The Effects of Barge Shocks on Soybean Basis Levels in Arkansas: A Study of Market Integration

Andrew M. McKenzie

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The response of Arkansas, Memphis and Gulf soybean basis levels to barge rate shocks are investigated. Results suggest basis levels react negatively to an increase in the barge rate – implying the burden of higher transportation costs are at least in part transmitted to the farm level. In addition, Gulf soybean shocks, which reflect unexpected changes in soybean export demand, are also transmitted to internal markets, and result in correspondingly higher Arkansas basis levels. The system dynamics, which show simultaneous basis movements across Arkansas locations, provide strong evidence of pricing efficiency and market integration.

1. Introduction

The order in which markets respond to new information is often termed "price discovery." The transmission of new information between spatially separated but economically related markets is loosely referred to as the process of market integration. Spatial market integration studies typically test for degrees of integration and price discovery in terms of price movements between markets. Price responses to information shocks, and the co-movement of prices between markets, are assumed to measure the speed and magnitude by which new information is disseminated across markets. A broad range of procedures have been developed to test for market integration ranging from simple price correlation and regression based approaches to more sophisticated threshold cointegration models, which take into account unobservable transaction costs (Goodwin and Piggott 2001). As noted by Gonzalez-Rivera and Helfand (2001) previous spatial market integration studies have usually adopted a bivariate approach by focusing attention on price relationships between two markets.

This paper departs from much of the previous spatial market integration research in two important ways. First, a multivariate time series approach, as opposed to a bivariate approach, is used to examine the dynamic effect of transportation cost shocks on a number of economically related U.S. soybean market locations. In this respect our modeling approach follows closely that of Goodwin and Schroeder (1991) who analyzed price dynamics in international wheat markets with respect to shocks in ocean freight rates. Gonzalez and Helfand note the multivariate approach is better given that markets are comprised of multiple-locations. Secondly, unlike earlier studies, which analyze spatial market integration in terms of price relationships between markets this paper highlights the importance of modeling spatial integration for commodity grain markets in terms of basis level relationships between markets. Basis is defined as the contemporaneous difference between cash and futures prices for a given commodity and market location.

There are two reasons for analyzing market integration in terms of basis. First, basis is the accepted means by which grain is traded within the industry. Grain elevators and merchandisers who form hedged cash positions are particularly concerned with basis, and seek to profit from expected changes in the basis over time. Thus basis movements, which are more predictable and less volatile than cash prices, determine trade and grain flows.

Secondly, market integration theory, for storable commodities with associated cash and futures markets, is based upon both spatial and temporal arbitrage conditions. Most market integration studies test for long-run spatial equilibrium using various versions of:

(1) $P_t^a + T = P_t^b$,

where P_t^a is the price of a commodity in market *a* at time *t*, P_t^b is the price of the same commodity in market *b* at time *t*, and *T* represents transaction costs, which include the costs of transporting the commodity from market *a* to market *b*. Furthermore, in empirical research trade flow is typically assumed to be unidirectional, always taking place from *a* to *b*, and *T* is assumed to be a constant.

However, even if trade flows are unidirectional between markets, the theory of storage imposes additional equilibrium constraints on market prices. For ease of exposition consider a two-market[1], two-period model with both storage and trade, and allowing transportation costs to be stochastic, any equilibrium condition must simultaneously satisfy the constraints:

(2) the intertemporal (cost-of-carry) arbitrage conditions in two markets, *a* and *b*, written in terms of basis ($P_t - F_t^{t+n}$):

(a) $P_t^a - F_t^{t+n} = E_t\left[C_t^{a,t+n} - W_t^{a,t+n} - D_{t+n}^a\right] - P_t^a r_t^{t+n}$, $S_t^a > 0$

(b) $P_t^a - F_t^{t+n} \le E_t\left[C_t^{a,t+n} - W_t^{a,t+n} - D_{t+n}^a\right] - P_t^a r_t^{t+n}$, $S_t^a = 0$

(c) $P_t^b - F_t^{t+n} = E_t\left[C_t^{b,t+n} - W_t^{b,t+n} - D_{t+n}^b\right] - P_t^b r_t^{t+n}$, $S_t^b > 0$

(d) $P_t^b - F_t^{t+n} \le E_t\left[C_t^{b,t+n} - W_t^{b,t+n} - D_{t+n}^b\right] - P_t^b r_t^{t+n}$, $S_t^b = 0$

(3) the conditions for equilibrium trade in period *t*:

(a) $P_t^a + T_t = P_t^b, \quad Z_t > 0$

(b) $\left|P_t^a - P_t^b\right| \leq T_t, \quad Z_t = 0$

(4) the zero-profit condition for arbitrage of futures prices by risk-neutral speculators:

(a) $F_t^{t+n} = E_t\left[P_{t+n}^a\right] + E_t\left[D_{t+n}^a\right],$

(b) $F_t^{t+n} = E_t\left[P_{t+n}^b\right] + E_t\left[D_{t+n}^b\right],$

where E_t is an expectations operator, C_t^{t+n} is the marginal convenience yield from an additional unit of inventory, W_t^{t+n} is the marginal physical cost of storage, D_{t+n} is the physical delivery cost in period *t+ n* associated with fulfilling the terms of the futures contract, r_t^{t+n} is the rate of interest per period, F_t^{t+n} is the futures price for delivery of the commodity in period *t+ n*, observed in period *t*, S_t is the amount of the commodity stored in period *t*, Z_t is the amount of the commodity traded in period *t*, and T_t is the transportation cost between markets in period *t*.

Clearly, the constraints specified in 3(a) through 4(b) hold for basis levels as well as price levels, and both price and basis relationships between markets are bounded by the above constraints. The constraints 2(a) through 2(d) form temporal constraints upon the basis for each market, while constraints 3(a) through 3(b) form spatial constraints on basis levels between markets. Whichever subset of the constraints, temporal or spatial are binding in any particular time period will depend upon the relative magnitudes of C_t^{t+n}, $W_t^{t+n}, D_{t+n}, r_t^{t+n}$ and T_t. For example, combining constraints 2(a), 2(c) and 3(a), the case of both trade and storage in markets *a* and *b*, the combined constraint becomes:

(5) $P_t^b = P_t^a + T_t(1+r)^{-1} + E_t\left[W_t^{a,t+n} + D_{t+n}^a - C_t^{a,t+n} - W_t^{b,t+n} + D_{t+n}^b - C_t^{b,t+n}\right](1+r)^{-1}.$

If $T_t(1+r)^{-1} + E_t\left[W_t^{a,t+n} + D_{t+n}^a - C_t^{a,t+n} - W_t^{b,t+n} + D_{t+n}^b - C_t^{b,t+n}\right](1+r)^{-1} \leq T_t$, the joint constraint in (5) will impose a tighter boundary on price differentials between markets than will the spatial market constraint specified in 3(a) alone. Thus, price movements in different markets are determined by factors affecting both the temporal and spatial components of basis.

Within the boundaries imposed by the temporal and spatial constraints, prices and basis levels are determined by local supply and demand conditions. The salient point, which motivates this paper, is that futures and cash prices for storable commodities should be considered jointly, and should be modeled as endogenous variables in empirical applications of spatial market integration models. Specifying the model in terms of basis represents a convenient way of endogenizing cash and futures prices.

In the next section a vector autoregressive (VAR) approach is developed to model market integration and price discovery. In the third section the data and model specifications are discussed in terms of basis level responses of Arkansas, Memphis and Gulf export soybean markets to barge rate shocks. In section 4 empirical results are presented and the degree of market integration with respect to a shock in barge rates is assessed. Section 5 concludes.

2. Approach

VAR's are used to examine dynamic relationships among economic variables without imposing spurious *a priori* restrictions on the dynamics (Sims 1972).

A VAR system for n variables may be defined as:

$$
(6) \qquad Y_t = \bar{c} + \sum_{k=1}^{k} \begin{bmatrix} b_{11}(k) & . & . & . & b_{1n}(k) \\ . & & & & \\ . & & & & \\ . & & & & \\ b_{n1}(k) & . & . & . & b_{nn}(k) \end{bmatrix} Y_{t-k} + \bar{\varepsilon}_t
$$

where

$\bar{c}$ = a vector of constant terms,

t = time ($t = 1,......T$),

Y_t = an n x 1 vector of economic variables,

k = the lag order of the system,

$b_{ij}(k)$ = the parameters to be estimated, and

$\bar{\varepsilon}_t$ = a vector of serially uncorrelated random errors (innovations) with constant variance.

Each equation in the VAR system is estimated using ordinary least squares (OLS). Model selection in terms of the number of lags k to include in the system is determined using SBIC and likelihood ratio tests in conjunction with residual diagnostic tests.

Following Bessler (1984), Featherstone and Baker (1987), and Goodwin and Schroeder (1991), the estimated innovation vector $\bar{\varepsilon}_t$ is then orthogonalized using Choleski decomposition, which transforms the covariance matrix of the innovations to an identity matrix. The Choleski decomposition of the VAR establishes a "Wold causal chain" that avoids misleading inferences with respect to the dynamic interactions caused by contemporaneous correlation of the innovations. In order to draw inferences regarding the dynamic adjustments in each of the variables to unexpected shocks in the series the standard VAR system, with orthogonalized innovations, is converted to a vector moving average representation (VMA). This allows the system dynamics to be analyzed using forecast error variance decomposition and impulse response functions.

Under the forecast error variance decomposition method, the VMA representation is used to compute conditional within-sample forecasts for each of the variables in the system over various forecast horizons. The forecast error variance, which by definition is comprised of the innovations or shocks to each of the variables, can then be decomposed, and the relative proportion of the movements in a sequence due to its "own" shocks versus shocks to other variables determined. If "own" shocks explain all of the forecast error variance of a series, the variable in question may be considered exogenous to the other variables in the system. On the other hand, if a large proportion of the forecast error variance associated with the sequence of a particular variable may be explained by shocks to one or more of the other variables, the variable in question would be considered to be endogenous to the system. In addition to determining the degree of endogeneity, the approach allows us to draw inferences as to the relative importance in terms of the magnitude and sequence of influence among the variables in the system.

The VMA representation of the system also allows us to determine the dynamic adjustments in terms of direction and magnitude for each variable in the system in response to unit shocks in the system's variables. The visual mapping of the dynamic responses of the system's variables to exogenous shocks to any one of the variables are known as impulse response functions. The impulses are generated by separately shocking innovations for each of the variables one standard deviation. Runkle style standard errors for the impulse responses are estimated using bootstrapping techniques as outlined in Runkle (1987).

A word of caution is in order with respect to both the forecast error variance decomposition and the impulse response analysis outlined above. Imposing the Choleski decomposition on the covariance matrix of the residuals in turn imposes a recursive system on the error structure of the model. In this case the ordering of the variables in the VAR implicitly assumes a specific sequence of effects between the variables in the system. Only innovations in the first ordered variable of the system can have a contemporaneous effect on the other variables in the system. Innovations in the second ordered variable in the system can have a contemporaneous effect on all the other variables in the system with the exception of the first ordered variable and so on. Innovations in all of the variables are allowed to have a lagged effect on all of the other variables. As such results derived from both the forecast error variance decomposition and the impulse response approaches may be sensitive to the ordering of the variables in the VAR system.

Variable ordering in this paper is determined first by economic theory and *a priori* assumptions about the relative exogeneity of the variables, and secondly by empirical causalities derived from standard Granger causality tests.

3. Data Considerations

A (VAR) model is applied to a system of reduced form equations for barge freight rates, soybean crush margins, and soybean basis levels for Memphis, Gulf export and major Arkansas cash markets. The VAR is estimated by using daily data observed once a week (every Friday) pertaining to the Arkansas soybean marketing system for the period April 26^{th} 1996 through December 10^{th} 1999. The set of reduced form equations for barge freight rates, soybean crush margins and basis levels are chosen to reflect supply and demand fundamentals in conjunction with the temporal and spatial market constraints specified in equations 2(a) through 4(b).

Cash transaction prices for delivered soybeans are observed at eight important Arkansas soybean cash market locations–a country elevator located in Jonesboro, two Mississippi river elevators located in Osceola and Blytheville, three Arkansas and White river elevators located in Augusta, Pine Bluff and Des Arc, and the only two Arkansas soybean processing plants, which are located in Little Rock and Stuttgart. Cash delivered soybean prices are also observed for the key Memphis and the Gulf export terminal markets. All cash market data are taken from various issues of "Grain Market News", which is compiled by the University of Arkansas Division of Agriculture Cooperative Extension Service. A small number of price quotes are missing for the Arkansas markets. Missing observations were replaced using cubic spline interpolation[2].

Soybeans are assumed to flow from the elevator market locations to either the Gulf for export, or to the internal processors at Little Rock and Stuttgart. It is further assumed that Arkansas produced soybeans destined for export are transported to the Gulf by barge, while trucks are used to transport soybeans to the internal processors. In terms of the system of equations 2(a)–3(b), prices for the final demand points located at Little Rock, Stuttgart and Gulf export markets are associated to P_t^b, while prices at the elevator locations are represented by P_t^a.

Chicago Board of Trade (CBOT) nearby soybean futures prices are used in conjunction with cash prices to calculate nearby basis positions. Nearby soybean futures prices are constructed by taking prices from the front month contract until the last day of the month prior to the expiration month of the front contract, at which time prices are rolled into the next maturing contract[3]. Basis levels are calculated for the all cash market locations by subtracting the nearby soybean futures prices from cash prices. This procedure yields ten different basis series–Gulf basis (G), Memphis basis (M), Little Rock basis (LR), Stuttgart basis (S), Osceola basis (O), Augusta basis (A), Blytheville basis (B), Pendleton basis (P), Des Arc basis (DA), Pine Bluff basis (PB), and Jonesboro basis (J).

Barge rate data is used to represent the cost of transporting soybeans, T_t, as in equations 3(a) –3(b), from the Memphis and Arkansas cash markets to the Gulf coast for export. Trucking costs between the cash markets to the internal processors are assumed to be constant, and so are not explicitly modeled. The barge rate (B), is an average spot barge rate in cents per bushel for grain shipments on the Mississippi River south of Memphis to Louisiana (Baton Rouge, Destrehan, Myrtle Grove or New Orleans). Spot barge rates (for delivery within 30 days) are quoted in terms of a percentage of tariff benchmarks, and each benchmark has its own tariff rate[4]. The benchmarks used in this paper are for nine river port locations in Arkansas (Barfield Landing, Cracraft Landing, De Soto Landing, Grand lake, Helena, Lake Village, Little Rock, Pine Bluff, Yellow Bend) and the river port of Memphis. To calculate the average spot barge rate, first the percentage of the tariff benchmarks is multiplied by the tariff rate for each origination point. This gives the cost of shipping grain in dollars per short ton from each origination point to the Gulf coast. Secondly, the rates from each origination point are converted into cents per bushel and the mean barge rate for all ten origination points are calculated.

Although not modeled explicitly, because data is unavailable, convenience yield, C_t^{t+n}, physical storage costs, W_t^{t+n}, and the physical delivery cost for Arkansas soybeans associated with the futures contract D_{t+n}, are captured by including monthly seasonal dummy variables and lagged basis values and in the VAR.

Soybean crush margins are included in the VAR model to reflect demand for Arkansas soybeans by the Arkansas processing plants. CBOT soybean, soybean meal and soybean oil futures prices are used to calculate gross crush margins. The soybeans futures crush spread or gross crush margin (CM), reflects the profitability of crushing soybeans into soymeal and soyoil at any point in time. Following Simon (1999) the gross crush margin is calculated using the USDA formula,

(3) $$\mathrm{CM} = [((Meal * 48)/2000lbs.) + ((Oil * 11)/100lbs.)] - Soybean,$$

where CM is the gross crush margin, *Meal* is the futures price of soybean meal per ton, *Oil* is the futures price of soybean oil per 100 pounds, and *Soybean* is the futures price of soybeans per bushel. The soybean, soybean meal and soybean oil futures prices form a nearby series, constructed by taking prices from the front month contract until the last day of the month prior to the expiration month of the front contract, at which time prices are rolled into the next maturing contract[5].

4. Results

Preliminary model estimations were performed on VAR systems incorporating from one to eight lags for each variable. The Schwartz Bayesian criterion (SBC) and likelihood ratio test statistics indicated that a parsimonious VAR system with a lag order of only one-week was optimal. However, Ljung-Box Q-statistics indicated four lags should be included in the system estimation to remove the presence of serial correlation, and hence all final model estimation and results are based upon a fourth order lag structure[6]

Prior to imposing a recursive system on the VAR, the contemporaneous correlations of the equation by equation residuals, which are presented in table 1, are examined. This allows any simultaneous interaction and contemporaneous price linkages between the variables to be uncovered. All of the correlation coefficients for the barge rate and crush margin are not significantly different from zero at the 5 percent level. This indicates basis levels for all market locations do not immediately adjust to unexpected movements in either the barge rate or crush margin.

