Forecasting Economic Impacts of The Third Harbor Tunnel

by

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ABSTRACT

In this thesis, we used two macroeconomic forecasting models, the Massachusetts model (a state model) and the Boston model (a substate model). From the state model, we derived a simple share model to represent Metropolitan Boston's share in the Massachusetts economy. Using the simple share model, we tested whether it could predict, relatively accurately, the same data predicted by the more sophisticated substate model (the Boston model). We found that the accuracy of the simple model for the totals of the variables is greater than 94 percent; across the industrial sectors for the same variables, we found that the accuracy is greater than or equal to 90 percent. The one exception is for regional demand.

There are assumptions about shifts in Metropolitan Boston's share of Massachusetts built into the Boston model. Given that we derived the simple model from the state model and that the state model cannot predict shifts in the substate's share of the state, this caused the large differences between the two sets of forecasts. If the analyst using the simple share model incorporates information about anticipated shifts, then the accuracy of the simple model will improve.

Considering the cost of these types of models and the unavailability of the substate model in other states, if the analyst already has the state model, then the analyst could derive a simple share model from the state model, and estimate, relatively accurately, the same data that the more sophisticated substate model would predict. Finally, the results of this analysis are limited to the case of Massachusetts and other states that have similar economic, political, and geographical structures.

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We take full responsibility for any remaining errors or omissions in this thesis.

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Chapter 1

Introduction

We use two general equilibrium macroeconomic forecasting models in this thesis. The models are the Boston Metro-Area FS-53 model (referred to, hereafter, as the Boston model) and the Massachusetts FS-53 model (referred to, hereafter, as the Massachusetts model). Both models were developed by Treyz (Regional Economic Models, Inc. (REMI), 1987). The Boston model is a substate model that forecasts for five counties in Metropolitan Boston; the Massachusetts model is a state model that forecasts for the entire state of Massachusetts. REMI developed the Massachusetts model first; then, REMI developed the Boston model, for the analyst who studies impacts occurring in Metropolitan Boston.

These types of models are expensive, and substate models are unavailable in many states. The existence of the Boston and the Massachusetts models offers a rare opportunity to investigate two related questions. The first question is:

> Does an analyst need to spend money to obtain a substate model, or can he/she estimate the same data relatively accurately using a naive approximation of the substate model?

We refer to the case of the Boston Redevelopment Authority (BRA) in discussing this question. First, the BRA purchased the Massachusetts model. When using this model, the BRA had to scale the forecasted figures to Metropolitan Boston equivalents. Later, the BRA purchased the Boston model. A member of the BRA staff indicated that the BRA purchased the Boston model because it best represents the "hub" of New England, that is, Metropolitan Boston. He indicated further that eastern Massachusetts and western Massachusetts do not trade significantly with each other; he, therefore, suggested that this is one reason why the Boston model is more appropriate than the Massachusetts model for studying impacts limited to Metropolitan Boston. As a public policy issue for local governments and other public agencies who are deciding how to allocate their scarce dollars, it is important for them to know what are the additional gains in the accuracy of forecasts by using the substate model, relative to using the state model and scaling forecasts to substate equivalents. This first question is related to cost.

The next question deals with availability. It is the following:

> If a substate model is not available and the analyst must use a state model to study a substate impact that is limited to the substate, then how different are the results from the two models?

As we mentioned earlier, many states do not have a substate model and must use their respective state models to study a substate impact that is limited to the substate. Does the analyst, in this situation, obtain forecasts that are significantly different from what a substate model would predict? As a public policy issue for local governments and other public agencies who are forced to use a state model as a result of the unavailability of a substate model, it is important for them to know what is the loss in accuracy by using the state model and scaling forecasts to substate equivalents, relative to using the substate model. In this thesis, we cannot generalize broadly the results from state to state because we are using models that are designed specifically for Massachusetts and Metropolitan Boston, respectively. Regions differ in terms of their economic and political system, and they differ in terms of their geography. The results, however, can provide insights in the case of Massachusetts and Metropolitan Boston and states that are similar.

A basic question embodied in the two questions above is, "how different are the two sets of forecasts." The two questions give the reasons why we will compare differences in the forecasts from the models in this thesis. We will set up the analysis of the differences in forecasts in the following way. To compare the forecasts from the models, we will convert forecasts from the Massachusetts model into Boston equivalents. We will use 1986 data to determine the percentage that Metropolitan Boston is of Massachusetts for four variables disaggregated by industrial sectors. Using these percentages to multiply corresponding forecasts of the same variables from the Massachusetts model, we will obtain Boston´s share of the Massachusetts forecasts. We will then compare these forecasts to forecasts from the Boston model for the same variables.

In comparing the two sets of forecasts, we will also consider the issue of data bias. Both the Boston and Massachusetts models use regionalized data in their respective forecasting processes. REMI uses the regional-purchase-coefficients method to regionalize data for both models; we, therefore, will investigate, from a theoretical perspective, whether or not data for one model are more accurate than data for the other model. The basis for this investigation is that a set regional purchase coefficients are estimated for each model in order to regionalize the respective data for the model. We will try to determine whether or not one set of coefficients is more accurately estimated than the other set. This is a difficult investigation because we do not know all the details of the regionalization process for the models; however, we will structure the analysis and incorporate all available information in trying to form a "best guess" about the relative accuracy of the two sets of data. We now will outline the chapters in the thesis.

In the second chapter, we will describe each model in detail, starting with the Boston model. In the third chapter, we will analyze the regional-purchase-coefficient method, the method used to construct data for the models. To evaluate this method, we will compare it with other commonly used estimation methods, the location quotient based on supply data, the location quotient based on employment data, and the supply-demand ratio. Finally, we will analyze how the regional-purchase-coefficient method affects forecasts of the models.

In the fourth chapter, we will adjust the control forecast for each model by changing employment growth rates to incorporate new information about the regional economies that was not known when the models were built.[1] The control forecast for the models begins in 1987. For Massachusetts, we will adjust its control forecast using historical data ending in 1989 (New England Business, 1989, pp. 10-12) and independent forecasts to the year 2010, acquired from staff at CSI and the BRA. In addition, as part of the data base in the model, we have historical data for 1969 through 1986. Given that the first year of the REMI control forecast is 1987, the historical data overlap from 1987 to first quarter 1989. We will use the historical data to test the validity of the control forecast for this period. For the Boston model, CSI staff provided a list of employment growth rate changes for Suffolk County and population growth rate changes for Suffolk County and the rest of Metropolitan Boston. We will use this list of growth rate changes and other information that we obtained from the BRA to adjust the control forecast for the Boston model. After adjusting the control forecasts for each

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[1]The control forecast is a forecast that is absent of any policy changes.

model, we will analyze data from the unadjusted and adjusted control forecasts for each model to determine how the employment and population growth rate changes affected the structures of the control forecasts of the two models; we will make inter- and intra-comparisons of the two regional economies using the unadjusted and adjusted forecasted data.

In the fifth chapter, we will describe the construction expenditures for the Third Harbor Tunnel. We will list the expenditures by industrial sector and by year, and we will indicate the expenditures that will affect regional demand and the expenditures that will affect regional sales. After entering these expenditures into the model, we will forecast the impacts of the expenditures on the regional economy to 1994; the expected construction period for the Third Harbor Tunnel is 1991 to 1994. From Tables 13 through 16 in Chapter 4, we will use the percentages (Boston as a percentage of Massachusetts) with forecasts from the Massachusetts model to produce Boston´s share of Massachusetts. We will compare these forecasts with forecasts from the Boston model. We will make the comparison across industrial sectors for four variables: total private nonfarm employment, regional production costs relative to the U.S., regional demand, and regional output. To summarize across years the differences in forecasts from the two models, we will use three difference measures: the mean absolute difference (MAD), the root mean square difference (RMSD), and the mean absolute percentage difference (MAPD). We will compare the MAD and the RMSD to show whether or not differences are uniform, on average, across years; we will use the MAPD to show, on average, the relative magnitude of differences for variables. In the final chapter, we will reiterate the methodology that we used in the analysis, we will summarize our results, and we will indicate areas for further research.

Chapter 2

Description of the Models

The appeal of the Boston and the Massachusetts models is that they allow the analyst to conduct a general equilibrium analysis of direct and indirect effects on the regional economy (Treyz, et al., 1980, p. 71). The models, for example, can determine interdependent effects of a factor cost change on employment, wages, income, population, labor force participation, consumption, personal taxes, and local government expenditures (Treyz, et al., 1980, p.71). These models are unlike input-output models; input-output models contain rigidities that limit their value when analyzing stabilization policies. They are also unlike econometric models; econometric models, generally, are based on ad hoc regression equations. Econometric models are less appealing when the analyst is looking for a system of simultaneous equations that reflect the regional economy. The Boston and Massachusetts models are eclectic. In theory, they incorporate the best features of input-output models and econometric models. The input-output part provides the basic framework of the models that reflects the basic structures of the Metropolitan Boston and Massachusetts economies, respectively; the econometric parts of the models provide the ability to conduct policy experiments. Thus, the Boston and Massachusetts models offer the analyst more flexibility, when analyzing stabilization policies, relative to input-output models and a more structured system of simultaneous equations relative to econometric models.

Boston Metro Multi-Area FS-53 Model

The Boston model is a substate economic forecasting and policy analysis tool. It produces comprehensive economic forecasts for each of the two subregions, Suffolk County and the rest of the Boston metropolitan region. The model accounts for the interaction of the two areas. Forecasts are highly detailed including prices, employment, local-national relative business costs, and many other variables. The model can produce the above variables for 53 sectors, employment and wage rate changes for 94 occupations, and aggregate measures, such as residential and nonresidential investment, the personal consumption expenditure (PCE) price index, and personal income.

Available for simulations and forecasts are policy variables. Most of the policy variables affect the model by one of five methods. They are the following:

1) directly changing the level of economic activity in an industry. (Examples are direct employment effects, the dollar output, agriculture and construction output, and changes in tourism),

2) changing the production costs. (Examples of these costs are energy costs, business taxes, transportation costs, a change in the wage rate, unemployment insurance, and the general cost of doing business),

3) changing final demands. (Examples are government demand, incremental taxes, transfer payments and other personal income components, investment, and consumption demand).

