sat104	1.4161* (1.985)	1.6032** (2.268)		0.7610 (1.030)
sat1042	−0.9953 (−1.609)	−1.1892* (−1.931)		−0.6316 (−0.990)
emp71_34		−0.4322* (−1.775)	−0.6026** (−2.612)	−0.6093** (−2.576)
hwyaccess			0.000458 (0.490)	0.000553 (0.545)
batched00			2.2911*** (2.692)	2.1123** (2.385)
unemp03			6.4519* (1.716)	5.5176 (1.414)
rural			−0.1144 (−1.156)	−0.078 (−0.732)
R^2	0.102	0.155	0.300	0.316
Adjusted R^2	0.068	0.105	0.229	0.214
F -statistic	2.97*	3.11**	4.20***	3.09***
n	55	55	55	55

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 20**Regression Results for Accommodations and Food Services**

	Model 1	Model 2	Model 3	Model 4
Intercept	0.1260** (2.577)	0.1399*** (2.828)	0.1066 (1.061)	0.1660 (1.573)
sat104	-0.3120 (-1.486)	-0.3599* (-1.706)		-0.3966* (-1.734)
sat1042	0.1969 (1.052)	0.2488 (1.315)		0.2826 (1.401)
emp72_34		-0.1724 (-1.505)	-0.1674 (-1.442)	-0.1663 (-1.421)
hwyaccess			-0.000028 (-0.071)	0.000018 (0.045)
batched00			-0.3259 (-0.986)	-0.1271 (-0.373)
unemp03			-0.1845 (-0.163)	0.1745 (0.155)
rural			-0.0198 (-0.554)	-0.0308 (-0.850)
R^2	0.048	0.070	0.034	0.078
Adjusted R^2	0.028	0.041	-0.017	0.008
F -statistic	2.45*	2.41*	0.66	1.11
n	100	100	100	100

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 21**Regression Results for Other Services (Except Public Administration)**

	Model 1	Model 2	Model 3	Model 4
Intercept	−0.0988*** (−2.706)	−0.0893** (−2.439)	0.0012 (0.017)	−0.0367 (−0.493)
sat104	0.3207** (2.061)	0.2834* (1.820)		0.1758 (1.106)
sat1042	−0.2999** (−2.200)	−0.2694* (−1.977)		−0.1954 (−1.422)
emp81_34		−0.1242* (−1.712)	−0.1337* (−1.930)	−0.1251* (−1.798)
hwyaccess			0.000564** (2.018)	0.000614** (2.200)
bached00			0.2168 (0.918)	0.2482 (1.022)
unemp03			−1.2369 (−1.565)	−1.1539 (−1.448)
rural			0.0059 (0.234)	0.0153 (0.590)
R^2	0.045	0.071	0.162	0.191
Adjusted R^2	0.027	0.044	0.121	0.134
F -statistic	2.48*	2.66**	3.94***	3.37***
n	108	108	108	108

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

Table 22
Regression Results for Unclassified

	Model 1	Model 2	Model 3	Model 4
Intercept	-1.5715 (-2.105)	-1.4059 (-1.759)	-0.9754 (-1.762)	-1.6043 (-1.154)
sat104	1.9049 (0.791)	1.4702 (0.580)		1.6130 (0.469)
sat1042	-1.1321 (-0.640)	-0.8312 (-0.448)		-1.0778 (-0.428)
emp99_34		0.1637 (0.661)	0.2043 (0.823)	0.1596 (0.577)
hwyaccess			0.000975 (0.875)	0.001018 (0.716)
batched00			0.6187 (0.504)	0.5194 (0.394)
unemp03			-0.3898 (-0.061)	1.0663 (0.147)
rural			-0.0185 (-0.107)	-0.0042 (-0.022)
R^2	0.109	0.133	0.182	0.204
Adjusted R^2	0.004	-0.030	-0.110	-0.260
F-statistic	1.04	0.82	0.62	0.44
n	20	20	20	20

NOTE: Numbers in parentheses are t -statistics; */**/** indicates significance at the 10/5/1 percent confidence levels.

In the information sector, the analysis shows a substantial positive impact of broadband availability on employment growth, ranging from 25.27 to 87.07 percent. This growth is not surprising because this sector contains primarily information technology jobs housed by broadband providers, computer hardware and software related industries, and other technology companies that are the most likely to adopt and use broadband extensively. Additionally, jobs within the information sector are likely to allow or even promote working from home. At a residential level, increased broadband availability improves the ability of these employees to telecommute, which reduces a firm's administrative (including real estate) costs. This allows businesses to expand and hire more telecommuters without incurring the administrative costs of keeping an office.

In administrative, support, waste management and remediation services, broadband's contribution

to employment growth ranges between 23.74 and 84.56 percent. This is another industry that provides likely opportunities for working from home, enabling reduced costs and potentially increased investment in labor. Additionally, this industry sector contains service industries such as call centers, which are highly dependent upon broadband. In recent years, several call centers have located or expanded in rural areas of Kentucky, but needed broadband service to do so.

Given that construction is a secondary industry, growth in construction depends on employment growth in other sectors. As other sectors grow, they demand additional facilities that create jobs in construction. In addition, economic growth often attracts new residents, which in turn increases the demand for residential construction. To the extent that we have already realized positive employment growth due to broadband in other industries, it is

not surprising that broadband contributes to employment growth at rates between 0.62 and 21.76 percent in the construction industry in the 2004-05 period.

Broadband deployment also had a positive and significant impact on the mining industry. This result is also not surprising, because the industry relies heavily on broadband technology for many of its production and communication processes, including the transmission of market prices on which production decisions are made. However, given the small sample size in this sector we cannot generalize the result.