In addition, residual correlation coefficients between the individual markets in Arkansas (with the exception of Little Rock), and between the Memphis market are not significantly different from unity. This suggests new information, not associated with barge rate and crush margin movements, and contained in an unexpected basis level shock to any one of these markets, is simultaneously transmitted to and impounded by the other markets. The large correlation coefficients between these markets, and to a lesser extent between these markets and the Little Rock and Gulf markets, indicate that a significant portion of new information is reflected in basis level adjustments between all markets within the current week. In summary, the results presented in table 1 provide strong evidence of rapid basis level adjustments and a high degree of integration among the respective markets.

The VAR system is then triangularized in order from highest to lowest as follows: barge rate, crush margin, Gulf export basis, Memphis basis, Little Rock basis, Stuttgart basis, Osceola basis, Augusta basis, Blytheville basis, Pendleton basis, Des Arc basis, Pine Bluff basis, and Jonesboro basis. The reasoning behind this particular ordering may be explained in terms of three distinct sub-groupings of the variables. Exogeneity is the determining factor used to choose the ordering in the first tier group, which included the barge rate, crush margin and Gulf export basis. Theoretically, barge rate should be the most exogenous variable considered in this paper, followed by crush margin and the Gulf export basis. The important terminal markets of Memphis, Little Rock and Stuttgart comprised a second tier group. *A priori*, one would expect price discovery to be generated and sequence of information flows to pass through these markets prior to the other internal markets, which are included in the third tier grouping. The ordering of the internal markets in the third tier group lacks theoretical justification and is thus based purely upon Granger causality results.

Table 2 reports forecast error variance decompositions and standard errors for in-sample forecasts for periods one, three, six, 12, 24 and 50 weeks ahead. In all cases as the forecast horizon increases the standard errors grow, as would be expected, but tend to level off – implying the system is stationary. The proportion of the forecast error explained by innovations in all of the system variables are documented with respect to barge rate, crush margin and gulf export basis forecasts. All three variables are found to be in large part exogenous, at least over relatively short-forecast horizons of up to three weeks. Interestingly, over longer forecast horizons shocks to the Stuttgart and Osceola markets have some degree of forecasting power for the Gulf export market, suggesting a possible feedback mechanism exists between this important export market and the hinterland. In addition, innovations in basis levels for the two processors at Stuttgart and Little Rock have a noticeable effect on the crush margin. One possible explanation for this effect would be that the processors correctly anticipate changes in the crush margin and adjust their basis quotes appropriately. These results are robust to different orderings of all the variables within the system.

The forecast decompositions of the internal market basis levels, with respect to the barge rate, crush margin and Gulf export basis innovations are also reported in table 2. The Gulf export market seems to play an important price discovery role for all of the internal markets. This may be a reflection of supply and demand shocks in important US soybean export markets, which are transmitted as price shocks from the Gulf to the hinterland. Barge rate tends to have a relatively small effect on basis levels across all locations in comparison to other supply and demand shocks captured by unexpected basis movements. The barge rate appears to have the greatest influence on basis levels for the Memphis and Little Rock markets. These results are also robust to alternative orderings of the variables.

The decompositions of internal market basis level forecasts with respect to innovations in internal market basis levels are not reported in table 2, as results are highly sensitive to the ordering of the variables. Specifically, when the tier two and three groupings are combined, whichever, internal market basis level is placed first in the overall ordering, it explains nearly all of its own forecast error variance and the forecast error variance of all the other internal market basis levels. As an example, the proportion of the Memphis basis forecast error decomposition attributed to innovations in the Memphis basis are presented in table 2. This is consistent with the residual correlation coefficient results reported in table 1 and implies that a basis level shock in any one of the internal markets is simultaneously transmitted across all locations. Certainly the time series procedures used in this paper are unable to uncover any discernable sequence of influence among the internal markets.

Impulse responses for the barge rate and basis levels for the Gulf export market and all internal markets generated by one standard deviation shocks to the barge rate are presented in Figures 1 through 12. The statistical significance of each impulse response is presented by graphing 95 percent confidence intervals around the point estimates for the impulse responses. The barge rate shock, which represents an initial price hike of approximately one and a half cents per bushel, takes about six weeks to be fully realized in the barge freight market, at which time the barge rate returns to pre-shock levels (see Figure 1). This reflects a relatively slow adjustment process for barge rates to unexpected "own" price shocks. The cumulative effect of the shock results in a price increase of about 7 cents per bushel in freight.

Figure 2 illustrates the response of the Gulf export basis to the barge shock. The initial response is a positive half-cent price increase, which is only marginally insignificant from zero at the 5 percent level, and takes place in the contemporaneous period (week-zero). However, a significant negative price response of approximately one-cent per bushel occurs through weeks two through four. Thereafter the Gulf basis returns to pre-shock levels. *A priori* it was expected that if the Gulf basis reacted at all, it would respond positively to a price shock in the barge rate. The relative elasticity of buyers' demand for soybeans should determine the impact of barge price shocks on internal basis levels. In the case where buyers' demand for soybeans is perfectly elastic, the total amount of any increase in the barge rate would be fully absorbed by elevators. Basis levels for internal elevators would fall with no change in the Gulf basis level. As noted by

Fuller and Shanmughan (1978), and Sarwar and Anderson (1989), country elevators are considered price takers in their transactions with grain buyers with the terms of trade increasingly controlled by exporters and other operatives within a world market setting. In the case where buyers' demand is not perfectly elastic, the Gulf basis should increase while internal basis levels fall. A possible explanation of the observed fall in the Gulf basis level might be that higher ocean grain freight rates, not modeled here, are coincidental with higher domestic barge rates, and hence lead to lower a Gulf export basis.

Figures 3 through 12 show the effect of the barge rate shock on the various internal market basis levels. The impulse responses for each of the market locations are almost identical and also mirror the Gulf basis response. In all cases the contemporaneous response (week-zero) is insignificantly different from zero. The Memphis and Little Rock basis levels show the most significant responses. Memphis basis levels fall significantly in weeks one through five. Similarly Little Rock basis levels fall for the first three weeks following the shock. In both cases basis levels decrease from two to three cents per bushel each week over this period before returning to pre-shock levels.

A significant one time fall in basis, of on average one and a half cents per bushel, for each of the other internal markets is recorded during the first week following the barge rate shock. These results suggest basis levels are adjusted downwards to a corresponding positive shock in barge rates and that the effect is quickly and simultaneously transmitted across internal Arkansas markets. The Memphis and Little Rock basis levels show a stronger and more persistent reaction to unexpected movements in the barge rate, but basis responses for all locations are negative, and are in line with prior expectations. The negative response of basis levels for the processors at Little Rock and Stuttgart reflect a substitution effect with respect to the other internal markets. Theoretically internal elevator basis levels should be directly affected by the barge rate, which represents the cost of transporting soybeans originating at these locations to the Gulf export market. The processors at Little Rock and Stuttgart offer alternative final destination or demand points for soybeans originating in Arkansas. As internal elevator basis levels fall in response to an increase in the barge rate, *ceteris parabus* a greater supply of soybeans will be transported to the processors, inducing a corresponding fall in the Little Rock and Stuttgart basis levels.

Figures 13 through 23 depict the impulse responses of each of the internal basis levels to a one standard deviation shock in the Gulf export basis – equivalent to approximately a five and a half cent per bushel increase. The initial shock results in another five weeks of successively smaller but positive basis level adjustments, for the Gulf export market, before returning to pre-shock levels (see Figure 13). As in the case of a barge price shock, this reflects a relatively slow adjustment process for Gulf export basis levels to unexpected own basis shocks.

Significant and positive basis level responses to the Gulf export basis shock are revealed for each of the internal markets. As in the case of a barge rate shock, impulse responses for basis levels in each of the internal markets follow an almost identical pattern. Memphis basis levels adjust the most in terms of magnitude and persistence – the contemporaneous increase of approximately four cents per bushel is followed by significant and positive basis adjustments for weeks one, three, four and five. Little Rock basis level adjustments are smaller in magnitude but also take up to five weeks to be fully incorporated. All of the other internal markets register significantly positive basis adjustments for the contemporaneous period (week-zero) and for week one.

The impulse response analysis results reported so far are robust to different orderings in the variables of the VAR. However, as was the case for the forecast error variance decomposition analysis, results of impulse response analysis, used to deduce the effect on internal market basis levels with respect to shocks in any one of the internal basis levels, are highly dependent upon variable ordering. The dynamic responses of all internal basis levels to a one standard deviation shock in the basis level for the first placed location in the overall ordering, are virtually identical to the "own" basis level dynamic response for the first placed location. This result is insensitive to the choice of the first placed variable. The impulse responses of internal basis levels to shocks in the basis levels of lower ordered locations are insignificantly different from zero and are not formerly presented because of the sensitivity issue. Thus it may be assumed the internal markets cannot be separated in terms of basis level responses. A shock in any one market's basis level is immediately reflected in corresponding adjustments in the basis levels of other internal markets. As an example, the "own" response of the Memphis basis to a shock in the Memphis basis is presented in Figure 24, and the Little Rock basis response to a shock in the Memphis basis is presented in figure 25. The dynamic time paths, shown in figures 24 and 25, respond in an almost identical fashion to an initial ten cents per bushel shock in the Memphis basis. The Little Rock basis increases by almost nine cents per bushel in the contemporaneous period (week-zero). Thereafter both basis levels react negatively to the initial shock during weeks one through three. As noted previously, the results imply that a positive basis level shock in any one of the internal markets is instantaneously transmitted, in terms of an almost one for one correspondence, across all locations. In a similar vein to the forecast error variance decomposition approach the impulse response analysis procedure is unable to uncover any discernable sequence of influence among the internal markets.

5. Concluding Comments

The study highlights the importance of modeling market integration in storable commodity markets in terms of basis movements as opposed to price movement. A multi-market integration model is then presented to examine the effect of barge rate shocks on basis levels for Gulf, Memphis and Arkansas soybean markets.

The results provide strong evidence of pricing efficiency and integration among locations. In terms of price discovery, Gulf basis shocks play an important role in transmitting pricing signals from export markets. Internal market basis shocks, which may reflect local supply and demand shocks, are simultaneously realized across market locations.

Changes in barge transportation costs have a significant impact on the Arkansas soybean marketing system. Increases in barge rates translate into higher transportation costs to ship soybeans to export market. These higher costs represent a pricing signal, which is quickly transmitted across the marketing system, and which is at least in part borne at the farm-level in terms of lower basis offers.

Endnotes

1. The constraints specified in equations (2a) through (4b), which are adapted from Williams and Wright (1991), could easily be extended to include more than two markets.

2. Missing observations ranged from zero up to 10% of total sample population for the different market locations.

3. Soybean futures contracts trade for expiration months of January, March, May, July, August, September and November.

4. Bunge Corporation kindly provided spot barge rates. The benchmarks are from the Bulk Grain and
Grain Products Freight Tariff No. 7, which was issued by the Waterways Freight Bureau (WFB) of the Interstate Commerce Commission (ICC). In 1976, the United States Department of Justice entered into an agreement with the ICC and made Tariff No. 7 no longer applicable. Today, the WFB no longer exists, and the ICC has become the Surface Transportation Board of the United States Department of Transportation. However, the barge industry continues to use the benchmarks as rate units.

5. Soybean meal and oil futures contracts trade for expiration months of March, May, July, August, September, October and December. The only exception to the contract switching rule is that in the beginning of September, when the September soybean contract is dropped and the November soybean contract is picked up, the September meal and oil contracts are dropped and the December meal and oil contracts are picked up. As noted by Simon (1999), this is consistent with the tendency for the crush spread in the new crop to be traded in November versus December meal and oil.

6. Results are robust for different lag structures ordered from one to four.

Table 1. Contemporaneous correlation coefficients of VAR system residuals, April 1994 through December 1999

	variable												
variable	BR	CM	G	M	LR	S	O	A	B	P	DA	PB	J
BR	1.00												
C	-0.25^{+}	1.00											
G	0.12^{+}	-0.08^{+}	1.00										
M	0.03^{+}	-0.06^{+}	0.38^{*+}	1.00									
LR	-0.01^{+}	0.00^{+}	0.19^{*+}	0.85^{*+}	1.00								
S	0.06^{+}	0.04^{+}	0.30^{*+}	0.89^{*}	0.84^{*+}	1.00							
O	0.06^{+}	-0.04^{+}	0.35^{*+}	0.90^{*}	0.82^{*}	0.96^{*}	1.00						
A	0.08^{+}	-0.02^{+}	0.30^{*+}	0.89^{*}	0.84^{*+}	0.97^{*}	0.98^{*}	1.00					
B	0.08^{+}	-0.03^{+}	0.36^{*+}	0.90^{*}	0.83^{*+}	0.97^{*}	0.99^{*}	0.98^{*}	1.00				
P	0.08^{+}	0.04^{+}	0.30^{*+}	0.89^{*}	0.84^{*+}	1.00^{*}	0.96^{*}	0.96^{*}	0.97^{*}	1.00			
DA	0.07^{+}	0.04^{+}	0.30^{*+}	0.88^{*}	0.84^{*+}	0.99^{*}	0.97^{*}	0.97^{*}	0.97^{*}	0.99^{*}	1.00		
PB	0.09^{+}	-0.04^{+}	0.33^{*+}	0.90^{*}	0.83^{*+}	0.97^{*}	0.99^{*}	0.99^{*}	0.99^{*}	0.97^{*}	0.97^{*}	1.00	
J	0.06^{+}	0.03^{+}	0.30^{*+}	0.89^{*}	0.84^{*+}	0.99^{*}	0.97^{*}	0.97^{*}	0.97^{*}	0.99^{*}	0.99^{*}	0.97^{*}	1.00

* denotes significantly different from zero at the 5% level (for a two tailed test);

+ denotes significantly different from 1 at the 5% level (for a one tailed test).

Table 2. In-sample forecast error variance decompositions allocated to innovations in respective series, April 1994 through December 1999

Variable	Weeks ahead	Std. Error	BR	CM	G	M	LR	S	O	A	B	P	DA	PB	J
BR	1	1.49	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	2.37	83.0	0.4	5.3	0.1	2.2	0.3	0.8	0.6	0.2	0.9	0.4	0.5	0.3
	6	3.16	70.3	1.3	3.5	0.6	2.3	5.0	5.9	0.5	2.0	6.2	1.2	0.6	0.5
	12	3.75	54.4	1.3	5.3	1.6	2.5	8.0	15.5	0.5	2.4	5.8	0.9	1.2	0.6
	24	3.88	50.9	4.5	5.4	1.6	3.0	7.6	14.9	0.8	2.3	5.7	1.4	1.3	0.7
	50	3.96	49.6	6.0	5.2	1.7	3.0	7.9	14.4	0.9	2.2	5.8	2.0	1.2	0.8
CM	1	5.25	6.1	93.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	8.64	7.1	61.6	5.7	0.0	8.5	12.3	0.6	2.1	0.4	1.1	0.4	0.1	0.1
	6	11.96	5.1	51.1	5.6	2.0	8.3	21.0	1.7	1.5	1.2	1.3	0.8	0.1	0.2
	12	15.57	7.9	43.4	3.3	4.8	5.3	21.5	2.9	3.9	1.0	3.2	2.0	0.3	0.6
	24	19.07	6.0	45.1	2.6	4.4	4.1	20.7	2.6	4.5	0.8	2.3	5.1	0.3	1.5
	50	22.07	4.6	46.1	2.2	3.9	3.4	18.8	2.5	7.1	0.6	1.7	7.3	0.2	1.6
G	1	5.84	1.4	0.3	98.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3	7.94	5.8	8.6	64.6	1.1	4.6	3.5	1.3	0.2	6.6	0.2	0.3	2.9	0.3
	6	11.67	5.0	4.8	48.2	2.8	5.2	18.0	7.7	0.4	4.8	0.4	0.3	1.9	0.3
	12	14.56	6.1	4.0	32.1	6.2	4.6	17.3	21.0	1.8	4.2	0.5	0.3	1.9	0.4
	24	16.33	7.3	6.2	28.1	5.1	3.8	14.0	19.6	1.9	3.6	7.8	0.4	1.6	0.6
	50	17.37	6.7	10.2	25.3	4.9	3.3	13.5	17.6	4.0	3.2	8.8	0.4	1.5	0.6