4) changing labor supply and population. (An example is migrant influx that would increase the general population), and

5) changing other variables. (This is any policy change that can be translated into a change in one of the model equations.)

Policy variables are divided into two groups. They are regular policy variables and special translator policy variables. Examples of regular policy variables are the following:

1) DEMPOL--this variable is used to increase spending in an area. With this variable, we are spending a specified number of dollars per year in the area, but only the usual proportion of use supplied from within the area. DEMPOL represents an across-the-board increase in demand for imported as well as locally produced goods.

2) SALPOL--this variable is used to represent an exogenous change in the sale of locally produced goods.

Each special translator policy variable represents a broad-based economic activity that is passed to the model through a combination of regular policy variables. The four major categories of special translator policy variables are:

1) changes in production for agricultural sectors (DEMPOL is affected),
2) changes in levels of spending for construction projects (DEMPOL is affected),
3) changes in tourism (DEMPOL and SALPOL are affected), and
4) changes in trucking costs (other regular policy variables are affected).

Massachusetts FS-53 Model

The Massachusetts model is similar to the Boston model, except for the following difference. The Massachusetts model is not multiregional; it simulates and forecasts for the economy of Massachusetts only. Outside of this difference, the structure of the models is fairly similar, and the above discussion on policy variables applies to it as well. In the next chapter, we will analyze the nonsurvey estimation method used to construct data for the models.

Chapter 3

Nonsurvey Estimation Methods

When survey data do not exist, the analyst must construct data using a nonsurvey estimation method. There are several methods available. In this chapter, we will discuss the ones most frequently used. First, we will discuss the regional purchase coefficients method; Treyz uses this method in constructing unavailable data for both the Boston and Massachusetts models. We will describe the theoretical basis for estimating regional purchase coefficients, and we will present the mathematical form of the estimating equation. To evaluate the accuracy of the method, we will refer to a study that details results from two different tests. To provide a context for evaluating the method, we will present the results of a test that compared the alternatives to the RPC method. These alternative methods are the supply location quotient, the employment location quotient, and the supply/demand ratio. Finally, we will discuss the RPC method with respect to the theoretical structures of the models to show how it affects the models. We will also include a brief discussion on data biases and how they may affect the accuracy of forecasts from the Boston and the Massachusetts models.

RPC Estimation Method

In their article, Stevens, et al. (1976) indicate that using a set of region-specific, regional-purchase coefficients with the most detailed available form of national input-output technology represents the most efficient, and potentially, the most accurate nonsurvey method for producing data for the region. A general definition for a regional purchase coefficient is the proportion of a good or service, used to fulfill intermediate demand or final demand, or both in a region, that is supplied by the region to itself rather than being imported (Stevens, et al., 1980, p. 1). Mathematically, the regional purchase coefficient for a good in region L is the following:

$$R^{L} = S^{LL}/(S^{LL} + S^{UL}), \qquad (1)$$

where

S^{LL} = amount of a good shipped from region L to itself; and

S^{UL} = amount of the same good shipped from the rest of the nation to region L.[2]

In theory, the analyst could use this equation to produce nearly accurate data; however, for empirical applications, equation (1) is not in an appropriate form for estimation. Equation (1) only provides a theoretical basis for estimating regional purchase coefficients. They rewrite equation (1) as follows:

$$R^{L} = 1/[1 + 1/(S^{LL}/S^{UL})] \qquad (2)$$

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[2]Stevens and Trainer indicate that S^{UL} includes inputs from both the nation and foreign countries.

Stevens, et al. contend that the proportion of each input a region purchases from itself is systematically related to comparative delivered costs. They further suggest that these costs depend on relative production costs, industrial concentration, weight-to-value ratios, and the spatial density of suppliers. This is their rationale for equation (4); however, data limitations necessitates calculating proxies for these measures. The procedure is to use the equation below with available data to calculate a sample of RPCs. The equation is as follows:

$$R_i^L = (Q_i^L/D_i^L)\ P_i^L \tag{5}$$

where

Q_i^L = the amount of i produced in L;

D_i^L = the total use of i in L; and

P_i^L = the proportion of i produced in L, which is shipped to destinations in L.

They fit equation (4) to the sample of regional purchase coefficients, and they use it to estimate the remaining coefficients. Stevens, et al. note two caveats concerning the proxies. First, they indicate that the proxies for some of the determinants of relative delivered costs are not fully satisfactory. Second, they suggest that measures of relative transportation costs from suppliers are questionable. With this understanding of the regional-purchase-coefficient method of estimation, we now focus attention on the performance of the method for producing nonsurvey data relative to survey

The ratio S^{LL}/S^{UL} is generally what cannot be estimated because of large gaps in the Census of Transportation data. A proxy for this ratio is the following:

$$S^{LL}/S^{UL} = f_1(c^{LL}/c^{UL}), \tag{3}$$

where

c^{LL} = delivered costs in L of a unit of a good produced in L; and

c^{UL} = corresponding average of delivered cost from sources in the rest of the United States.

Unfortunately, this proxy cannot be estimated directly either. After a series of further assumptions, however, they produce the following equation:

$$R_i^L = \frac{K(w_i^L/w_i^U)^{b1} (e_i^L/e_i^U)^{b2} (W_i^U/[e_i^U\ w_i^U])^{b3}}{([e_i^L/E^L]/[e_i^U/E^U])^{b4} (A^L/A^U)^{b5}} \tag{4}$$

where

w_i^L, w_i^U = average annual wages per worker in industry i in region L and in the United States, respectively;

e_i^L, e_i^U = total employment in industry i in region L and in the United States, respectively;

E^L, E^U = total manufacturing employment in region L and the United States, respectively;

W_i^U = total tonnage of i shipped domestically in the United States;

A^L, A^U = land area of region L and the United States, respectively; and

K = a constant.

data.

Also, in their article, Stevens, et al. present results of tests for the regional-purchase-coefficient method. The two that we look at are tests of how well the method performs in producing cross-sectional data and how well the method performs in producing time-series data. They conducted these tests for Washington State. In the first test, they take a set of estimated regional purchase coefficients for Washington and use them with the national input-output matrix to construct an adapted input-output matrix. They then compare this adapted input-output matrix to the corresponding results from a survey-based model.

Stevens, et al. report that the nonsurvey input-output model performs satisfactorily relative to the survey model; however, they also report that nonsurvey coefficients systematically underestimated survey coefficients. In the second test, they make the regional purchase coefficients endogenous in a forecasting and policy simulation model. In other words, by using this test, they allow changes to occur in relative wages and they allow relative employment in an industry in the region to influence the size of the regional purchase coefficients endogenously. The authors make the assumption that the underlying technology for the economy does not change over time. Results of this test are disappointing and suggest that using equation (4) to estimate RPCs for a given year is likely to give more satisfactory results than using its parameters to change RPCs over time. The results also indicate, however, that by not changing the RPCs in a forecast over time, an analyst will underestimate these measures by more than he will underestimate the measures in which the RPCs are allowed to change; the Boston model and the Massachusetts model are forecasting and simulation models in which the RPCs change endogenously over time. The conclusion of these tests, therefore, is that an analyst using the regional-purchase-coefficient method will underestimate the true regional purchase coefficients, but in a forecasting and simulation situation, the analyst is better off allowing the RPCs to change endogenously over time. Given this, a logical query to explore is whether or not there is a better alternative to the regional-purchase-coefficient method. We present this in the next section.

Alternative Estimation Methods

We present three commonly-used alternative estimating techniques to the regional-purchase-coefficient method in this section. They are the location quotient based on supply data (LQS_i), the location quotient based on employment data (LQE_i), and the supply/demand ratio (SDR_i). We discuss each of these below, beginning with LQS_i.

Mathematically, LQS_i is defined as follows:

$$LQS_i = (S_i{}^k/S^k)/(S_i{}^n/S^n) \qquad (6)$$

where

S_i^k = supply of sector i in region k;

S^k = total output in region k;

S_i^n and S^n = corresponding measures for the nation;

(S_i^k/S^k) = proportion of supply contributed by sector i in region k; and

(S_i^n/S^n) = contribution by sector i to the national economy.

LQS_i is a measure of regional concentration of production in sector i relative to the nation. When LQS_i is less than 1, we assume that the region is less able to satisfy its own demands for i than if it had the same relative concentration of supply of i as the nation. When LQS_i is greater than 1, we assume that regional demands for sector i goods are totally met, and that the sector exports the rest of the goods.

Annual data for output, however, is generally unavailable. Many analysts, therefore, use the employment location quotient. It is similar in principle to LQS_i, except that it uses employment data as a proxy for supply data. Stevens et al. suggest that LQE_i is actually superior to LQS_i. The final alternative measure is SDR_i. SDR_i is simply the ratio of supply to demand. In theory, it more closely approximates the true RPC given that it reflects the ability of the region to fulfill its own needs. All three of these alternative techniques do not allow for crosshauling; the RPC technique does.

The Regional Science Research Institute staff compared the RPC technique with the alternatives. We note that their testing equation for RPCs differs substantially from our equation (4); however, it is similar in principle. Their results indicate that the RPC technique performs best; next is SDR_i and then LQE_i. Based on their results, we agree that the RPC method is better than the alternatives, assuming that the required data exist. We now turn attention to the regional-purchase-coefficient technique with respect to the models.

RPC's Affect On the Models

Before proceeding with this analysis, we briefly discuss the basic theoretical structure of the models (Treyz, et al., 1980). Treyz builds the foundation of the models on input-output relationships in employment equations. The basic employment accounting identity is:

$$E_i = E_i^L + E_i^X \qquad (7)$$

where

E_i = total regional employment in industry i;

E_i^L = employment in the local-serving portion of industry i; and

E_i^X = employment in the export-serving portion of sector i.

He defines, further, the portion of regional employment in the local-serving portion of i (E_i^L) as follows:

$$E_i^L = e_{ij}^L E_j + d_{ih}^L D_h \qquad (8)$$

where

E_j = the total regional employment in industry j;

D_h = regional final demand in sector h; and

e_{ij}^L and d_{ih}^L are coefficients.