For some industries, namely, real estate, rental and leasing (Table 13), arts, entertainment and recreation (Table 19), and other services (Table 21), broadband is positive and significant in Model 1 but becomes insignificant when we add control variables. *F*-statistics indicate the overall significance of Model 4 in those industries, implying that the variables jointly explain employment growth. This suggests that broadband does contribute to employment growth, though the other variables are more influential to employment growth than broadband. Adding control variables in Model 4 overshadows the impact of broadband deployment on employment growth. Similarly for educational services (Table 17), broadband deployment is positive and significant in Models 1 and 2, but it becomes insignificant in Model 4. However, given the small sample size and Model 4 being insignificant, the results for educational services are inconclusive.

For an additional set of industries, there is weak evidence that broadband deployment affects employment growth. Broadband deployment has a positive sign but is not significant in any of the four models for the retail trade (Table 9), professional, scientific, and technical services (Table 14), and health care and social assistance (Table 18) sectors. Although the broadband parameters are statistically zero, the positive value does suggest nominal correlation between broadband deployment and employment growth in these industries. Additional evidence is found in the *F*-test for overall model significance: All of the models containing the broadband parameters are statistically significant. These results seem consistent with these

industries, as they are sectors that consist chiefly of secondary industry jobs that are dependent on primary industries. Additionally, as has been documented elsewhere (see Varian et al., 2002), health care has been one of the slowest industries to adopt broadband and still has the lowest adoption rates of any sector. Without at least a propensity to adopt, it is understandable why broadband availability alone may not immediately affect job growth in this sector.

For the above mentioned industries, then, broadband infrastructure appears to lower costs and/or make markets more accessible, leading to employment growth. It should be noted that these industries are made up of primarily higher wage jobs, suggesting that broadband deployment encourages the growth of higher wage jobs.

The broadband impact is negative and significant for only one industry sector, accommodations and food services (Table 20). The results suggest that broadband deployment will decrease employment by 0.34 to 39.68 percent in this sector. One explanation for this finding could be that individuals are relying more on the Internet for information about travel destinations and hotel arrangements rather than working through related service providers, which may decrease employment within the travel agency industry. An additional and broader explanation is that broadband access increases worker productivity such that employment declines when firms adopt broadband technologies. Given the typically low wages of this industry (which could be indicative of low productivity), it is possible that broadband availability enables firms to substitute technology for labor.

Although broadband shows a negative impact for utilities (Table 5) and management of companies and enterprises (Table 15), sample sizes are very small for both of these industries, so the results are not representative across Kentucky counties and will not be considered further.

The industries where no variables are significant in any models, and none of the models is significant, are forestry, fishing, and hunting (Table 3), manufacturing (Table 7), finance and insurance (Table 12), and unclassified (Table 22). However, the sample sizes in forestry, fishing, and hunting and unclassified are too small to draw any conclu-

sions. For manufacturing and finance and insurance, the insignificance of our control variables and models suggest that we have poor models. That is to say, our independent variables are not explaining the variance in employment growth between 2004 and 2005. Regression results for transportation and warehousing show only previous employment growth being significant with a negative sign (see Table 10). However, none of the models is significant according to the *F*-test, suggesting that broadband infrastructure has no statistical impact on employment growth for transportation and warehousing.

CONCLUSIONS

Based on the results above, we conclude that broadband deployment has a significant positive impact on a region's overall employment growth. Broadband infrastructure appears to reduce costs and/or increase market access, and thus lead to job creation and growth in total employment. At the sectoral level, broadband deployment positively impacts mining; construction; information; and administration, support, and waste management and remediation services. Broadband deployment does contribute to employment growth within real estate, rental, and leasing; arts, entertainment, and recreation; and other services; however, for these three sectors, other economic variables appear to be more influential to job growth than the availability of broadband. Weak evidence suggests that broadband availability may positively impact retail trade; professional, scientific, and technical services; and health care and social assistance, though the impact is likely to be indirect given the supporting nature of these industries to the economy. Broadband deployment appears to negatively impact accommodation and food services. These job losses, however, may be the result of substituting broadband technologies for less productive workers, which should lead to higher wages in the long run.

The results also suggest that broadband infrastructure contributes most to employment growth when counties are neither sparse nor saturated in their deployment. That is to say, employment growth seems to be highest around the mean level

of saturation, and this result stems from the diminishing returns to scale of broadband infrastructure, manifested by the significant but negative saturation squared term. From a productivity perspective, this result captures the notion that a critical amount of broadband infrastructure may be needed to sizably increase employment, but once a community is completely built out (i.e., saturation rate equals 1), additional broadband infrastructure will not (indeed, cannot) further affect employment growth. The policy implication is that investment in broadband infrastructure achieves its greatest return, measured by employment growth, in communities that have average saturation levels. Additionally, policymakers may want to encourage investment in broadband in poor counties, which also tend to be rural and/or characterized by low-income households, so that they can benefit from the higher levels of employment generation.

Extensions to this research are threefold. First, we have assumed that all broadband infrastructures are equal; however, they are not. In the United States, broadband is typically characterized as having an upload or download speed greater than 200 kilobits per second. Many service providers greatly exceed this standard, though some do not. Ideally, one would want to differentiate the broadband infrastructure to identify the speed and/or platform that are most conducive to employment growth. Policymakers need such information to make wise choices about the kind of broadband infrastructure to deploy. Second, broadband availability and broadband adoption are two very different concepts; we would like to revise this study using measures of broadband adoption. Third, we want to use the broadband deployment and adoption data to examine their impacts on different demographics, such as the poor and the elderly.

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