Table 2. Continued

Variable	Weeks ahead	Std. error	BR	CM	G	M
M	1	10.96	0.1	0.3	14.4	85.2
	3	12.80	7.2	2.0	16.8	65.4
	6	15.76	10.4	1.6	18.1	46.1
	12	19.29	9.3	1.7	14.4	33.5
	24	20.79	9.0	4.3	14.4	29.0
	50	21.85	8.4	8.2	13.5	26.7
S	1	10.79	0.3	0.3	9.1	
	3	12.44	1.7	0.8	10.1	
	6	14.06	2.7	0.7	8.7	
	12	15.66	2.7	1.3	7.9	
	24	16.98	3.4	4.2	8.4	
	50	18.16	3.1	9.1	8.0	
A	1	10.27	0.6	0.0	8.9	
	3	11.91	2.3	0.3	9.7	
	6	13.43	4.4	0.4	8.6	
	12	15.19	4.3	1.1	7.8	
	24	16.36	4.5	4.1	8.2	
	50	17.52	4.0	9.2	7.8	
P	1	10.66	0.6	0.4	9.0	
	3	12.06	1.9	1.1	10.2	
	6	13.74	3.1	1.0	8.4	
	12	15.47	3.2	1.6	8.0	
	24	16.86	3.4	5.1	8.7	
	50	18.23	3.1	10.9	8.1	
PB	1	10.28	0.8	0.0	10.6	
	3	11.59	2.0	0.7	12.5	
	6	13.14	3.6	0.8	10.9	
	12	14.90	3.3	1.3	10.0	
	24	16.25	4.0	4.0	10.4	
	50	17.42	3.6	8.9	9.7	

Variable	Weeks ahead	Std. error	BR	CM	G
LR	1	10.16	0.0	0.0	3.6
	3	13.47	10.5	0.9	2.5
	6	16.09	10.2	0.9	8.6
	12	19.02	8.2	1.9	8.8
	24	20.31	8.3	4.1	9.1
	50	21.30	7.6	7.7	8.7
O	1	10.30	0.4	0.1	11.8
	3	11.63	2.5	0.6	14.1
	6	13.24	6.7	0.7	12.5
	12	15.08	7.3	1.2	11.0
	24	15.87	7.0	2.9	11.4
	50	16.44	6.7	5.9	10.9
B	1	10.75	0.6	0.0	12.2
	3	11.95	2.0	0.5	14.0
	6	13.42	5.1	0.5	12.6
	12	15.18	5.7	1.1	11.3
	24	16.07	5.6	2.8	11.6
	50	16.74	5.3	6.1	11.1
DA	1	10.86	0.4	0.4	9.0
	3	12.53	2.3	0.9	9.9
	6	14.09	3.9	0.9	8.7
	12	15.75	3.5	1.6	8.3
	24	17.05	4.9	4.5	8.5
	50	18.09	4.5	8.6	8.1
J	1	10.76	0.4	0.2	8.7
	3	12.41	2.0	0.7	9.0
	6	14.02	4.3	0.6	7.7
	12	15.61	4.4	1.1	7.1
	24	16.64	4.7	4.0	7.3
	50	17.63	4.2	8.4	7.1