We rewrite equation (8) as follows:

$$E_i^L = A + B \qquad (9)$$

where

$A = e_{ij}^L E_j$; and

$B = d_{ih}^L D_h$.

In our regional economy, local output is used as an input in other regional industries and is used to satisfy final regional demand. E_i^L, thus, represents the sum of the total regional employment in the local-serving portion of industry i needed to satisfy input demands by other regional industries, represented by A in equation (9), plus the total regional employment in the local-serving portion of industry i needed to satisfy the regional final demand in sector h, represented by B in equation (9). The coefficients in equation (9) are analogues to input-output coefficients differing in that they refer to employment rather than output, and they relate to employment for local use rather than total regional employment. Treyz derives the coefficients from additional employment relationships using input-output terminology

(Treyz, et al., 1980, pp. 64-65).

So far, we presented accounting identities of the internal input-output structure of the regional economy; this is the basic framework of the models. To permit factor substitution in response to changes in relative input prices, Treyz merges the identities with neoclassical employment demand functions. To estimate coefficients in equation (9), he makes four assumptions:

a) Firms seek to maximize profits,

b) The regional and national production processes of industry i are the same and can be described by a Cobb-Douglas production function with constant returns to scale (CRS) and factor-neutral technical change,

c) The marketing advantage of local production for local use is sufficiently strong and stable to assure that q_i, the proportion of the regional use of commodity i that is supplied from local production, will remain constant, at least over the forecast period, even if there are changes in relative regional production costs, and

d) The distribution of production of national market goods and services among all regions will respond to changes in relative production costs.

For the most part, these assumptions are not satisfactory; however, as Treyz indicates, these assumptions are necessary in order to estimate the coefficients, and, for the most part, they are acceptable to many scholars in the field (Treyz, et al., 1980, p. 65). For empirical application, he modifies some of the identities. One example is using regional output data when they derived e_{ij}^{L} because region-specific interindustry shipment data, generally, are not available (Treyz, et al., 1980, p. 66). He adds to the relationships an estimating equation for export employment obtained ex post from equation (7). Next, he incorporates the direct effects of cost changes that allow for a partial equilibrium analysis of the employment effects of a given change in regional factor costs. Complementing all of the above, he adds additional equations to determine the interdependent effects of a factor cost change on employment, wages, income, population, labor force participation, consumption, personal taxes, local government expenditures, and other relevant variables. This represents the general structure of the models. We now analyze the effect of the RPC method on the models.

RPC directly affects e_{ij}^{L} and d_{ij}^{H}, the coefficients in equation (9). Treyz defines the first coefficient as follows (Treyz, et al., 1980, p. 65):

$$e_{ij}^{L} = q_i * e_{ij} \tag{10}$$

$$d_{ij}^{h} = q_i * d_{ih} \tag{11}$$

where

q_i = the regional purchase coefficient for industry i; and

e_{ijh} and d_{ih} are national equivalents to $e_{ij}{}^{L}$ and $d_{ij}{}^{h}$, respectively.

This is the same RPC that we discussed in the first part of the chapter. Ceterus paribus, when we underestimate RPC, we underestimate both $e_{ij}{}^{L}$ and $d_{ij}{}^{h}$. Ultimately, we underestimate E_i, total regional employment in industry i.

We now investigate data bias and its effect on forecasts from the models. Recall, that to regionalize data for the models, we must calculate a sample of RPCs from available data using equation (5), $R_i{}^L = (Q_i{}^L/D_i{}^L)\ P_i{}^L$. Then, we must fit equation (4), $R_i{}^L = K(w_i{}^L/w_i{}^U)^{b1}\ (e_i{}^L/e_i{}^U)^{b2}\ (W_i{}^U/[e_i{}^U\ w_i{}^U])^{b3}$ $([e_i{}^L/E^L]/[e_i{}^U/E^U])^{b4}\ (A^L/A^U)^{b5)}$, to the sample of RPCs and use it to estimate the remaining coefficients. How accurately we estimate the coefficients depends on the quality of the data and the specification of the estimating equations. Treyz uses the same estimating equations for both models; therefore, when focusing on the relative accuracy of the estimated RPCs, we can limit the scope to the relative availability of data. An important question then is, "Are the sample sizes that are used to estimate the sample of RPCs equal for the models and are the sample sizes that are used to fit equation (4) equal for the models?" In theory, assuming that we correctly specify the estimating equations, the larger the sample size, the more accurately we estimate the parameters because a larger sample size includes more actual data. If we knew what the sample sizes were, then we could investigate this issue further; however, we do not have this information. We suspect that more data are available at the state level, but this is only a guess. We leave this issue for future research and turn attention to adjusting the control forecast for the models.

Chapter 4

Adjusting The Control Forecast

The models generate an automatic control forecast for the specific region using the standard REMI U.S. forecast, based on the Bureau of Labor Statistics forecast, or an adjusted REMI U.S. forecast. REMI will adjust their U.S. forecast for its clients if the clients have suppressed data. Data from the Bureau of Economic Analysis (BEA) and County Business Patterns Data that violate the confidentiality of a firm are suppressed; in addition, the BEA does not report estimates for categories containing only a few firms. In this thesis, we will use the Boston Redevelopment Authority's (BRA) version of the Boston model and Treyz's own version of the Massachusetts model. The BRA has suppressed data for Metropolitan Boston; therefore, REMI adjusted the U.S. forecast for their model. Treyz does not have suppressed data for Massachusetts; therefore, his model is not adjusted. BRA staff indicated, however, that this should have little effect on the comparison of the two models given that data suppression involves suppressing information for categories containing a small number of firms.

Four adjustments analysts frequently make to the models are the following:

1) employment growth rate changes,
2) relative wage rate changes,

3) employment level changes, and

4) changes in the level of the components of personal income based on partial data.

We will make only the first adjustment because we do not have information to change relative wage rates, and we do not have information to change the level of components of personal income. With respect to the second adjustment (employment level changes) we could make this adjustment, but we will not make it in this thesis due to the complexity and the amount of time involved in making it. If we were to make this adjustment, we would need to undertake the following. After we adjust the control forecasts using employment growth rates, and after we forecast the impact of the construction expenditures of the Third Harbor Tunnel, then, we would need to analyze the forecasts for the exogenous employment created in industrial sectors. We would then need to add (subtract) employment to (from) sectors where levels are inconsistent with predicted levels for a project of the magnitude of the Third Harbor Tunnel. We have, for example, information from CSI to determine the number of construction workers and engineers needed annually for the project. In the next chapter, we will use this information to construct employment targets over the life of the project, and we will evaluate how close each model comes to the targets.

To make the adjustments correctly, when we add employment to an industrial sector, we must subtract construction expenditures from that sector to maintain the size of the project. Using EMPOL, another regular policy variable, we would make employment adjustments to industrial sectors. When we add employment through EMPOL, we generate demand in the regional economies. Initially, however, we will increase demand in the regional economies using DEMPOL; that is, when we first forecast the impact of the construction expenditures, we use DEMPOL. Thus, to offset the new demand generated using EMPOL, we must reduce our level of spending in the economies by reducing our expenditures for DEMPOL. This will maintain the size of the construction project. Unfortunately, there is no apparent relationship between the number of jobs added through EMPOL and the amount of dollars spent through DEMPOL. Thus, this part of the adjustment is ad hoc. Furthermore, CSI staff indicated that yet other regular policy variables may need adjusting if the size of the project is not maintained after experimenting with different combinations of EMPOL and DEMPOL adjustments. These are the aspects of the adjustments that make them complex and time consuming. Thus, we will not attempt to make them in this thesis. We believe, however, that these adjustments will affect the relative differences between the two sets of forecasts; we suggest that future research explore this issue further.

Adjusting the Control Forecast for Metropolitan Boston

Recall from the last chapter that the Boston model is a two-region model: it represents Suffolk County and the rest of Metropolitan Boston, a five-county region. There is a model for each region. The sum of the models equals the Boston model. We adjust each model. The adjustments that we will make are based on notes and memos from CSI and the BRA staff. We will strictly follow their recommendations when we adjust the control forecast, because these adjustments represent acceptable modifications. We have independent forecasts for the five-county region that we obtained through staff at CSI and the BRA. We will provide further details about these independent forecasts in the subsection "Five-County Region." We will graph the adjusted control forecast (the sum of the two regions) with the independent forecasts to compare them.

We will make many adjustments for Suffolk County based on the information from CSI and BRA staff, but we will make only one adjustment for the rest of Metropolitan Boston. We believe that this represents their extensive knowledge about Suffolk County, as well as the significance of Suffolk County to the regional economy. We are surprised, however, that they only recommend changing the population growth rate for the rest of Metropolitan Boston. We will begin with a detailed description of the changes for Suffolk County, and, in the following section, we will show and discuss the effect of these changes (along with the population growth rate change for the rest of Metropolitan Boston) on the five-county region.

Suffolk County

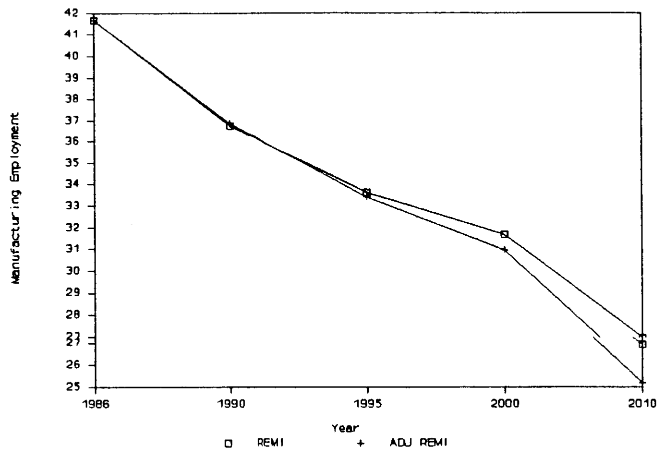
The CSI and BRA staff agree that the REMI control for employment in manufacturing is reasonable and does not need adjusting. For nonmanufacturing, they suggest several adjustments. The CSI and BRA staff did not explicitly indicate their rationale for the adjustments. We were able, however, to obtain unpublished information that indicates their reasoning for some of the changes. We detail this information in the following two subsections.

First, they believe that contract construction falls off too much in the forecast period; they prefer to see modest growth. Second, they think that employment in transportation/communication/public utilities is a bit high for 1995. Their focus is on the air transportation sector. They suggest constraining the growth here, because it is unlikely that further expansion will occur at Logan airport. Third, they indicate that employment in finance/insurance/real estate sectors are close to projections made by the BRA for 1995; however, they recommend slight adjustments to growth rates in subsectors to make the forecasts closer to BRA's projections. Fourth, they believe that the marked decline in employment for retail trade runs counter to the recent retail trend in Boston and contradicts the expected retail development in Boston. Fifth, they believe that employment in wholesale trade declines too sharply. Sixth and final, they determined that employment in hotel firms grew too slowly for expected hotel development in Boston; that medical services show a decline that contradicts pervious BRA analysis (that is, hospitals are not expected to grow at past rates, but other medical services are expected to take up enough slack to produce modest growth); professional services are expanding too rapidly; and business services are not expanding enough. In general, the sixth modification constrains the forecast to levels previously projected by the BRA.

The REMI forecast for population decreases steadily throughout the forecast range. The CSI staff suggest modest growth. Figure 1 shows adjusted and unadjusted forecasts for manufacturing employment; Figure 2 shows adjusted and unadjusted forecasts for nonmanufacturing employment; and Figure 3 shows adjusted and unadjusted forecasts for population. These figures illustrate the large adjustments that we made to the control forecasts. In other words, the control forecast now is more consistent with present trends and our expectations of future trends.

Five-County Region

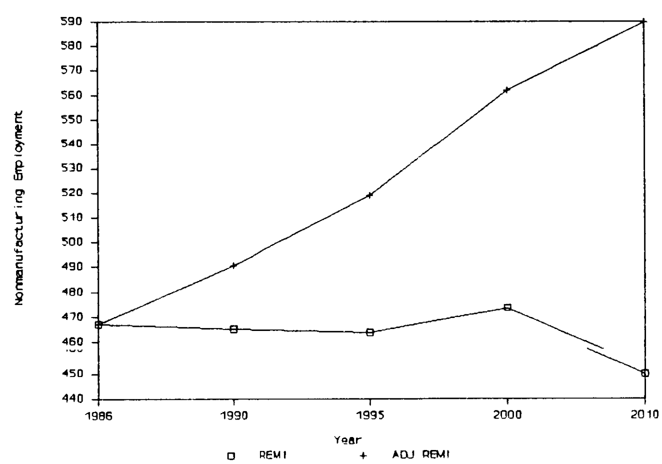
Independent forecasts for the rest of Metropolitan Boston for employment in manufacturing and in nonmanufacturing and for population are unavailable; however, we have independent



Source: REMI forecasts.

Figure 1
Suffolk County: Manufacturing Employment

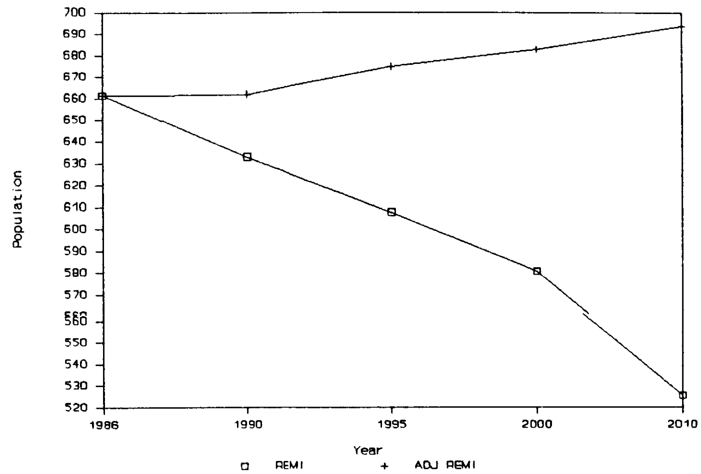
(thousands of workers)



Source: REMI forecast

Figure 2
Suffolk County: Manufacturing Employment

(thousands of workers)



Source: REMI forecasts

Figure 3
Suffolk County: Population
(thousands of people)

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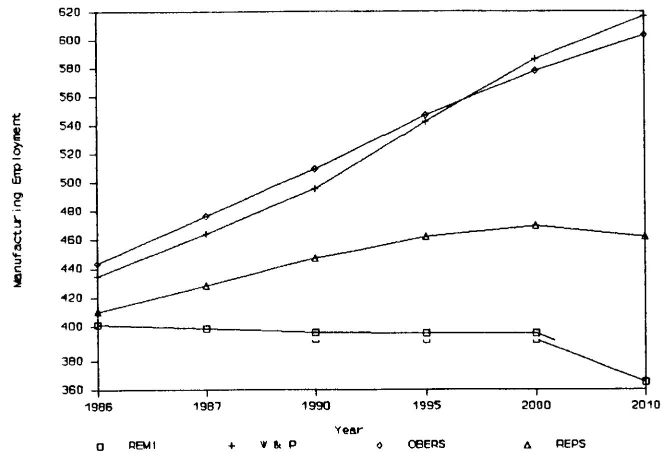
forecasts for the above for the Five-County region. We, therefore, will add an adjusted Suffolk County model to an unadjusted rest of Metropolitan Boston (RMB) model to obtain the sum for the region that we will compare to the independent forecasts for the Five-County region. The sources of the independent forecasts are Woods & Poole Economics (W&P), the Bureau of Economic Analysis (BEA), and Regional Economic Projections Series (REPS).

The independent estimates are not useful when comparing total employment in manufacturing because their respective growth rates are positive; this contradicts historical growth rates between 1986 and 1989. Figure 4 shows the independent



Source: REMI, Woods & Poole, OBERS, and REPS.

Figure 4
Metropolitan Boston: Manufacturing
(thousands of workers)

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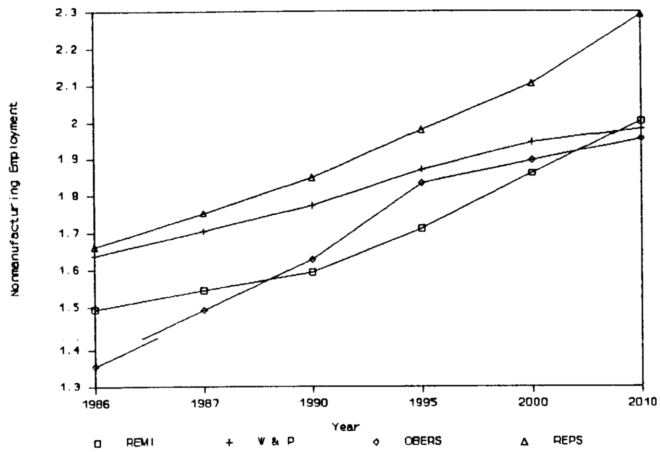
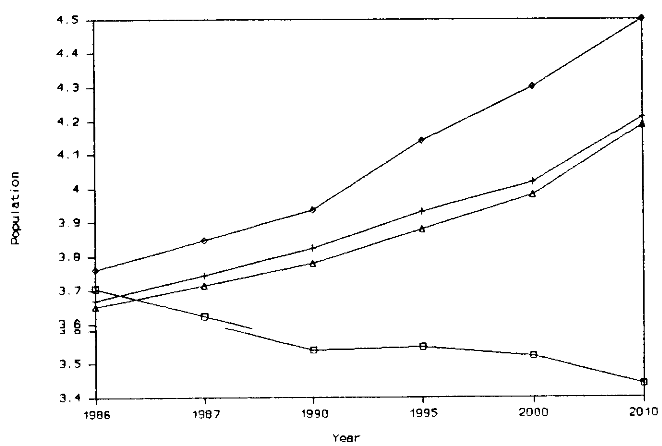
forecasts and the REMI adjusted forecast. CSI staff recommended that we not adjust the growth rates in manufacturing for the RMB model for manufacturing given that the REMI control forecast for the sum is consistent with previous projections from the BRA.

For nonmanufacturing employment, Figure 5 shows the independent forecasts and the REMI forecast for the sum. The REMI forecast is generally in the range of the independent forecasts. The independent forecasts are consistent with CSI and BRA staff's predictions for employment growth in this sector. Given that the REMI control forecast is within the range of the independent forecasts, we will not make adjustments to the RMB model for nonmanufacturing. Figure 6



Source: REMI, Woods & Poole, OBERS, and REPS.

Figure 5
Metropolitan Boston: Nonmanufacturing
(tens of thousands of workers)



Source: REMI, Woods & Poole, OBERS, and REPS.

Figure 6
Metropolitan Boston: Population
(tens of thousands of people)

shows the independent forecasts and the REMI forecast for population. The independent forecasts have a relatively high positive growth rate; this contradicts previous projections by CSI and BRA staff. The CSI staff, therefore, suggest changing the population growth rate in the RMB model to zero to make the growth rate for the sum of the two regions more consistent with CSI staff's projections.

To summarize, the recommendations for Suffolk County are for total manufacturing employment to decrease at a higher negative rate, for total nonmanufacturing employment to increase at a fairly high positive rate, and for population to increase slightly throughout the forecast range. Table 1 details the changes to employment and population growth rates. We focus on the control forecast for Massachusetts.

Adjusting the Control Forecast for Massachusetts

For Massachusetts, we also have independent forecasts for employment in manufacturing and in nonmanufacturing and for population from the same sources used in the previous subsection. We will refer to these forecasts when we adjust the control forecast for the Massachusetts model. Before discussing these forecasts in detail, we will present a brief overview of recent and historical trends in the Massachusetts economy to provide a context for analyzing the independent forecasts and for adjusting the REMI control forecast.