Figure 1. Barge Rate Impulse Response to a Shock in the Barge Rate

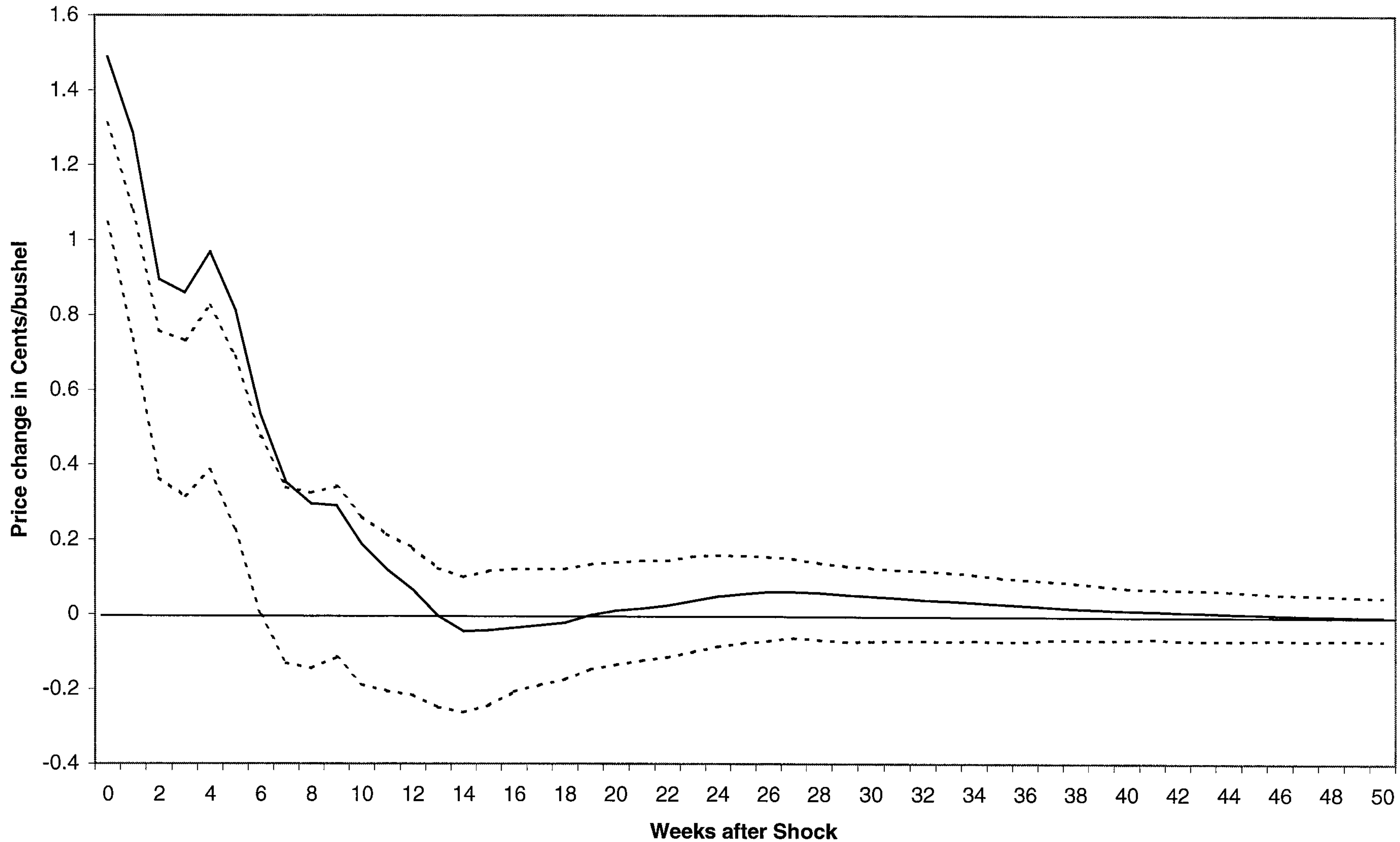


Figure 2. Gulf Basis Impulse Response to a Shock in the Barge Rate

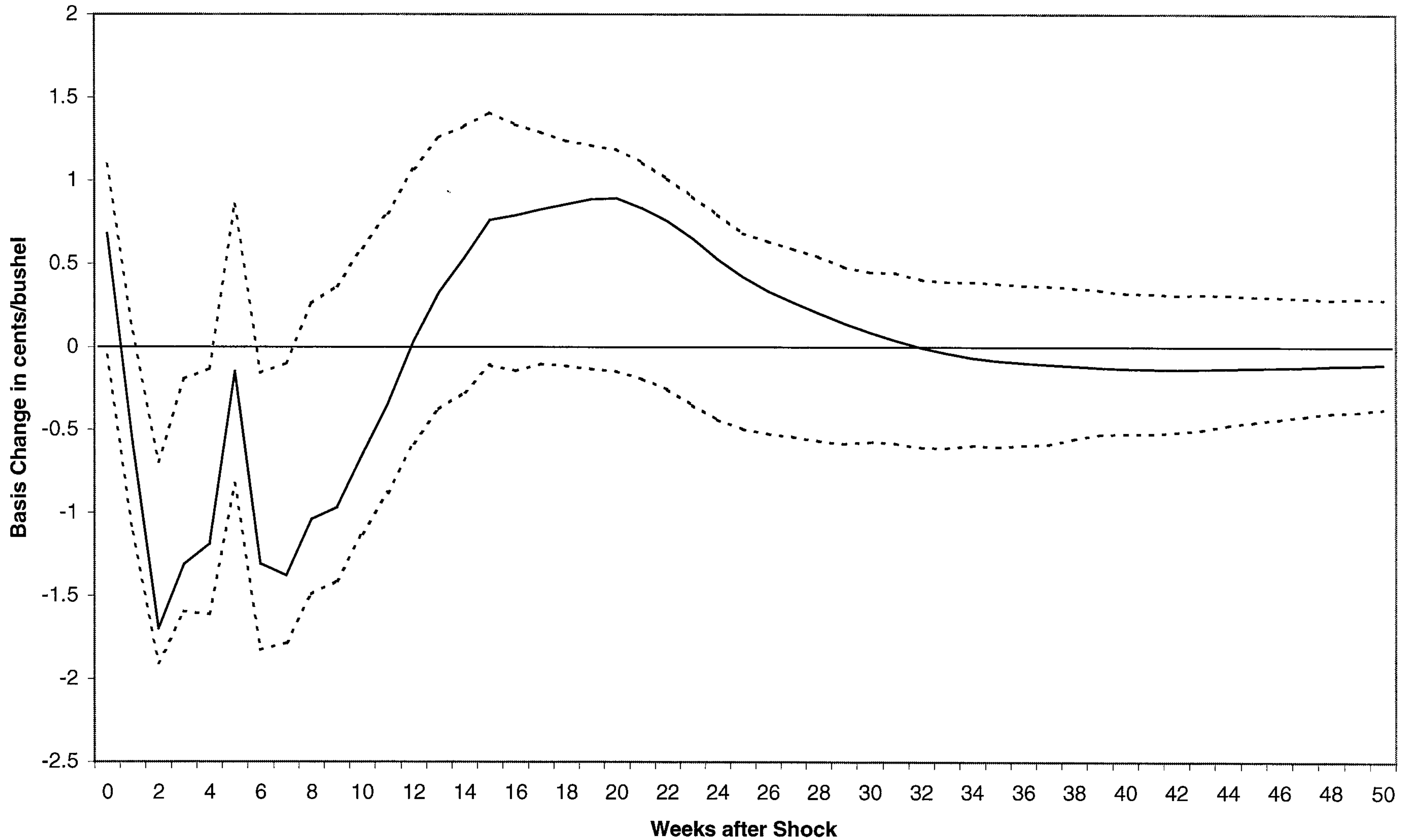


Figure 3. Memphis Basis Impulse Response to a Shock in the Barge Rate

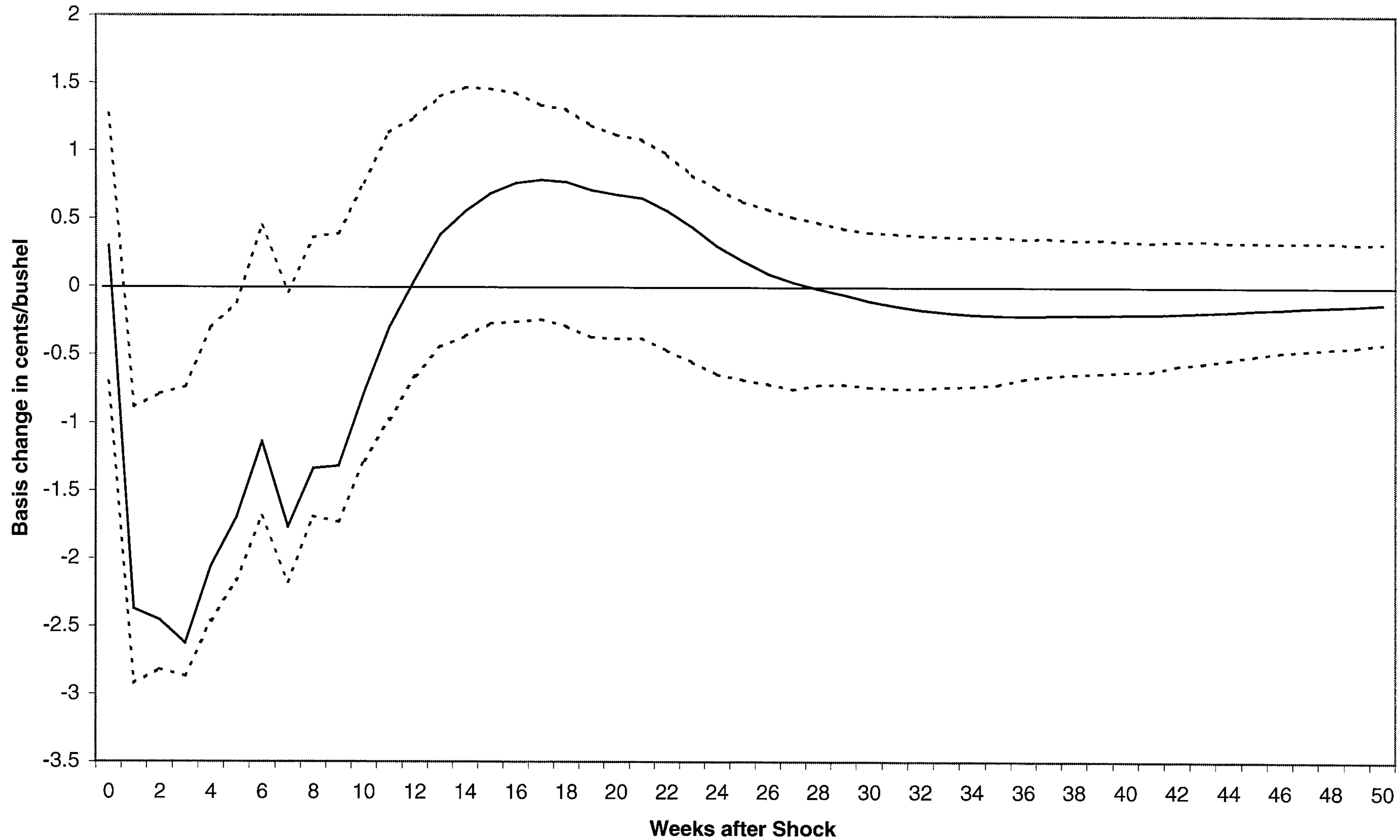


Figure 4. Little Rock Basis Impulse Response to a Shock in the Barge Rate

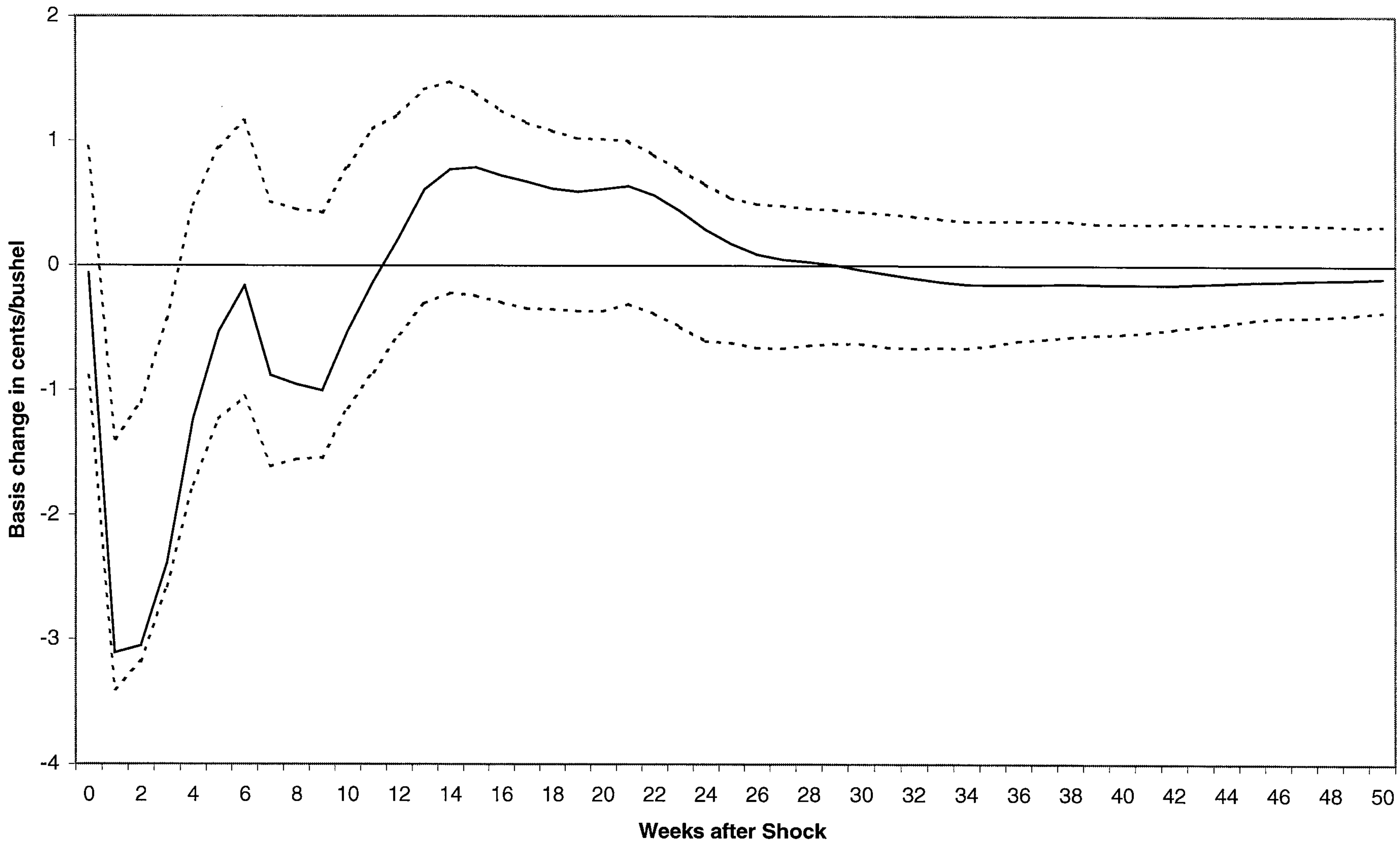


Figure 5. Stuttgart Basis Impulse Response to a Shock in the Barge Rate

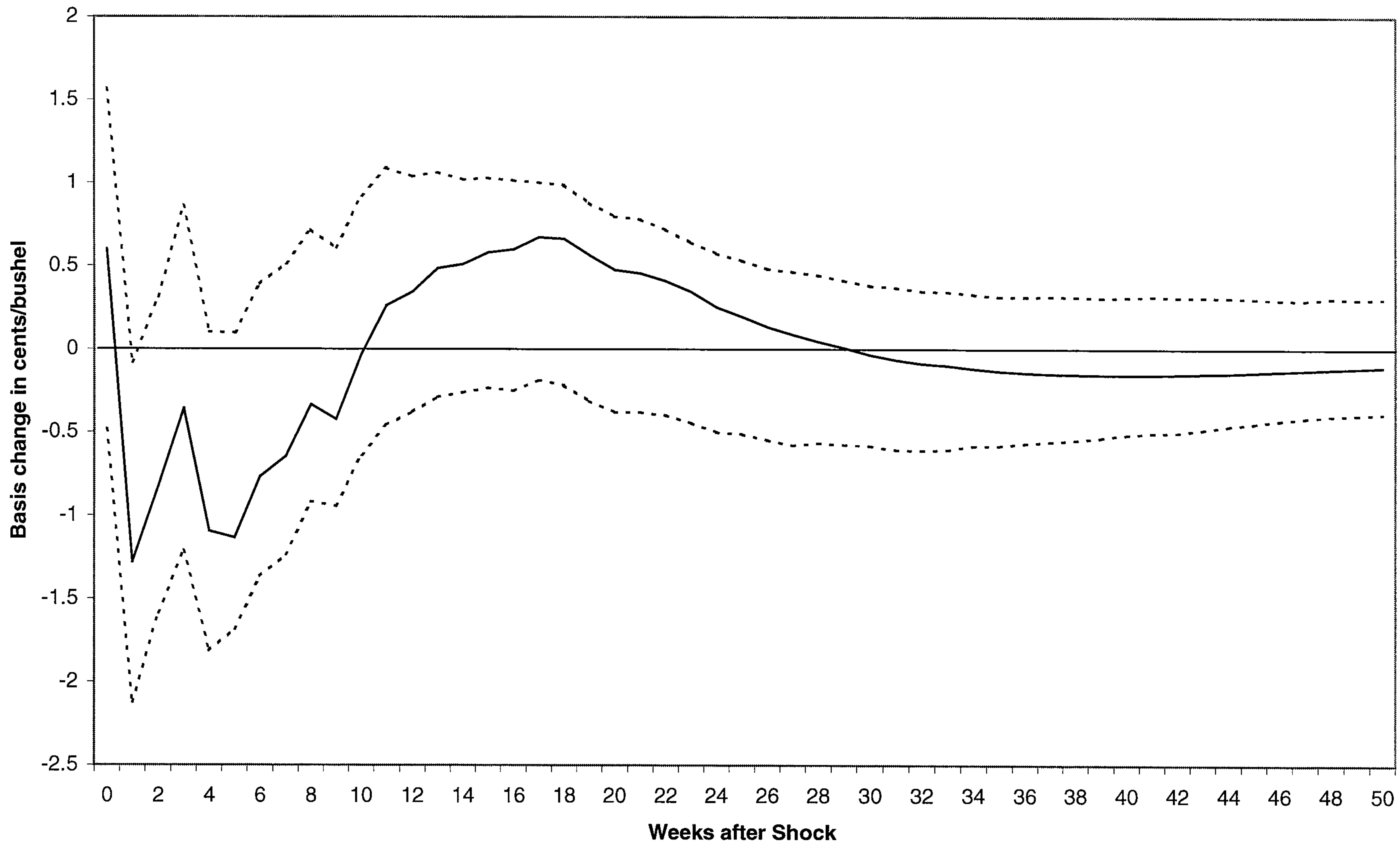