Total employment in manufacturing is expected to continue

Table 1

Growth Rates Adjustments for The Boston Model

SIC Code	Variable	Original	Adjusted
	Suffolk County		
	Employment		
23	Construction	-0.0385	-0.0005
25	Trucking	-0.0069	-0.0080
27	Air Transportation	0.0288	0.0080
28	Other Transportation	0.0103	0.0015
29	Communication	0.0017	0.0008
30	Public Utilities	0.0022	0.0001
31	Banking	0.0253	0.0210
32	Insurance	-0.0194	-0.0193
33	Credit & Finance	0.0332	0.0290
34	Real Estate	0.0355	0.0340
36	Rest of Retail	-0.0431	-0.0160
37	Wholesale Trade	-0.0390	-0.0330
38	Hotels	-0.0083	-0.0045
39	Personal Services and Repairs	-0.0229	-0.0114
42	Miscellaneous Business Services	-0.4296	0.0005
45	Medical	-0.0215	-0.0040
46	Miscellaneous Professional Services	0.0226	0.0007
47	Education	0.0208	0.0005
	Population	-0.0120	-0.0035
	Rest of Metropolitan Boston		
	Population	-0.0090	0.0000

Source: REMI control forecast and unpublished information from staff at Cambridge Systematics, Inc.

to decline, but by less in the coming years then in the past ten years. Major influences of the decline are (Annual Report, 1989, p. 2):

1) manufacturers are expected to continue leaving the state for more labor-rich or lower-wage areas,
2) some manufacturers are expected to cut employment; for example, the General Motors plant in Framingham closed as part of a national operating strategy, and
3) other manufacturers are expected to restructure (leading to a reduction in employment) in order to become more competitive. This will take the form of contracting out their manufacturing processes to lower-wage regions outside of New England; This appears to be true particularly for firms in the electric and non-electric machine categories.

Major reasons why the decline is not expected to be as great as previously thought are (Annual Report, 1989, p. 2):

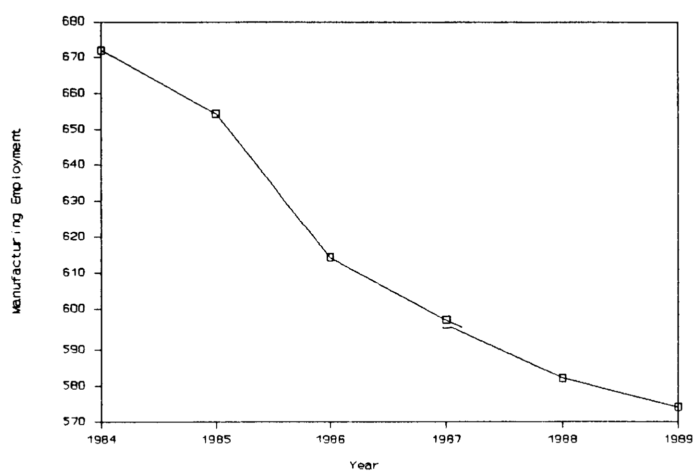
1) firms in high-tech industry appear to be stable,
2) firms in the printing and publishing categories have been consistently adding employment both in 1987 and 1988,
3) demand for capital goods still seems to be present,
4) defense-related work is already on the horizon, and

5) durable goods manufacturing firms are doing better. In particular, firms in primary metals, fabricated metals, electric, and nonmachine categories are recording smaller losses compared with 1987. This is important given that 45% of total manufacturing employment in the state is in these categories.

Total employment in nonmanufacturing is expected to continue to grow, but at a decreased rate. The strength of the continued growth is expected to come from firms in the construction and the transportation/utility categories. Contributing to the decline in growth are the remaining major nonmanufacturing categories. In particular, trade, services, and finance, insurance and real estate are expected to add fewer jobs than were added in the past. Also contributing to the decrease will be a reorganization of manufacturing processes and corporate moves by firms. Now, we look again at the independent forecasts.

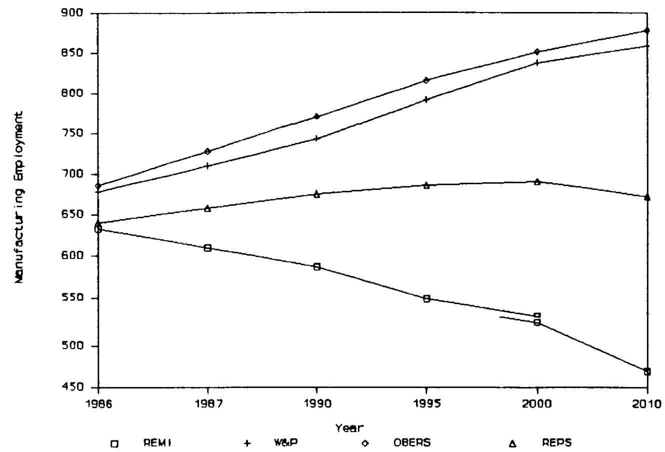
Although the independent forecasts represent the best available, we cannot regard them, in some respects, to be the best guidelines to use for adjusting the model. W&P and BEA's last historical year, for example, is 1983; this is a six-year lag in information. REPS is more recent. Its last historical year is 1987.

Figure 7 shows historical data for total manufacturing employment for 1984 through 1989. The trend for total manufacturing employment shows a steady, but not steep, decline. Figure 8 shows forecasts for the three independent sources and the REMI unadjusted control forecast. Also, for the case of Massachusetts, the independent forecasts for employment in manufacturing between 1986 and 1987 have positive growth rates that contradict historical growth rates for the same time period. We, therefore, find these forecasts less helpful for adjusting growth rates for employment in manufacturing. The REMI control forecast is consistent with the historical data, but given the information that we just presented on the expected trends in the Massachusetts economy, we believe that the decline in manufacturing employment from



Source: New England Annual Report

Figure 7
State: Manufacturing, History
(thousands of workers)

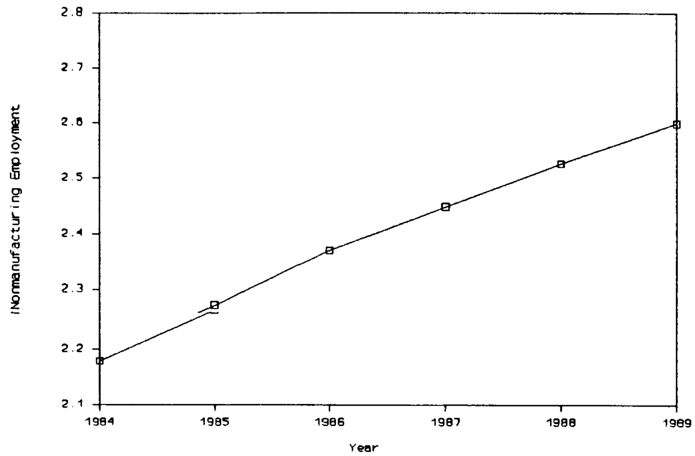


Source: REMI, Woods & Poole, OBERS, and REPS.

Figure 8
State: Manufacturing
(thousands of workers)

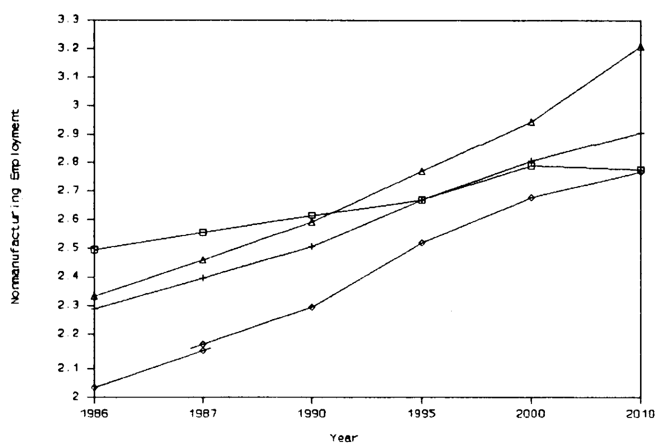
1990 to 2010 should be less negative. We are assuming that major restructuring by manufacturers should be completed, thus, losses in employment should decrease or stabilize.

Figure 9 shows historical data for total nonmanufacturing employment for 1984 through 1989. The trend in these data is upward, but is dampened near the end of the range. Figure 10 shows corresponding independent and REMI unadjusted forecasts. The trend for total nonmanufacturing employment shows a steady increase, but tapers off between 1987 and 1989. All independent forecasts reflect similar trends. A CSI staff member recommended that we focus more on growth rates of forecasts rather than on absolute levels because independent forecasts may have different bases than the REMI control



Source: New England Annual Report.

Figure 9
State: Nonmanufacturing, History
(tens of thousands of workers)



Source: REMI, Woods & Poole, OBERS, and REPS.

Figure 10
State: Nonmanufacturing
(tens of thousands of workers)

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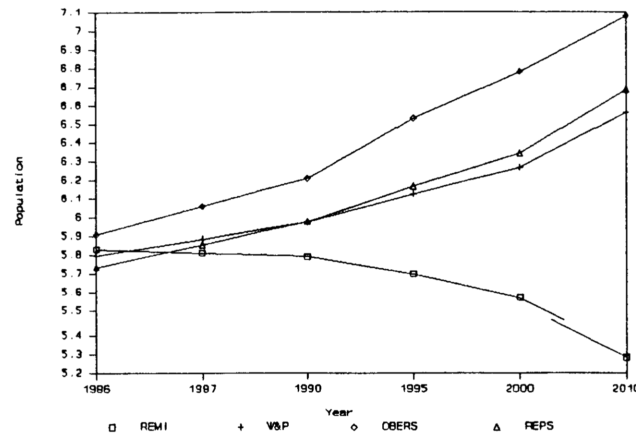
forecast. Between 2000 and 2010, the growth rate for the REMI control is negative, while growth rates for independent forecasts are positive. Given this information and information in the Annual Report, we believe that nonmanufacturing employment will not decline during this period, although it is unlikely to grow at its present rate. We are able to make a minor adjustment to reduce its decline. We do this indirectly by reducing the negative rate of decline in printing and in miscellaneous manufacturing. The end result is to increase business activities printing services, etc.

We are unable to obtain historical data for population between last quarter 1986 to first quarter 1989; however, we believe that Massachusetts′ population will remain at least constant until 1995. Perhaps, there will be a slight increase. Figure 11 shows independent and REMI unadjusted forecasts for population. REMI′s forecast is unacceptable; it declines throughout the entire forecast range, and it drops steeply in 2010. The independent forecasts increase more than seems reasonable; a staff member at the BRA suggested that we have population increase slightly over the forecast range.