Figure 6. Osceola Basis Impulse Response to a Shock in the Barge Rate

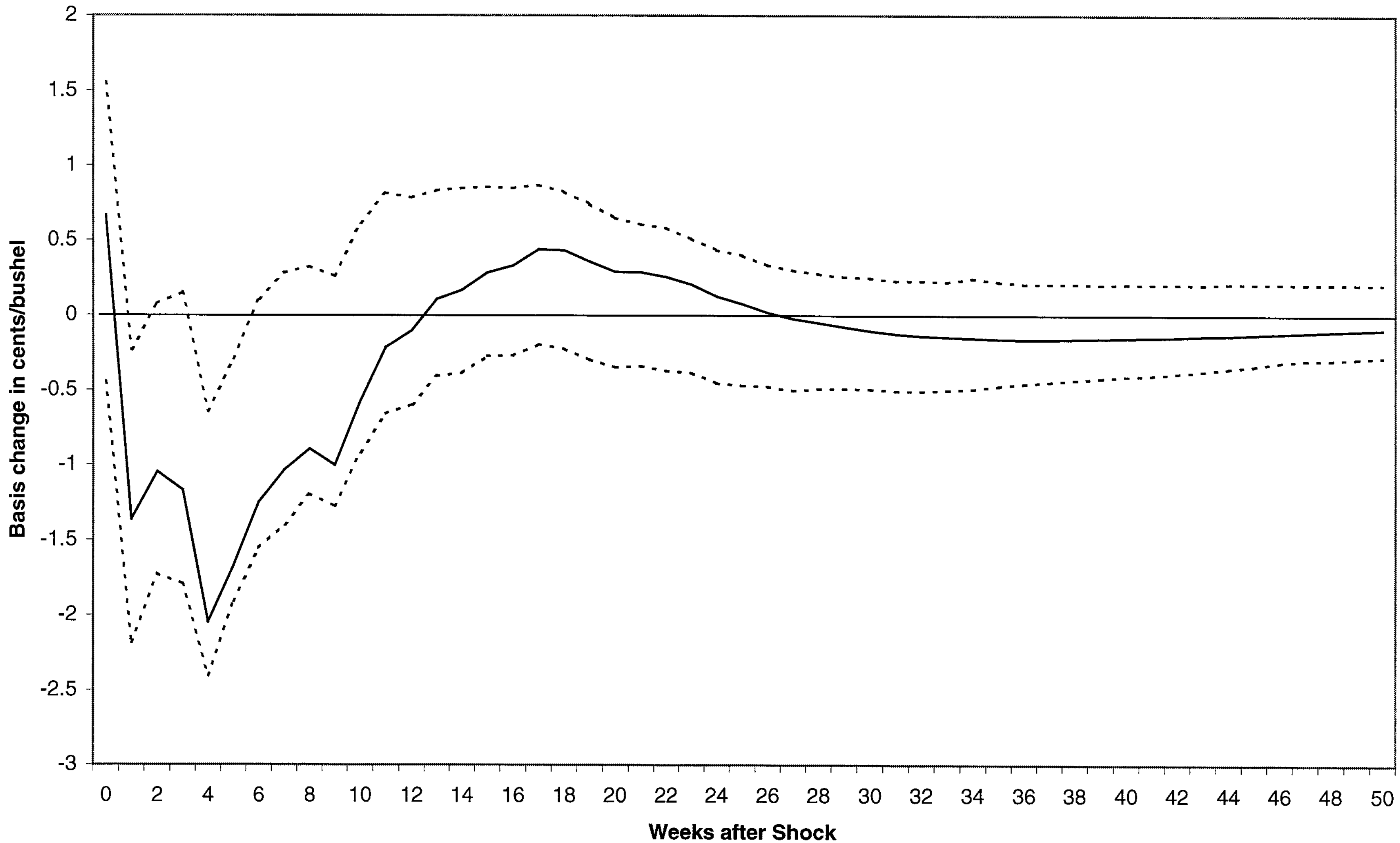


Figure 7. Augusta Basis Impulse Response to a Shock in the Barge Rate

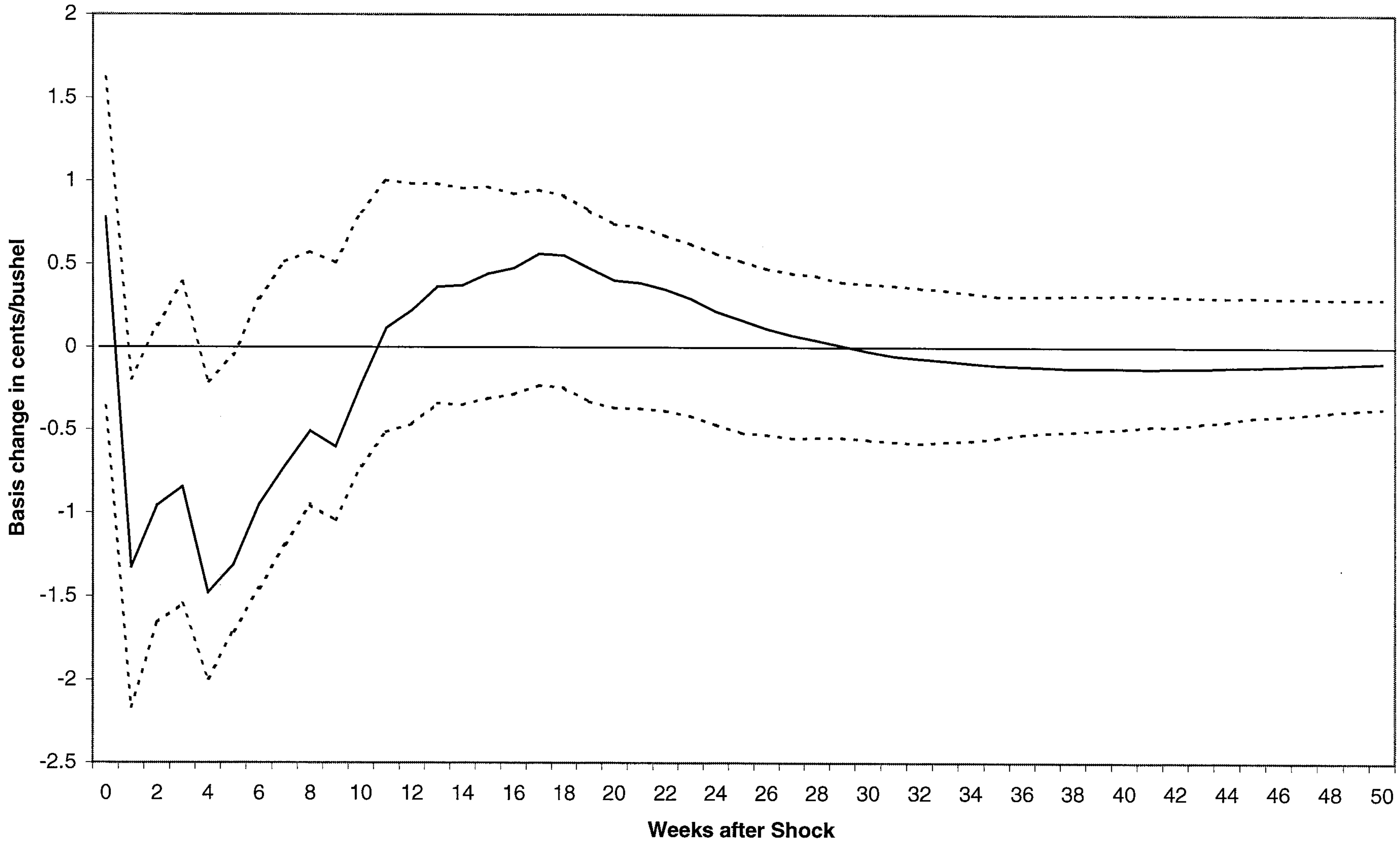


Figure 8. Blytheville Basis Impulse Response to a Shock in the Barge Rate

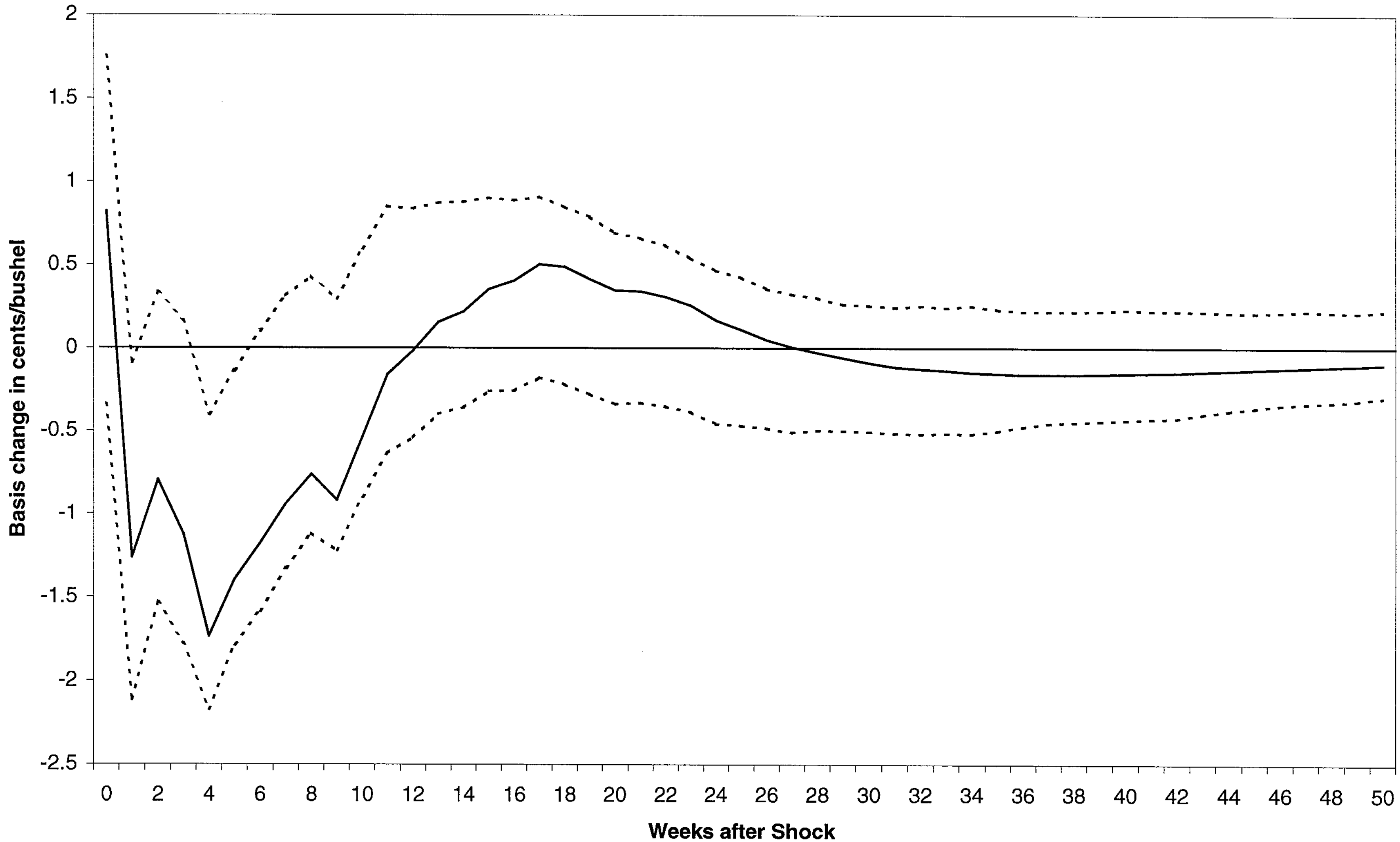


Figure 9. Pendleton Basis Impule Response to a Shock in the Barge Rate

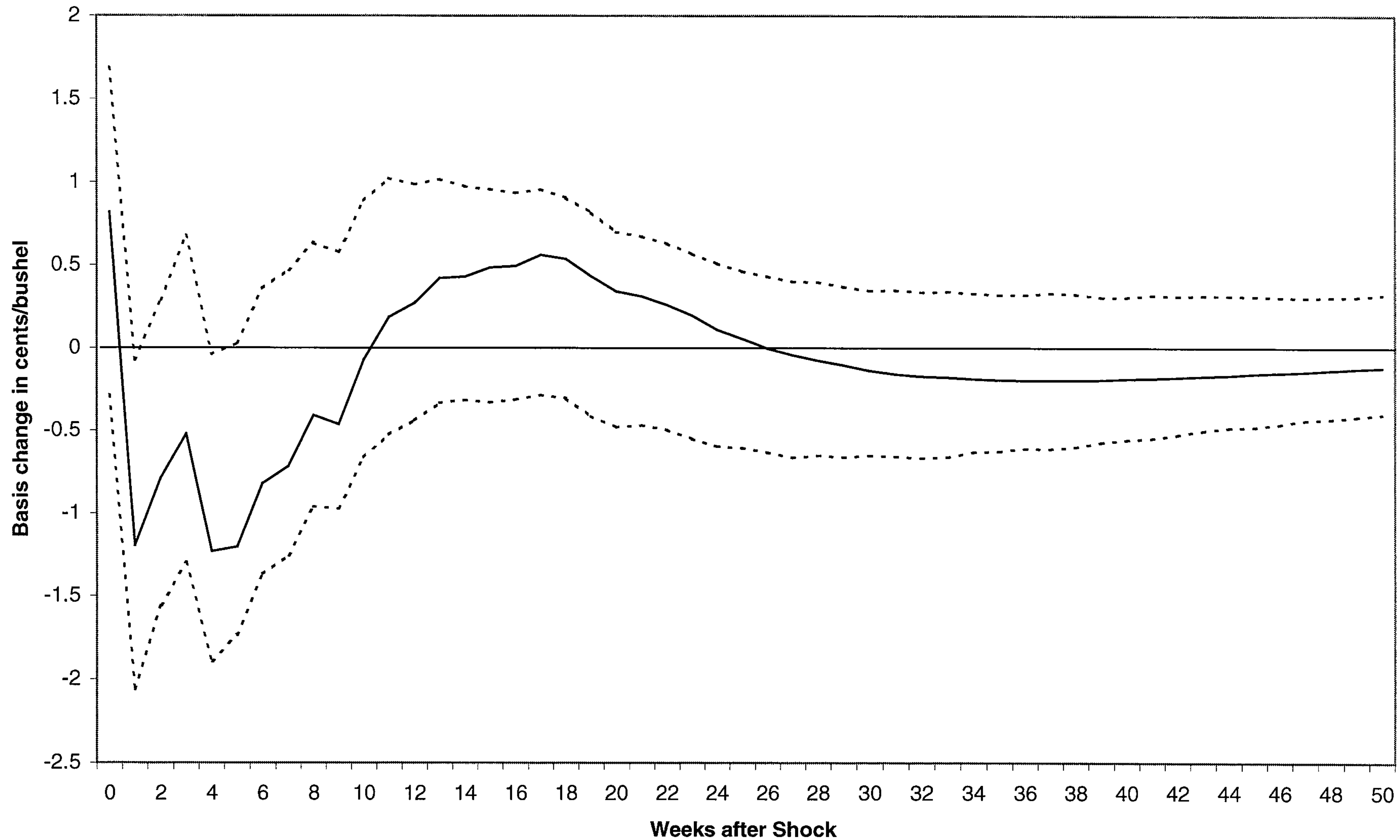


Figure 10. Des Arc Basis Impulse Response to a Shock in the Barge Rate

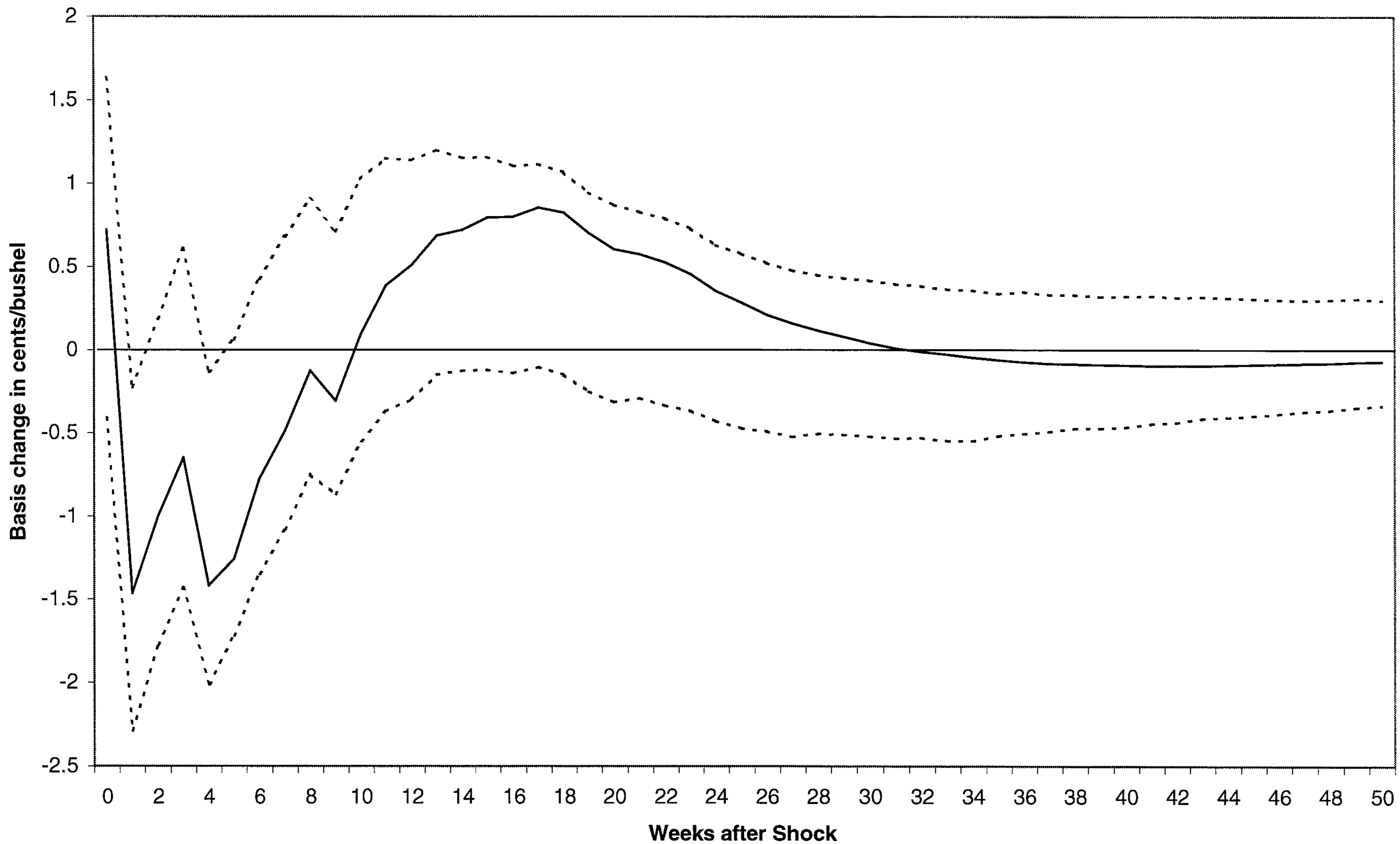


Figure 11. Pine Bluff Basis Impulse Respone to a Shock in the Barge Rate

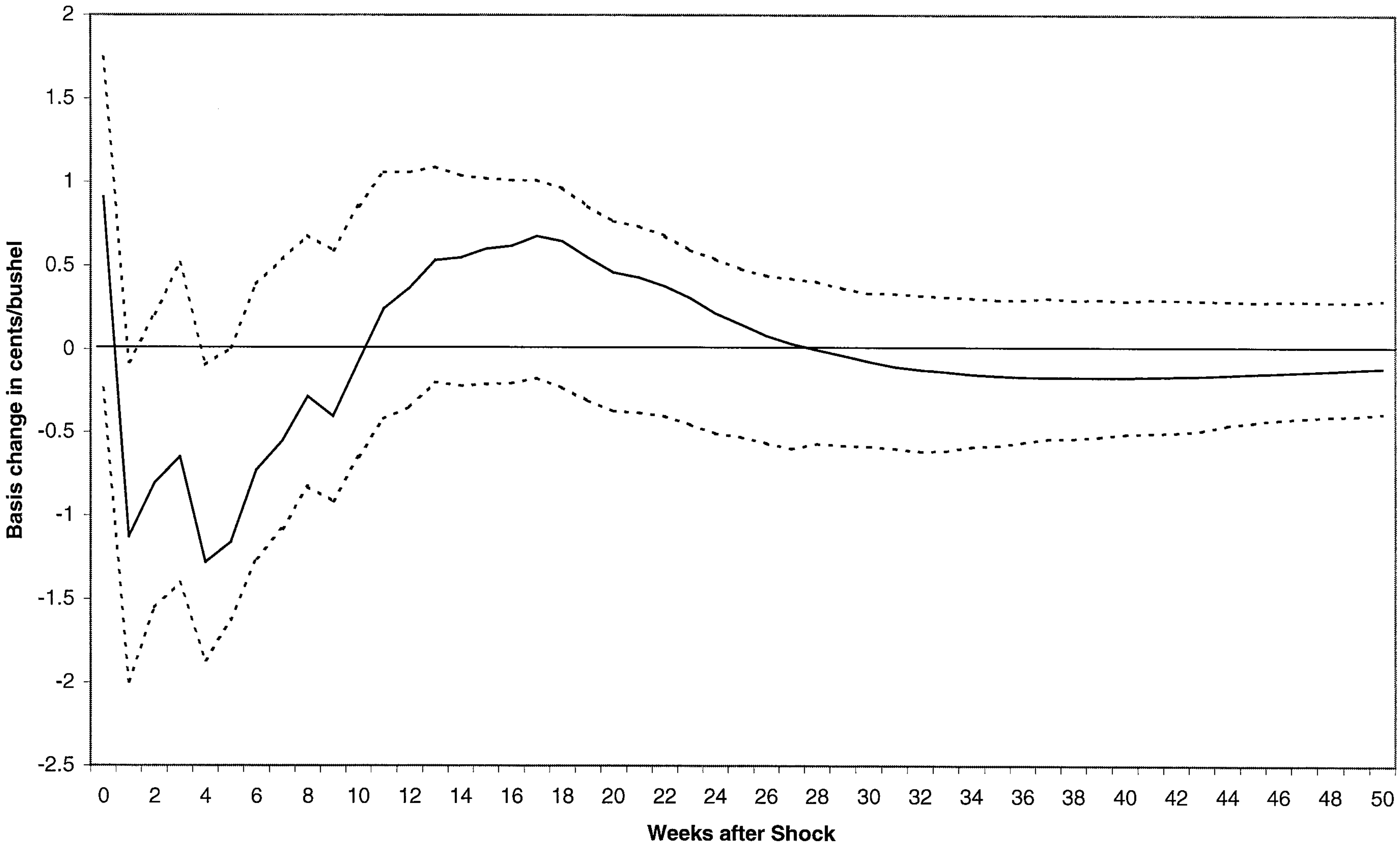


Figure 12. Jonesboro Basis Impulse Response to a Shock in the Barge Rate

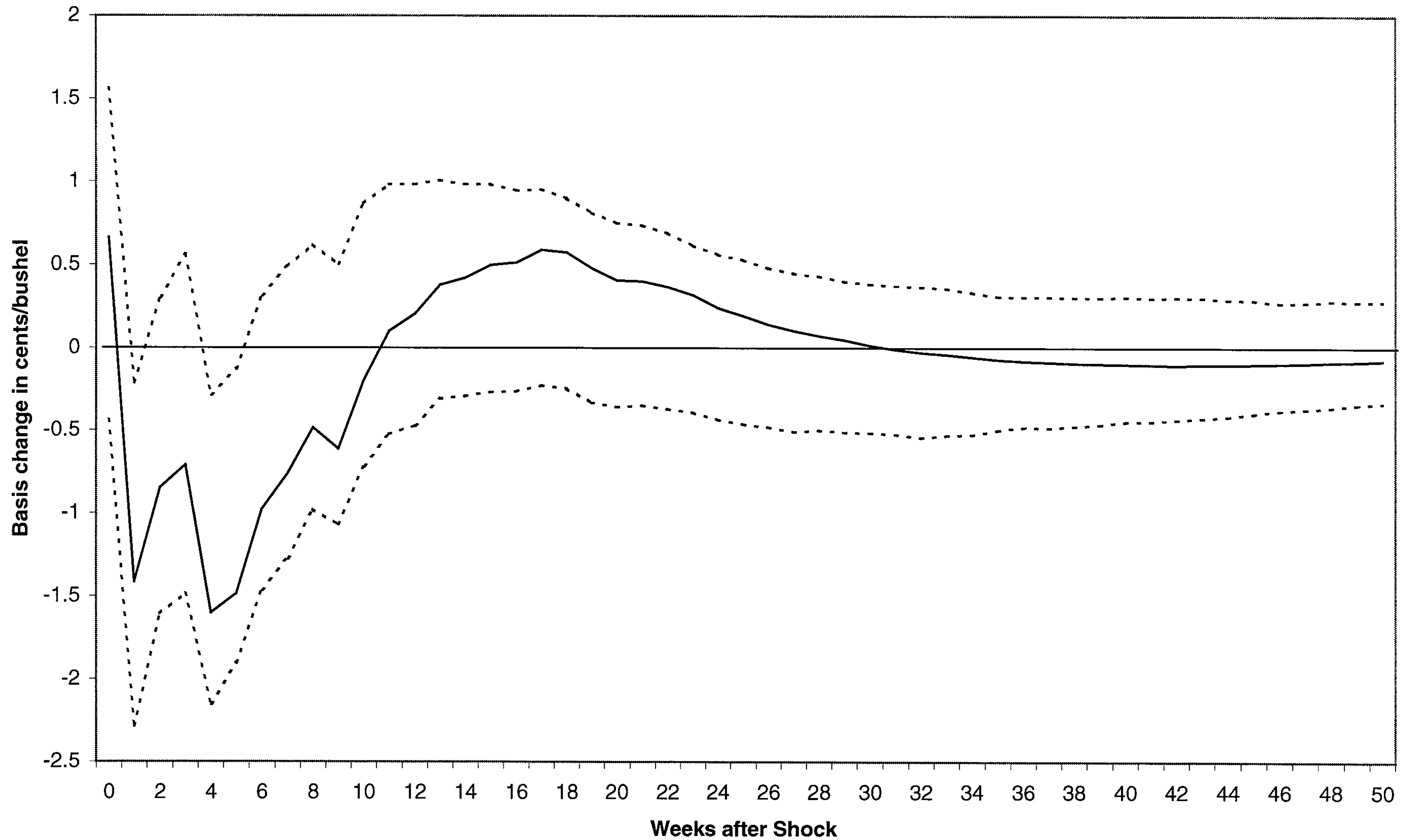


Figure 13. Gulf Basis Impulse Response to a Shock in Gulf Basis

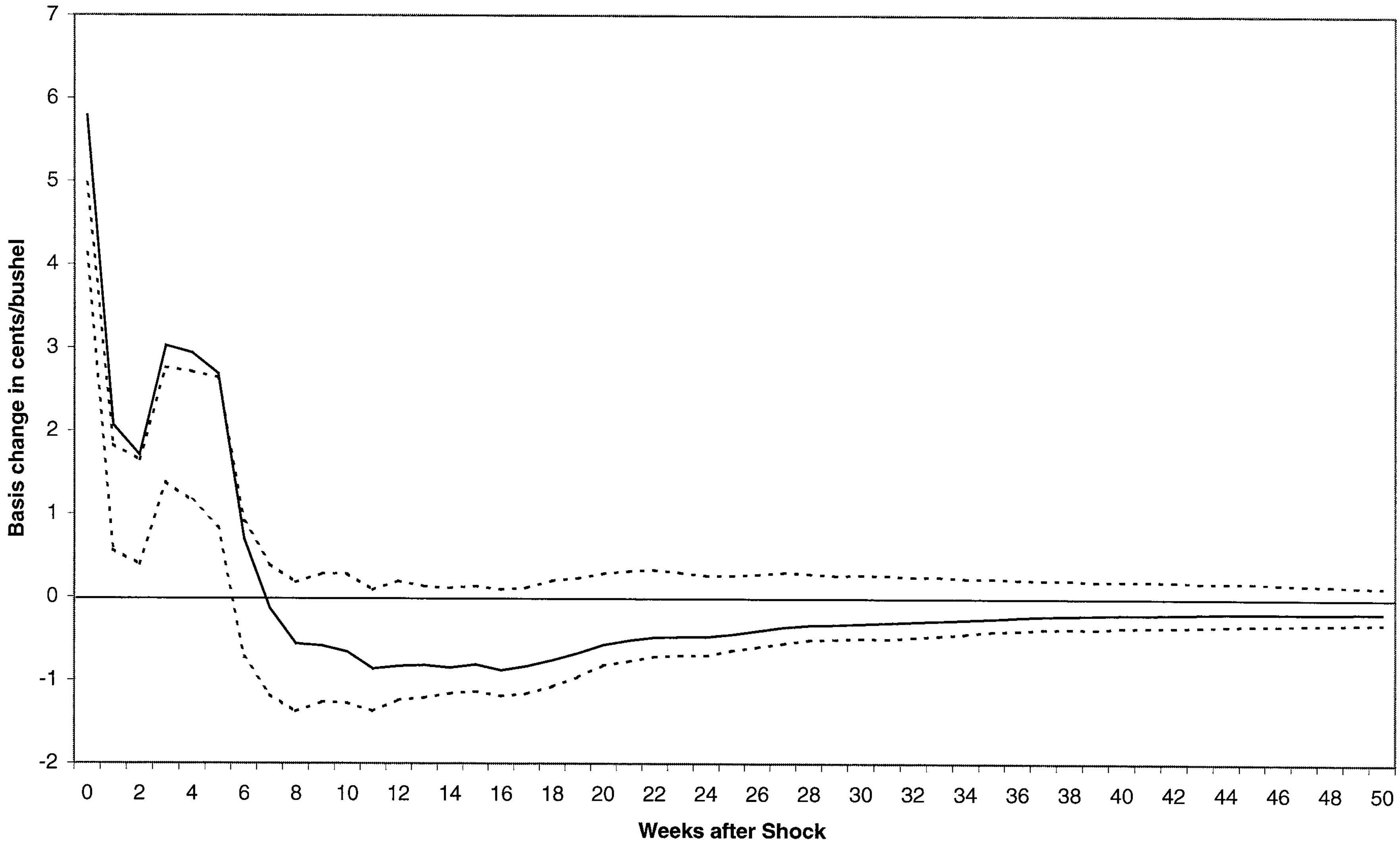


Figure 14. Memphis Basis Impulse Response to a Shock in Gulf Basis

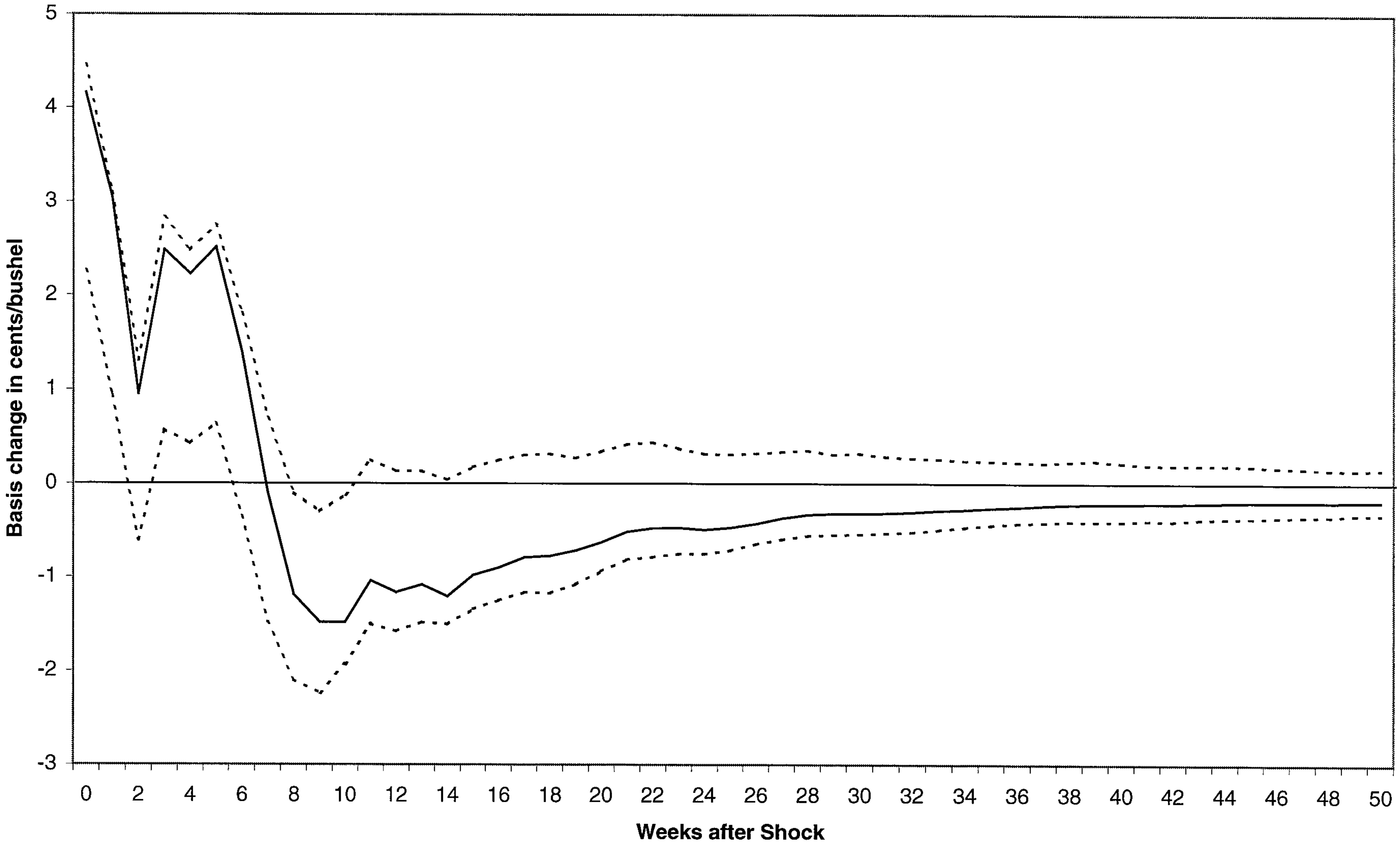


Figure 15. Little Rock Basis Impulse Response to a Shock in Gulf Basis

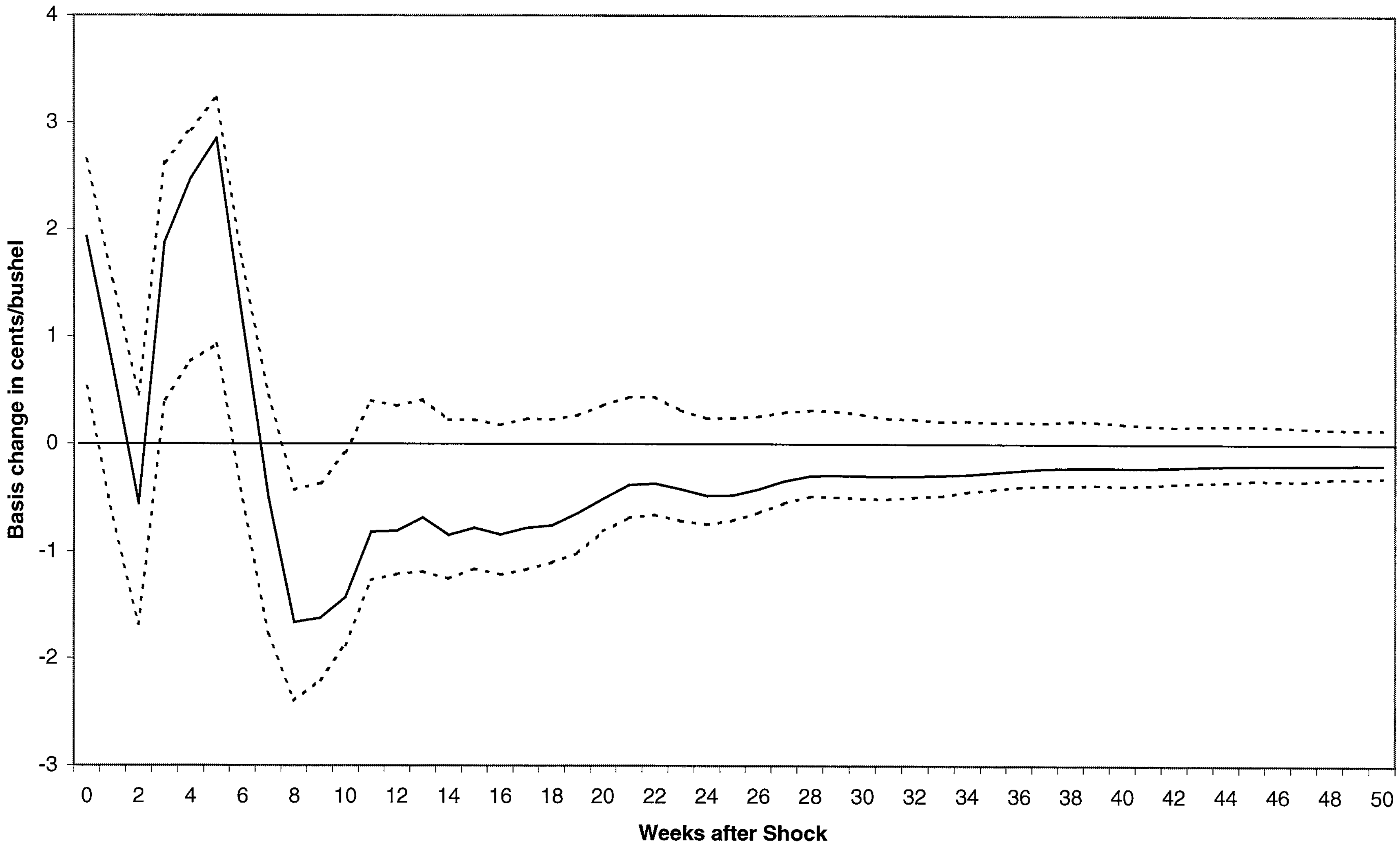