To summarize, we prefer to have total manufacturing employment decrease, but at a less negative rate; total nonmanufacturing employment to increase, but at a less positive rate; and population to increase slightly over the entire forecast range. Following the above-mentioned



Source: REMI, Woods & Poole, OBERS, and REPS.

Figure 11
State: Population
(tens of thousands of people)

discussion on historical and recent employment trends in manufacturing, we adjust employment growth rates to make them less negative for fabricated metals, nonelectrical machinery, electrical equipment, instruments, miscellaneous manufacturers, and printing. We also make the growth rate for population less negative. Table 2 lists the changes we made to growth rates for six industries. Both models are adjusted, and we now look at the Third Harbor Tunnel project to determine empirically the differences between forecasts results for the state and the subregional model.

Table 2

Growth Rates Adjustments for Massachusetts

SIC Code	Variable	Original	Adjusted
	Employment		
29	Printing	-0.0042	-0.0090
34	Fabricated Metals	-0.0107	-0.0090
35	Non-electrical Machines	-0.0174	-0.0090
38	Instruments	-0.0171	-0.0090
39	Miscellaneous Manufacturing	-0.0055	-0.0090
	Population	-0.0090	-0.0045

Source: REMI control forecast and unpublished information from staff at Cambridge Systematics, Inc.

Analysis of the Adjustments

In the last section, we adjusted the control forecasts for each model. We will now examine how the changes affected the forecasts. There are many variables to select from to examine the effects. We choose four that will broadly characterize the two economies. They are total private nonfarm employment, regional production costs, regional demand, and regional output. Using the four variables, we will perform three analyses. In the first analysis, we will compare the unadjusted and the adjusted forecasts of the variables across industrial sectors to determine if, for example, employment shifts from one sector to another; we will focus on the period 1991 to 1994 and will make the comparison for each model. The first comparison, however, will not include production costs, because the figures are ratios; in this case, forming ratios from ratios produces meaningless results. In the second analysis, we will compare the unadjusted and adjusted forecasts for Boston as a percentage of Massachusetts over the same time period. Finally, in the third analysis, we will compare historical data for 1986 to the adjusted forecasted data for 1994 to determine if there is a shift in Boston's share of the Massachusetts economy. Concerning the historical data, these are the latest available from the REMI models for the regions; we are unable to obtain more recent historical data from other sources with the desired level of detail. For both Metropolitan Boston and Massachusetts, we will calculate the percentage distribution of jobs in 1986 and 1994, the respective growth rates from 1986 to 1994, and the ratio of Metropolitan Boston to Massachusetts (by industrial sector) for the same years. We will begin with the first analysis.

For Boston, we list the percentage distribution for total private nonfarm employment, regional demand, and regional output in Tables 3, 4, and 5, respectively. In each table, we first show the distribution using the unadjusted control forecasts; we, then, show the distributions using the adjusted control forecasts. For all variables, there is little to no shift in the distributions. Where shifts occur, the resulting difference equals approximately 1 percentage point. This is a small change. For Massachusetts, we list the percentage distributions for the same variables in Tables 6, 7, and 8, respectively, in the same manner as we did for Boston. There are virtually no shifts for Massachusetts. Thus, the adjustments that we made to the models did not significantly affect distributions among the industrial sectors.

Focusing now on the ratio, Metropolitan Boston as a percentage of Massachusetts, we list the comparisons between unadjusted and adjusted forecasts for the four variables in Tables 9 through 12. The adjustments we made to the growth rates slightly changed Boston's share relative to Massachusetts for all variables. There is no uniformity in the changes; some are negative, some are positive, and others are zero. In general, however, negative and positive changes are not greater than 5 percentage points.

Using historical data for the four variables, we can compare Massachusetts with Metropolitan Boston. For total private nonfarm employment, see Table 13, the figures for Boston as a percentage of Massachusetts indicate that the Boston model predicts (relative to the Massachusetts model) a uniform increase in the substate's share of total employment. Both the Boston and the Massachusetts models predict a slight change in the percentage distribution of jobs in Metropolitan Boston and Massachusetts, respectively. For Metropolitan Boston, the industrial sectors that will have a

Table 3

Boston: Private Nonfarm Employment
(percentage distribution)

Industrial Sector	Year			
	1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	15	15	15	15
Nondurables	5	5	5	5
*Mining	0	0	0	0
Construction	5	5	5	5
Transportation	5	5	5	5
Finance	9	9	8	8
Retail Trade	19	19	19	18
Wholesale Trade	6	6	7	7
Services	37	37	37	37
Agriculture	1	1	1	1
Total	100	100	100	100
Adjusted <u>Control Forecast</u>				
Durables	14	14	14	14
Nondurables	5	5	5	5
*Mining	0	0	0	0
Construction	5	5	5	5
Transportation	5	5	5	5
Finance	9	9	9	9
Retail Trade	19	19	19	19
Wholesale Trade	6	6	6	7
Services	36	37	37	37
Agriculture	1	1	1	1
Total	100	100	100	100

Source: Author's calculations, based on REMI forecasts.

Zeros in the table equal small positive numbers. In subsequent tables, the reader should interpret the figures for mining and for agriculture with caution.

Table 4

Boston: Regional Demand
(percentage distribution)

Industrial Sector	Year 1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	29	30	31	32
Nondurables	15	15	14	14
Mining	1	1	1	1
Construction	3	3	3	3
Transportation	8	8	8	8
Finance	12	12	11	11
Retail Trade	9	9	9	8
Wholesale Trade	6	6	6	6
Services	16	16	16	16
*Agriculture	0	0	0	0
Total	100	100	100	100
Adjusted <u>Control Forecast</u>				
Durables	28	29	30	31
Nondurables	15	15	14	14
Mining	1	1	1	1
Construction	4	3	3	3
Transportation	8	8	8	8
Finance	13	12	12	12
Retail Trade	9	9	9	9
Wholesale Trade	6	6	6	6
Services	17	17	16	16
*Agriculture	0	0	0	0
Total	100	100	100	100

Source: Author's calculations, based on REMI forecasts.

Zeros in the table equal small positive numbers. In subsequent tables, the reader should interpret the figures for mining and for agriculture with caution.

Table 5

Boston: Regional Output
(percentage distribution)

Industrial Sector	Year 1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	34	35	36	37
Nondurables	9	9	9	9
*Mining	0	0	0	0
Construction	3	3	3	3
Transportation	7	7	7	7
Finance	11	11	11	10
Retail Trade	8	8	8	8
Wholesale Trade	7	7	7	7
Services	20	20	20	19
*Agriculture	0	0	0	0
Total	100	100	100	100
Adjusted <u>Control Forecast</u>				
Durables	33	34	35	35
Nondurables	9	9	9	8
*Mining	0	0	0	0
Construction	3	3	3	3
Transportation	7	7	7	7
Finance	12	12	12	12
Retail Trade	8	8	8	8
Wholesale Trade	7	7	7	7
Services	20	20	20	19
*Agriculture	0	0	0	0
Total	100	100	100	100

Source: Author´s calculations, based on REMI forecasts.

Zero´s in the table equal small positive numbers. In subsequent tables, the reader should interpret the figures for mining and for agriculture with caution.

Table 6

Massachusetts: Private Nonfarm Employment
(percentage distribution)

Industrial Sector	Year 1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	12	12	12	12
Nondurables	6	6	5	5
*Mining	0	0	0	0
Construction	6	6	6	6
Transportation	4	4	4	4
Finance	9	9	9	9
Retail Trade	19	19	19	19
Wholesale Trade	5	5	6	6
Services	37	38	38	38
Agriculture	1	1	1	1
Total	100	100	100	100
Adjusted <u>Control Forecast</u>				
Durables	12	11	12	12
Nondurables	6	5	5	5
*Mining	0	0	0	0
Construction	6	5	6	6
Transportation	4	4	4	4
Finance	9	14	9	9
Retail Trade	19	18	19	19
Wholesale Trade	5	5	6	6
Services	37	36	38	38
Agriculture	1	1	1	1
Total	100	100	100	100

Source: Author´s calculations, based on REMI forecasts.

Zeros in the table equal small positive numbers. In subsequent tables, the reader should interpret the figures for mining and for agriculture with caution.

Table 7

Massachusetts: Regional Demand
(percentage distribution)

Industrial Sector	Year 1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	26	27	27	28
Nondurables	15	15	15	14
Mining	2	2	2	2
Construction	4	4	4	4
Transportation	7	7	7	7
Finance	15	15	15	15
Retail Trade	9	9	8	8
Wholesale Trade	5	5	5	5
Services	16	16	16	16
*Agriculture	0	0	0	0
Total	100	100	100	100
Adjusted <u>Control Forecast</u>				
Durables	27	27	28	28
Nondurables	15	15	14	14
Mining	2	2	2	1
Construction	4	4	4	4
Transportation	7	7	7	7
Finance	15	15	15	15
Retail Trade	9	8	8	8
Wholesale Trade	5	5	5	5
Services	16	16	16	16
*Agriculture	0	0	0	0
Total	100	100	100	100

Source: Author's calculations, based on REMI forecasts.

Zeros in the table equal small positive numbers. In subsequent tables, the reader should interpret the figures for mining and for agriculture with caution.

Table 8

Massachusetts: Regional Output
(percentage distribution)

Industrial Sector	Year 1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	31	31	32	32
Nondurables	11	11	11	10
*Mining	0	0	0	0
Construction	4	4	4	4
Transportation	7	7	7	7
Finance	13	13	13	13
Retail Trade	9	9	8	8
Wholesale Trade	6	6	6	6
Services	20	19	19	19
*Agriculture	0	0	0	0
Total	100	100	100	100
Adjusted <u>Control Forecast</u>				
Durables	31	32	32	33
Nondurables	11	11	10	10
*Mining	0	0	0	0
Construction	4	4	4	4
Transportation	7	7	7	7
Finance	13	13	13	13
Retail Trade	9	9	8	8
Wholesale Trade	6	6	6	6
Services	19	19	19	19
*Agriculture	0	0	0	0
Total	100	100	100	100

Source: Author's calculations, based on REMI forecasts.

Zeros in the table equal small positive numbers. In subsequent tables, the reader should interpret the figures for mining and for agriculture with caution.