Figure 16. Stuttgart Basis Impulse Response to a Shock in Gulf Basis

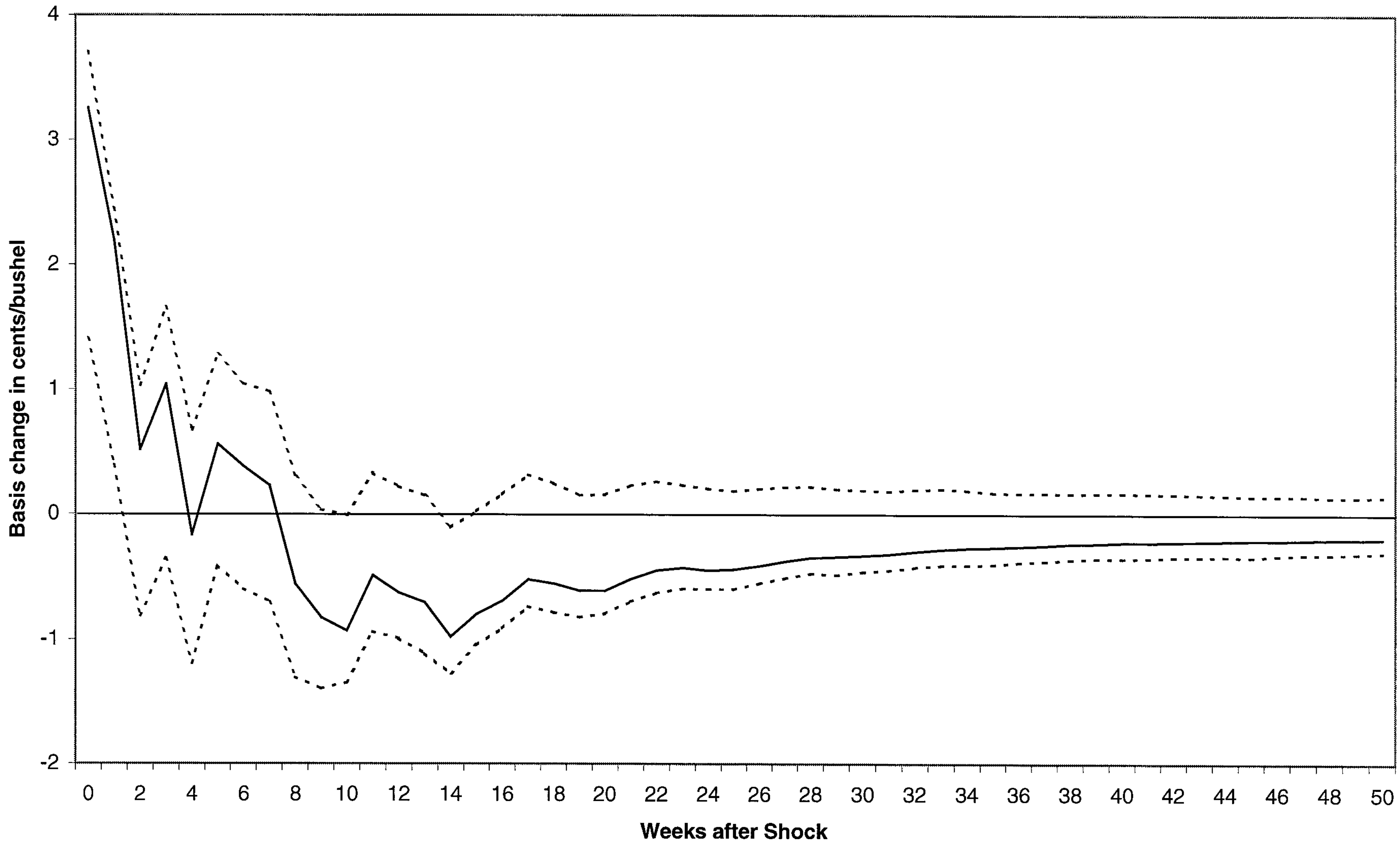


Figure 17. Osceola Basis Impulse Response to a Shock in Gulf Basis

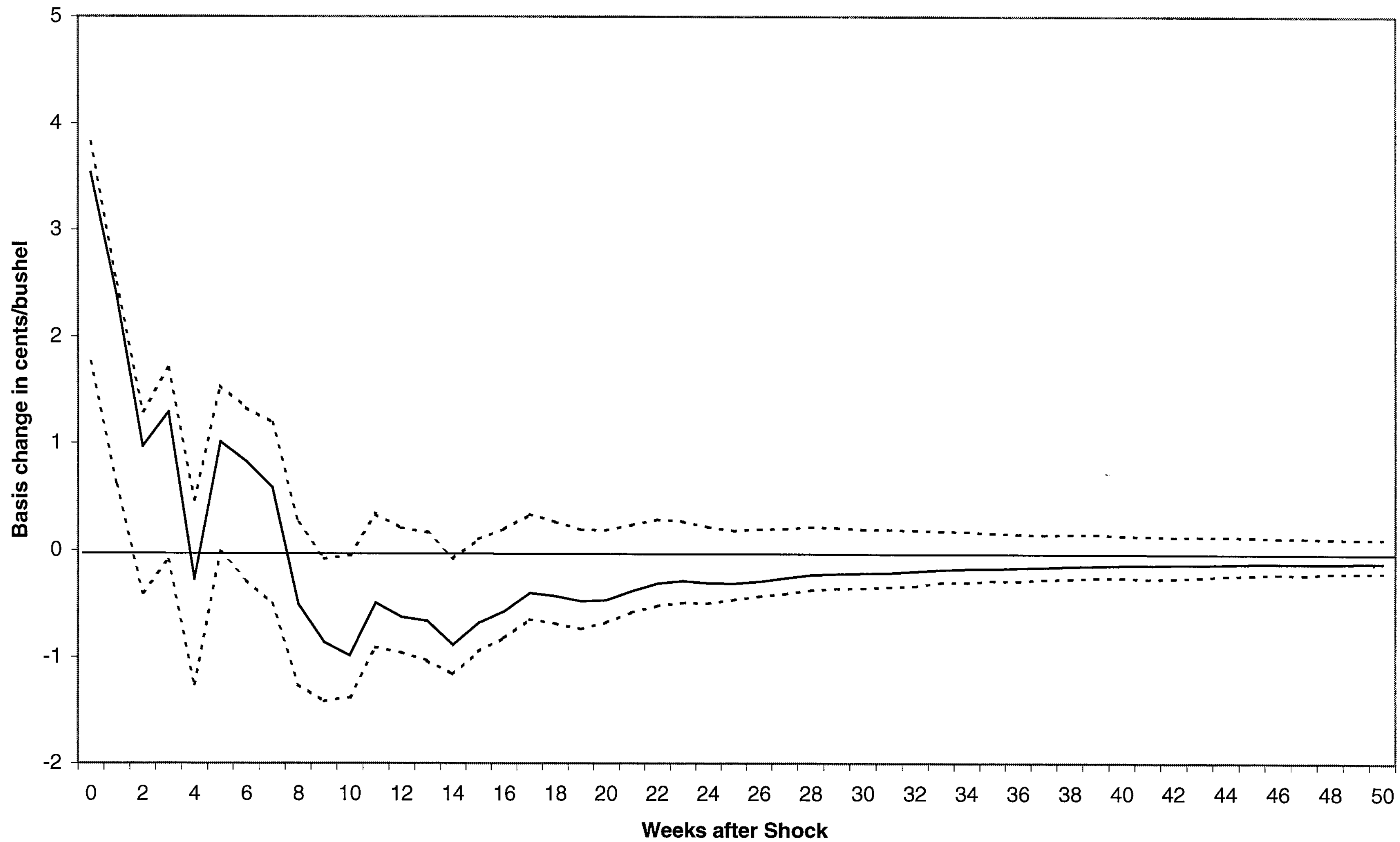


Figure 18. Augusta Basis Impulse Response to a Shock in Gulf Basis

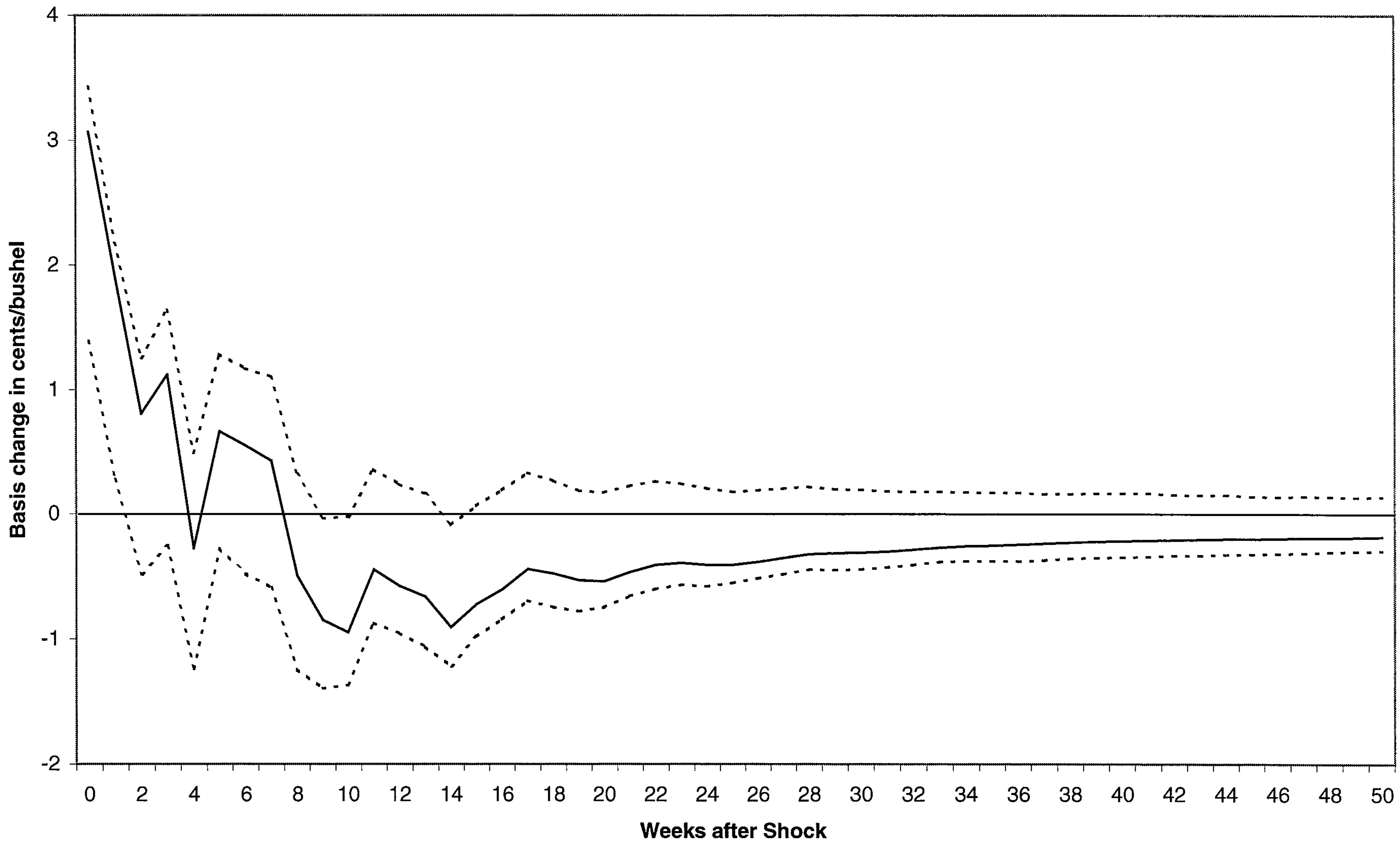


Figure 19. Blytheville Basis Impulse Response to a Shock in Gulf Basis

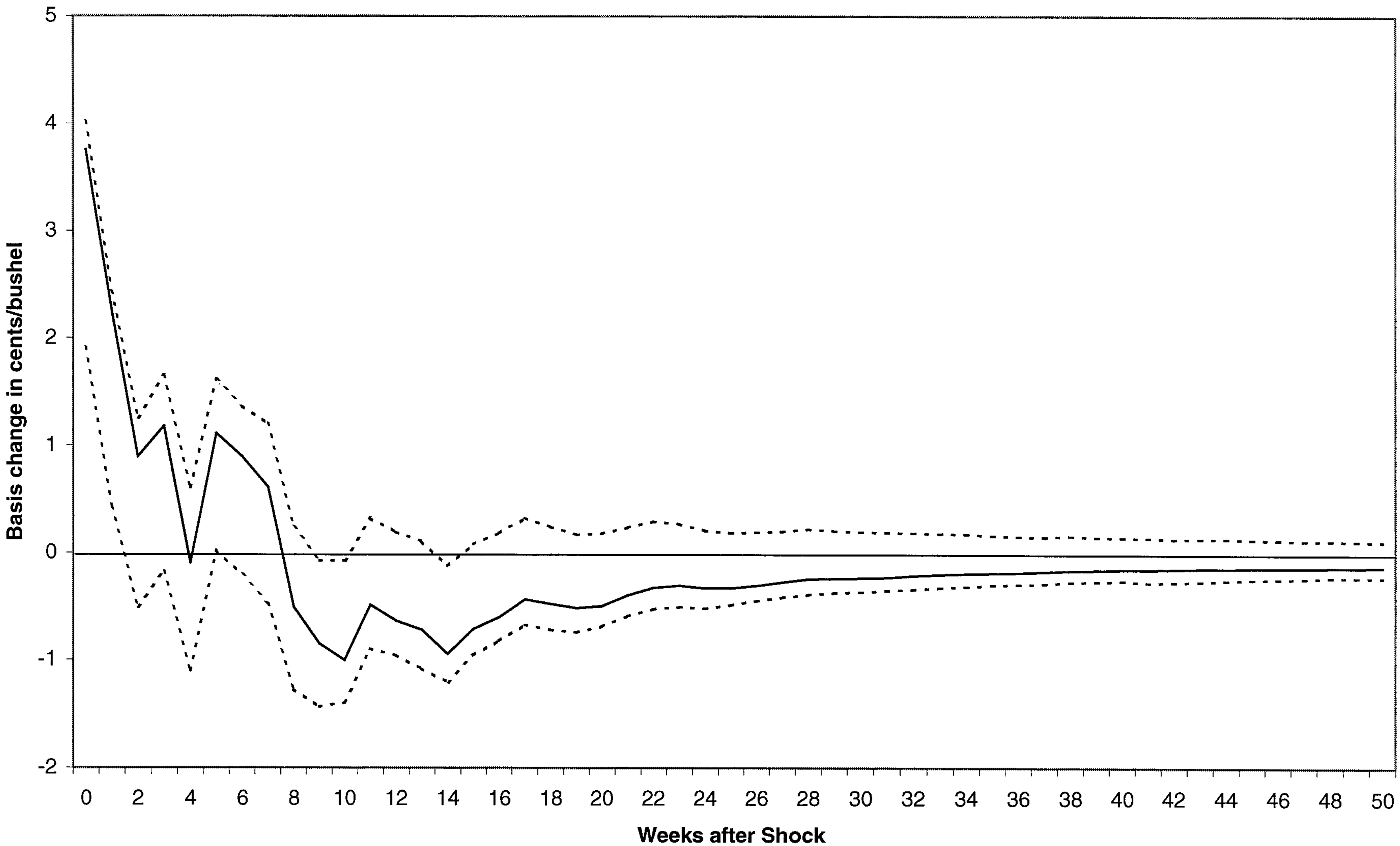


Figure 20. Pendleton Basis Impulse Response to a Shock in Gulf Basis

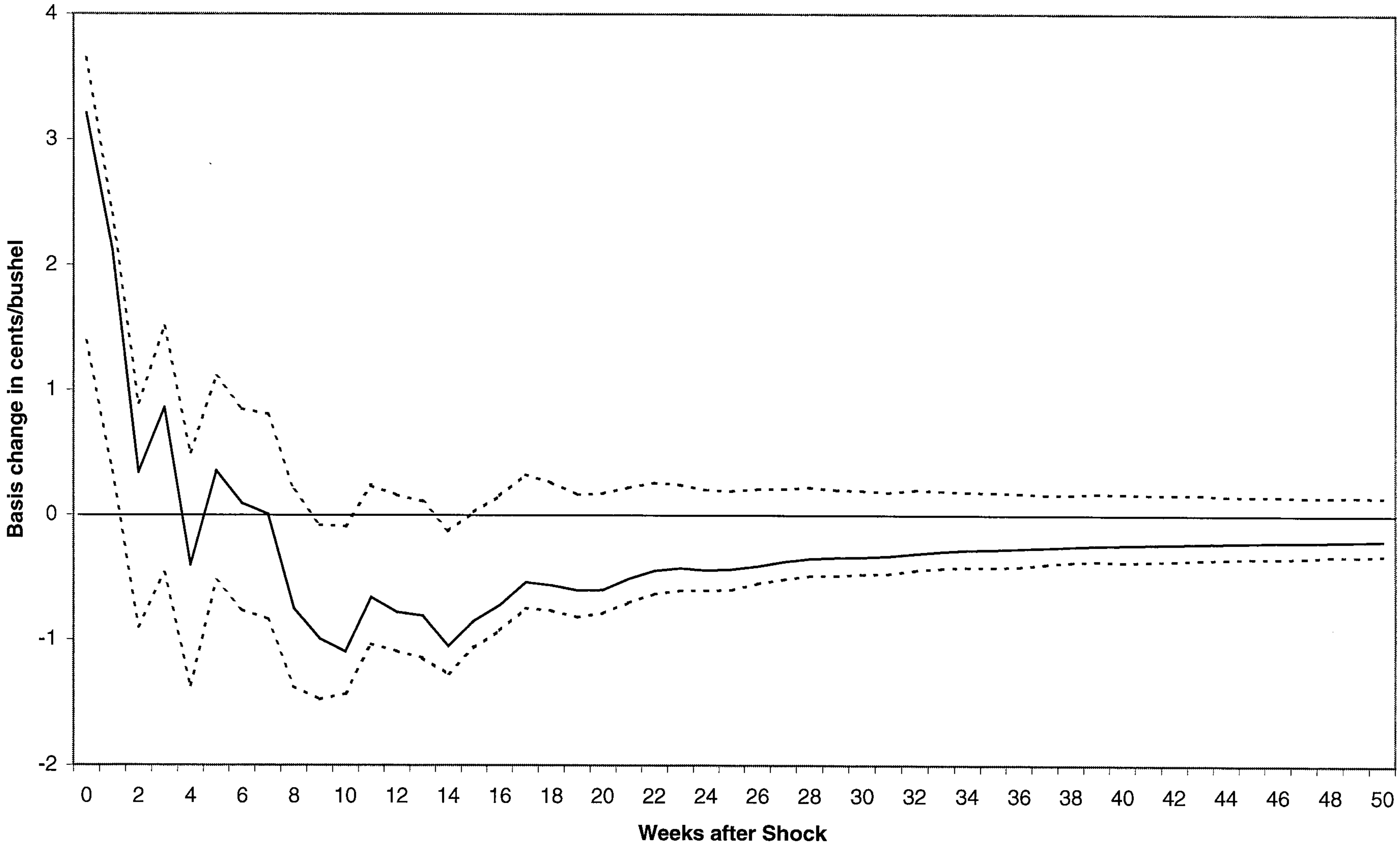


Figure 21. Des Arc Basis Impulse Response to a Shock in Gulf Basis