Table 9

Private Nonfarm Employment
(Boston as a percentage of Massachusetts)

Industrial Sector	Year			
	1991	1992	1993	1993
Unadjusted <u>Control Forecast</u>				
Durables	74	75	77	77
Nondurables	55	56	56	57
Mining	43	45	45	43
Construction	49	49	49	49
Transportation	67	67	67	67
Finance	57	57	58	58
Retail Trade	61	61	61	61
Wholesale Trade	71	73	74	76
Services	60	60	60	61
Agriculture	37	38	38	39
Adjusted <u>Control Forecast</u>				
Durables	73	74	75	76
Nondurables	56	57	58	59
Mining	43	45	45	47
Construction	51	52	52	53
Transportation	69	69	70	71
Finance	61	37	63	65
Retail Trade	63	63	64	64
Wholesale Trade	72	74	75	77
Services	61	62	62	63
Agriculture	37	38	39	40

Source: Author's calculations, based on REMI forecasts.

Table 10

Production Costs
(Boston as a percentage of Massachusetts)

Industrial Sector	Year			
	1991	1992	1993	1994
Unadjusted <u>Control Forecast</u>				
Durables	48	48	48	48
Nondurables	48	48	48	48
Mining	425	416	412	407
Construction	38	38	38	38
Transportation	45	45	46	46
Finance	46	46	46	46
Retail Trade	46	47	47	47
Wholesale Trade	46	46	46	46
Services	41	41	41	41
Agriculture	38	38	38	38
Unadjusted <u>Control Forecast</u>				
Durables	48	48	48	53
Nondurables	48	48	48	48
Mining	427	419	415	411
Construction	38	38	38	38
Transportation	45	45	45	45
Finance	45	45	45	45
Retail Trade	46	46	46	46
Wholesale Trade	46	46	46	46
Services	40	40	40	40
Agriculture	38	38	38	38

Source: Author´s calculations, based on REMI forecasts.

Table 11

Regional Demand
(Boston as a percentage of Massachusetts)

Industrial Sector	Year 1991	1992	1993	1993
<u>Unadjusted Control Forecast</u>				
Durables	71	73	75	77
Nondurables	65	65	66	66
Mining	62	63	64	65
Construction	57	57	57	58
Transportation	68	69	70	71
Finance	52	50	48	47
Retail Trade	67	67	67	67
Wholesale Trade	69	71	72	74
Services	67	67	67	68
Agriculture	57	58	59	58
<u>Unadjusted Control Forecast</u>				
Durables	70	71	73	74
Nondurables	67	68	69	70
Mining	62	63	65	66
Construction	60	60	61	62
Transportation	71	72	74	75
Finance	55	54	53	52
Retail Trade	69	70	70	71
Wholesale Trade	70	72	74	75
Services	69	70	71	71
Agriculture	58	59	60	60

Source: Author´s calculations, based on REMI forecasts

Table 12

Regional Output
(Boston as a percentage of Massachusetts)

Industrial Sector	Year 1991	1992	1993	1993
<u>Unadjusted Control Forecast</u>				
Durables	74	76	77	78
Nondurables	55	55	54	56
Mining	150	152	155	157
Construction	55	55	56	56
Transportation	69	70	70	69
Finance	58	57	56	56
Retail Trade	61	62	62	62
Wholesale Trade	74	75	76	78
Services	67	68	68	68
Agriculture	53	54	54	54
<u>Unadjusted Control Forecast</u>				
Durables	72	74	75	76
Nondurables	56	57	57	58
Mining	145	152	155	157
Construction	57	58	59	60
Transportation	72	74	74	73
Finance	64	64	64	65
Retail Trade	64	64	65	65
Wholesale Trade	75	76	78	79
Services	69	70	70	71
Agriculture	55	55	56	57

Source: Author´s calculations, based on REMI forecasts.

decreased share are durables, nondurables, and transportation. The same is predicted for Massachusetts, except that wholesale trade is predicted to loose some of its share as well.

In Table 14, we detail regional production costs for Boston and Massachusetts. Growth rates for the production costs are small. For Metropolitan Boston, growth rates are not predicted to grow as fast as for the state; for mining, the growth rate for Metropolitan Boston is negative. Note that mining and agriculture, relative to the other industrial sectors, are small. We, therefore, will not give attention to these sectors in subsequent analyses.

The prediction for regional demand is similar to that for total private nonfarm employment; that is, the Boston model predicts (relative to the Massachusetts model) a uniform increase in the substate´s share of regional demand, see Table 15. The one exception is finance; its share is predicted to decrease.The percentage distributions do not change much for either region. The prediction for Metropolitan Boston´s share of regional output is also similar to the one for employment and regional demand, see Table 16. Again, Metropolitan Boston is predicted to increase its share of the state´s regional output.

Table 14

Production Costs for Boston and Massachusetts

Industrial Sector	1986	Growth to 1994	1994
<u>Boston</u>			
Durables	2.15	0.003	2.20
Nondurables	2.16	0.002	2.19
Mining	4.59	-0.009	4.27
Construction	2.83	0.002	2.87
Transportation	2.30	0.002	2.34
Finance	2.31	0.002	2.34
Retail Trade	2.33	0.002	2.37
Wholesale Trade	2.31	0.002	2.34
Services	2.64	0.005	2.75
Agriculture	2.85	0.003	2.93
<u>Massachusetts</u>			
Durables	1.03	0.003	1.06
Nondurables	1.03	0.003	1.05
Mining	0.99	0.006	1.04
Construction	1.04	0.006	1.09
Transportation	1.03	0.003	1.06
Finance	1.03	0.004	1.06
Retail Trade	1.06	0.005	1.10
Wholesale Trade	1.04	0.004	1.07
Services	1.06	0.005	1.10
Agriculture	1.07	0.005	1.11

Table 13

Private Nonfarm Employment for Boston and Massachusetts
(thousands of workers)

Industrial Sector	1986	% Dist. in 1986	Growth to 1994	1994	% Dist. in 1994
<u>Boston</u>					
Durables	289.0	15	0.004	299.1	14
Nondurables	111.9	6	-0.014	99.7	5
Mining	1.1	0	0.022	1.4	0
Construction	82.9	4	0.023	99.4	5
Transportation	92.5	5	0.011	101.1	5
Finance	161.0	8	0.022	192.2	9
Retail Trade	363.5	19	0.013	403.1	19
Wholesale Trade	118.0	6	0.022	140.8	7
Services	665.3	35	0.023	795.2	37
Agriculture	9.7	1	0.025	11.7	1
Total	1894.9	100	-	2143.7	100
<u>Massachusetts</u>					
Durables	425.5	14	-0.009	394.3	12
Nondurables	208.0	7	-0.025	170.1	5
Mining	3.0	0	0.001	3.0	0
Construction	170.3	5	0.013	188.3	6
Transportation	141.4	5	0.002	143.4	4
Finance	271.8	9	0.012	297.9	9
Retail Trade	602.1	19	0.005	627.7	19
Wholesale Trade	178.8	6	0.003	183.1	6
Services	1101.9	35	0.018	1267.3	38
Agriculture	27.6	1	0.008	29.6	1
Total	3130.4	100	-	3304.6	100

Table 13 (continued)

Private Nonfarm Employment for Boston and Massachusetts
(thousands of workers)

Industrial Sector	1986	% Dist. in 1986	Growth to 1994	1994	% Dist. in 1994
Boston as a Percentage of Massachusetts					
Durables	68	-	-	76	-
Nondurables	54	-	-	59	-
Mining	39	-	-	46	-
Construction	49	-	-	53	-
Transportation	65	-	-	70	-
Finance	59	-	-	65	-
Retail Trade	60	-	-	64	-
Wholesale Trade	66	-	-	77	-
Services	60	-	-	63	-
Agriculture	35	-	-	40	-

Source: Author's calculations; 1986 are historical data and 1994 are forecasted data from REMI.

% Dist. = percentage distribution.

- indicates not applicable.

Table 14

Production Costs for Boston and Massachusetts

Industrial Sector	1986	Growth to 1994	1994
Boston			
Durables	2.15	0.003	2.20
Nondurables	2.16	0.002	2.19
Mining	4.59	-0.009	4.27
Construction	2.83	0.002	2.87
Transportation	2.30	0.002	2.34
Finance	2.31	0.002	2.34
Retail Trade	2.33	0.002	2.37
Wholesale Trade	2.31	0.002	2.34
Services	2.64	0.005	2.75
Agriculture	2.85	0.003	2.93
Massachusetts			
Durables	1.03	0.003	1.06
Nondurables	1.03	0.003	1.05
Mining	0.99	0.006	1.04
Construction	1.04	0.006	1.09
Transportation	1.03	0.003	1.06
Finance	1.03	0.004	1.06
Retail Trade	1.06	0.005	1.10
Wholesale Trade	1.04	0.004	1.07
Services	1.06	0.005	1.10
Agriculture	1.07	0.005	1.11

Table 14 (continued)

Production Costs for Boston and Massachusetts

Industrial Sector	1986	Growth to 1994	1994
Boston as a Percentage of Massachusetts			
Durables	208	-	208
Nondurables	210	-	209
Mining	464	-	410
Construction	272	-	263
Transportation	224	-	222
Finance	224	-	220
Retail Trade	221	-	216
Wholesale Trade	223	-	219
Services	250	-	249
Agriculture	268	-	265

Source: Author's calculations; 1986 are historical data and 1994 are forecasted data from REMI.

% Dist. = percentage distribution.

- indicates not applicable.