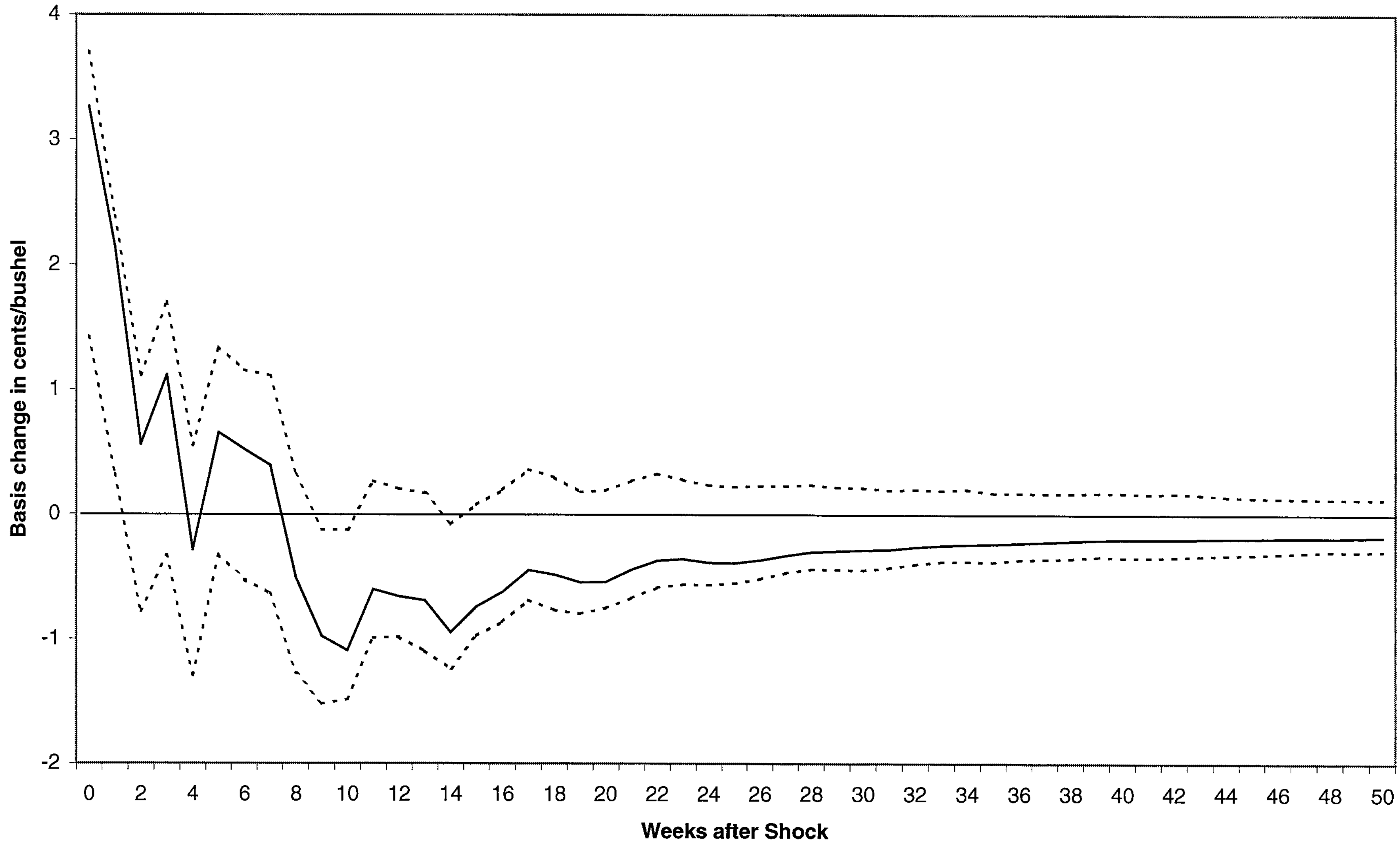


Figure 22. Pine Bluff Basis Impulse Response to a Shock in Gulf Basis

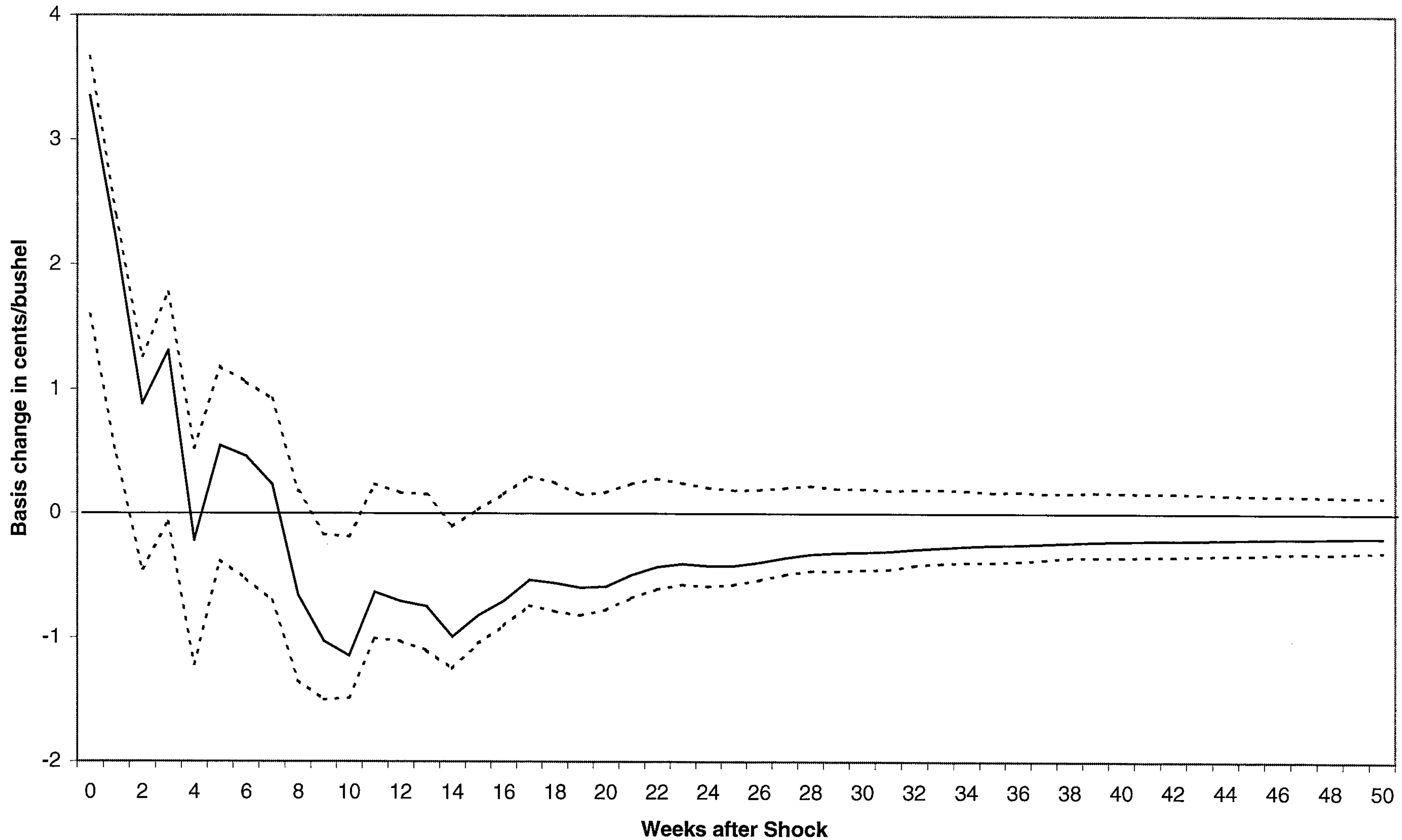


Figure 23. Jonesboro Basis Impulse Response to a Shock in Gulf Basis

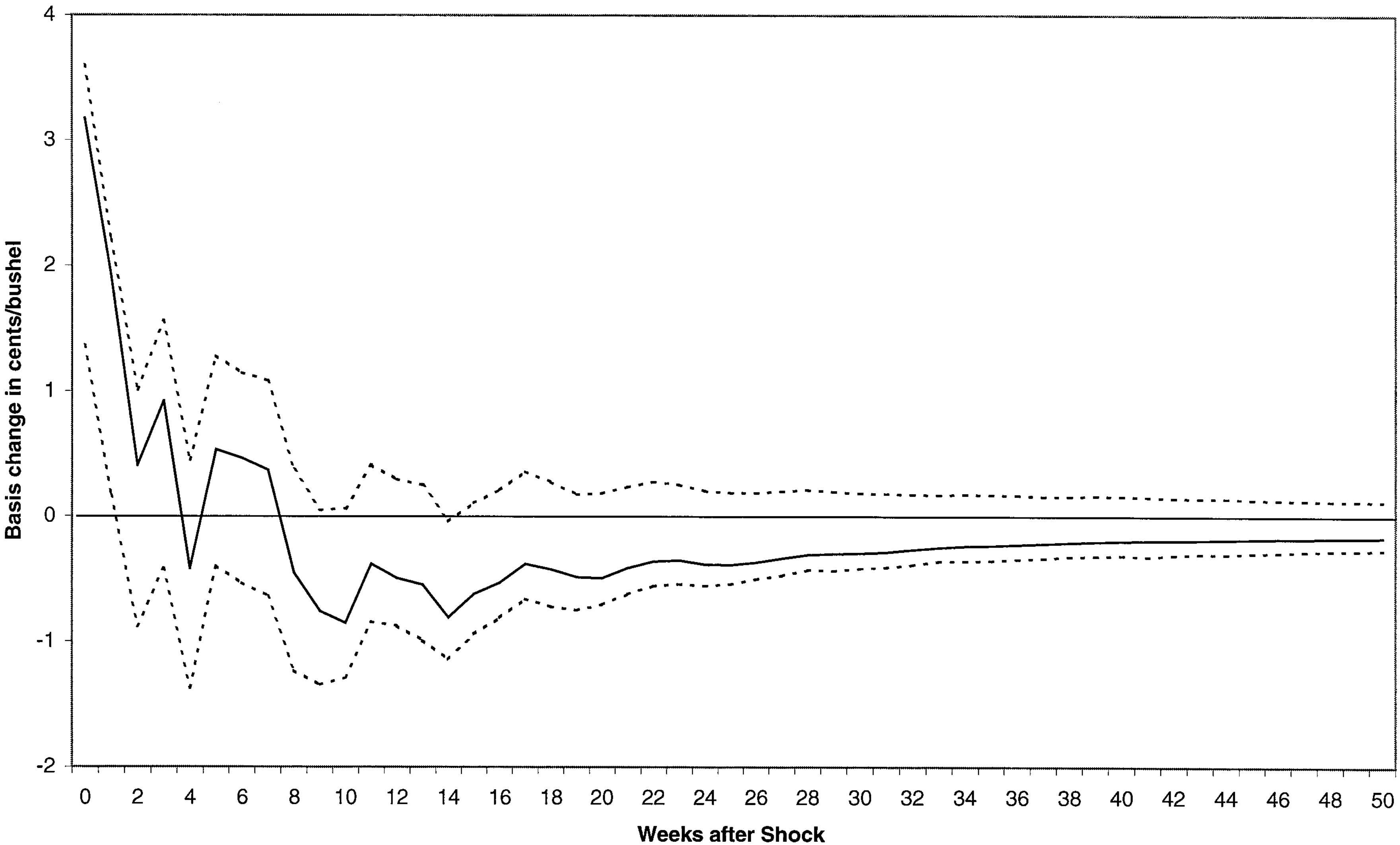


Figure 24. Memphis Basis Impulse Response to a Shock in Memphis Basis

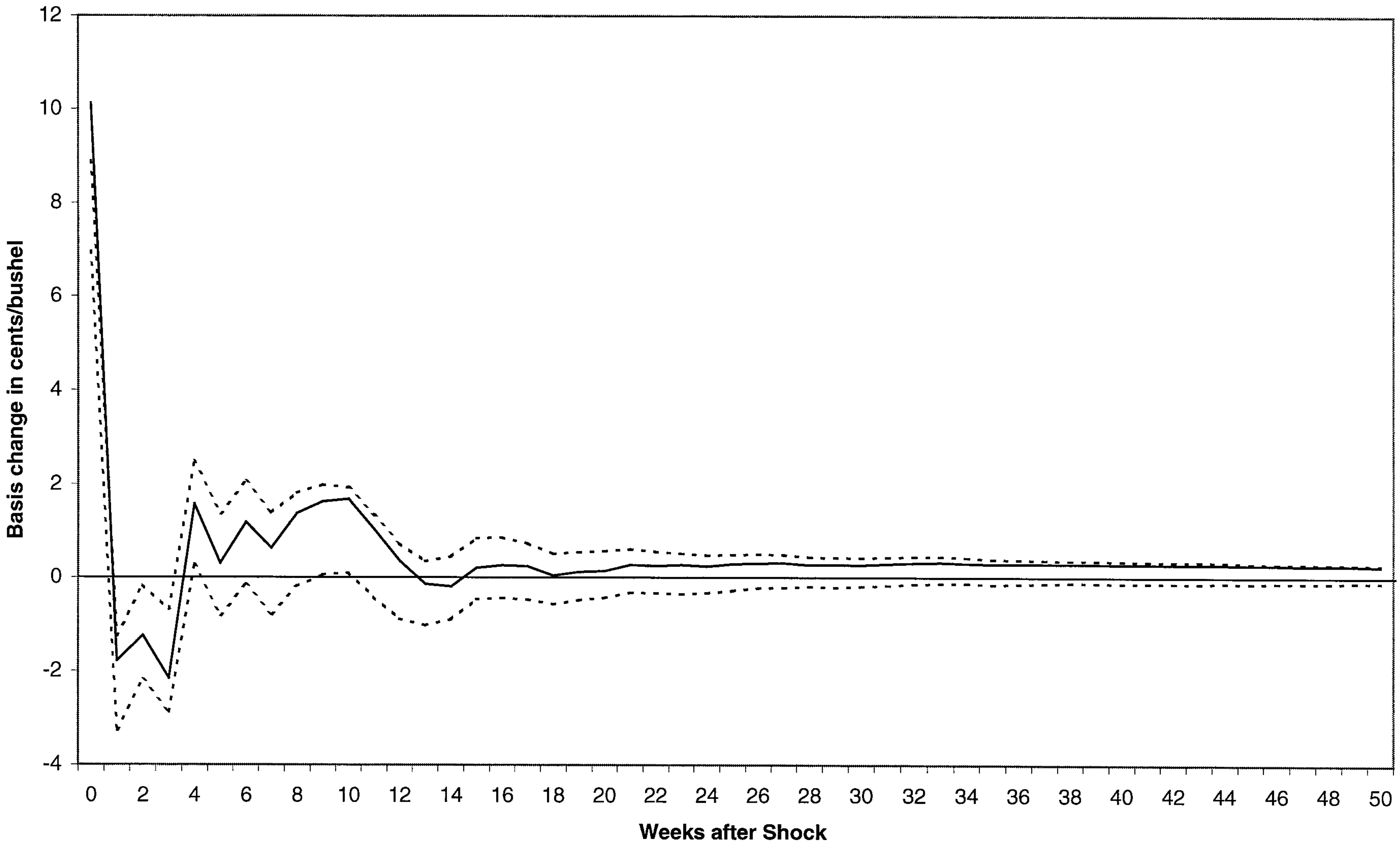
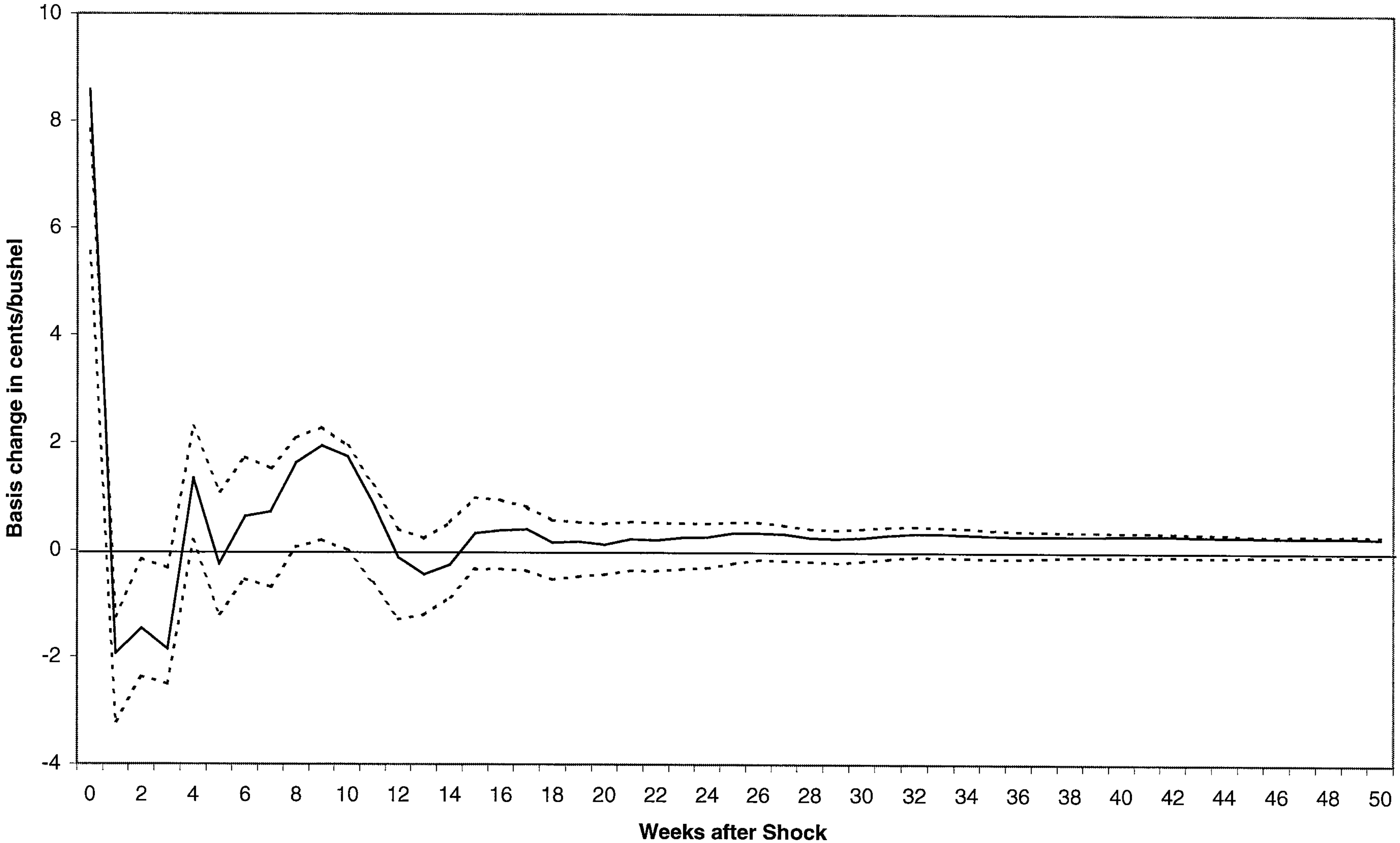


Figure 25. Little Rock Basis Impulse Response to a Shock in Memphis Basis



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