Table 15

Regional Demand for Boston and Massachusetts
(billions of 1977 dollars)

Industrial Sector	1986	% Dist. in 1986	Growth to 1994	1994	% Dist. in 1994
Boston					
Durables	18.3	24	0.064	30.0	31
Nondurables	12.4	16	0.015	13.9	14
Mining	1.1	1	0.030	1.4	1
Construction	2.7	4	0.026	3.3	3
Transportation	6.0	8	0.033	7.7	8
Finance	11.9	16	-0.006	11.3	12
Retail Trade	7.2	9	0.020	8.4	9
Wholesale Trade	4.2	5	0.037	5.6	6
Services	12.2	16	0.036	16.2	16
Agriculture	0.3	0	0.028	0.3	0
Total	76.2	100	-	98.2	100
Massachusetts					
Durables	28.8	24	0.044	40.5	28
Nondurables	19.6	17	0.002	19.9	14
Mining	1.9	2	0.014	2.1	1
Construction	4.8	4	0.014	5.4	4
Transportation	9.2	8	0.014	10.2	7
Finance	17.9	15	0.025	21.9	15
Retail Trade	10.8	9	0.012	11.9	8
Wholesale Trade	6.7	6	0.013	7.4	5
Services	18.4	16	0.026	22.6	16
Agriculture	0.4	0	0.022	0.5	0
Total	118.5	100	-	142.5	100

Table 15 (continued)

Regional Demand for Boston and Massachusetts
(billions of 1977 dollars)

Industrial Sector	1986	% Dist. in 1986	Growth to 1994	1994	% Dist. in 1994
Boston as a Percentage of Massachusetts					
Durables	63	-	-	74	-
Nondurables	63	-	-	70	-
Mining	58	-	-	66	-
Construction	56	-	-	62	-
Transportation	65	-	-	75	-
Finance	67	-	-	52	-
Retail Trade	67	-	-	71	-
Wholesale Trade	63	-	-	75	-
Services	66	-	-	71	-
Agriculture	58	-	-	61	-

Source: Author's calculations; 1986 are historical data and 1994 are predicted data from REMI.

% Dist. = percentage distribution.

- indicates not applicable.

Table 16

Regional Output for Boston and Massachusetts
(billions of 1977 dollars)

Industrial Sector	1986	% Dist. in 1986	Growth to 1994	1994	% Dist. in 1994
Boston					
Durables	22.2	30	0.059	35.2	35
Nondurables	7.7	10	0.010	8.3	8
Mining	0.3	0	0.043	0.5	0
Construction	2.5	3	0.028	3.1	3
Transportation	5.5	7	0.031	7.0	7
Finance	9.7	13	0.022	11.6	12
Retail Trade	6.6	9	0.020	7.7	8
Wholesale Trade	5.1	7	0.031	6.5	7
Services	14.7	20	0.036	19.4	19
Agriculture	0.3	0	0.032	0.4	0
Total	74.6	100	-	99.8	100
Massachusetts					
Durables	33.1	28	0.043	46.5	33
Nondurables	14.3	12	0.001	14.5	10
Mining	0.3	0	0.015	0.3	0
Construction	4.7	4	0.014	5.2	4
Transportation	8.4	7	0.017	9.6	7
Finance	14.9	13	0.024	18.0	13
Retail Trade	10.7	9	0.013	11.9	8
Wholesale Trade	7.4	6	0.013	8.2	6
Services	22.0	19	0.028	27.4	19
Agriculture	0.6	1	0.022	0.7	0
Total	116.3	100	-	142.1	100

Table 16 (continued)

Regional Output for Boston and Massachusetts
(billions of 1977 dollars)

Industrial Sector	1986	% Dist. in 1986	Growth to 1994	1994	% Dist. in 1994
Boston As a Percentage <u>of Massachusetts</u>					
Durables	67	-	-	76	-
Nondurables	54	-	-	58	-
Mining	127	-	-	157	-
Construction	54	-	-	60	-
Transportation	66	-	-	73	-
Finance	65	-	-	65	-
Retail Trade	62	-	-	65	-
Wholesale Trade	69	-	-	79	-
Services	67	-	-	71	-
Agriculture	52	-	-	56	-

Source: Author´s calculations; 1986 are historical data and 1994 are predicted data from REMI.

% Dist. = percentage distribution.

- indicates not applicable.

Chapter 5

Analysis of the Third Harbor Tunnel

In this chapter, we will (1) describe the construction expenditures for the Third Harbor Tunnel, (2) detail the types of expenditures and the industrial sectors affected by them, (3) describe the allocation of the expenditures over the life of the project, and (4) indicate the expenditures that will directly affect demand and supply in the economy. We will also detail annual employment requirements in construction and engineering. In the second section, we will forecast the impact of the construction expenditures using the Boston and the Massachusetts models. We then will convert the forecasts from the Massachusetts model to Metropolitan Boston equivalents and compare these to the forecasts from the Boston model for four variables: total private nonfarm employment, regional production costs relative to the U.S., regional demand, and regional output. We will form ratios from the two sets of forecasts. We will define an acceptance region for the ratios, and we will evaluate whether or not the ratios fall within the region; we will make this evaluation for the totals of the variables and the components of the variables. We then will compare the ratios to the acceptance region for the totals of the variables and the components of the variables. Finally, to summarize across years the differences between the two sets of forecasts, we will use three difference measures: the mean absolute difference, the root mean squared difference and the mean absolute percentage differences.

Description of The Project

Table 17 details the preliminary estimates of the project costs. We distribute these costs between regular policy variables DEMPOL and SALPOL. We use DEMPOL to represent increased spending in Suffolk County; we will spend approximately 71 million dollars in 1991, 100 million dollars in 1992, 50 million dollars in 1993, and 16 million dollars in 1994. These expenditures are increases in demand in the regional economy. Local production will satisfy only part of this new demand; imports will satisfy the rest. We note that imports include both foreign and domestic goods. We use SALPOL to represent an exogenous change in the sales of the locally produced good (immersed tube) in Suffolk County. We will spend 4.1 million dollars per year from 1991 to 1994. We also show in Table 17 that the Third Harbor Tunnel is a special kind of construction project, because it does not require demolition, utilities, structural steel, railroad, or acquisition of land and relocation of households or firms. We distribute costs for DEMPOL and SALPOL annually in Table 18. We show them both in percentages and in levels.

Table 17

Third Harbor Tunnel Project Costs
(Preliminary Estimates)

Construction Requirements	Costs Allocated To DEMPOL	Costs Allocated To SALPOL
Demolition	$ 0	$ 0
Earthwork	31,693,147	0
Instrumentation	1,000,000	0
Utilities	0	0
Concrete	51,932,374	0
Immersed Tube	79,153,663	16,400,000
Ventilation	13,940,000	0
Structural Steel	0	0
Finishes	18,443,324	0
Railroad	0	0
Other	0	0
Contingency	31,884,376	0
Acquisition and Relocation	0	0
Preliminary Engineering	9,075,019	0
Project Total	$ 237,121,903	$ 16,400,000

Source: Unpublished data from Cambridge Systematics.

Table 18

Distribution of Project Costs to Policy Variables

Regular Policy Variable	Year				Total
	1991	1992	1993	1994	
Percentage					
DEMPOL	30	42	21	7	100
SALPOL	25	25	25	25	100
Level (thousands of dollars)					
DEMPOL	71,136	99,591	49,796	16,598	237,122
SALPOL	4,100	4,100	4,100	4,100	16,400
Total	75,236	113,691	53,896	20,698	253,522

Source: Author's calculations upon data in Table 3.

Using the Standard Industrial Classification Manual and REMI documentation, we assign costs for DEMPOL, shown in Table 17, to industrial sectors. We allocate construction expenditures for earthwork and finishes to construction, instrumentation to instruments, concrete to stone, clay, etc., immersed tube to rest of transportation equipment, ventilation to nonelectrical machines, preliminary engineering to miscellaneous professional services, and contingency to all of the above-mentioned sectors according to their respective annual percentages of total annual expenditures for DEMPOL.[3] For SALPOL, we assign all expenditures to rest of transportation equipment. Table 19 shows these distributions.

Analysis of Forecast Results

Recall that we calculated Boston as a percentage of Massachusetts in Tables 13 through 16. Referring to these percentages for 1986, we will use them to convert forecasts from the Massachusetts model to Metropolitan Boston equivalents. We will do the following calculations. We will multiply the percentage for each industrial sector by corresponding levels predicted by the Massachusetts model for 1991 to 1994. When modifying the Massachusetts model in this way, we will refer to it as the Boston Share model or the Share model. We will then compare this model to the Boston model to evaluate the differences between the two sets of forecasts. First, we will compare the models using the control forecasts, absent of any policy changes. Finally, we will compare these two models accounting for the impact of the Third Harbor Tunnel. To compare the forecasts from the two models, we will form ratios, forecasts from the Share model

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[3]Some of REMI's standard industrial classifications are more aggregate than classifications listed in the SIC Manual. Thus, for example, although we initially make finer distinctions for different types of construction expenditures, REMI only defines one sector for all construction expenditures.

Table 19

Distribution of Project Cost to Industrial Sectors
(millions of dollars)

Standard Industrial Classification	Year			
	1991	1992	1993	1994
DEMPOL				
Construction	$ 17.38	$ 24.33	$ 12.16	$ 4.05
Stone, Clay, etc.	18.00	25.20	12.60	4.20
Nonelectrical Machines	4.83	6.76	3.38	1.13
Rest of Transportation Equipment	27.43	38.41	19.20	6.40
Instruments	0.35	0.49	0.24	0.08
Miscellaneous Professional Services	3.14	4.40	2.20	0.73
SALPOL				
Rest of Transportation Equipment	4.10	4.10	4.10	4.10
Total	$ 75.23	$ 103.69	$ 53.90	$ 20.70

Source: Calculations made by author, based on unpublished information from staff at Cambridge Systematics, Inc.

divided by forecasts from the Boston model. To evaluate the ratios after converting them to percentages, we will define an acceptance region for the ratios as greater than or equal to 90% or less than or equal 110%. This will allow us to measure when the difference between the two sets of forecasts is less than or equal to 10%, whether or not forecasts from the Share model are larger than forecasts from the Boston model. A difference of 10% or less is a reasonable range, and it is commonly used by forecasters when determining differences between the models.

Table 20 details the comparison of the two models for total private nonfarm employment. For the totals of this variable, forecasts from the Share model are approximately 93% to 95% of corresponding forecasts from the Boston model. By industrial sectors, forecasts from the Share model are generally within the 90% region. For wholesale trade, the Share model does not perform as well; however, on average it is close to the 90% acceptance region. Overall, these ratios indicate that the Share model uniformly underestimates the Boston model. This is consistent with our finding in Table 13; that is, the Boston model, relative to the Massachusetts model, predicts that Metropolitan Boston will increase its share of total private nonfarm employment. This is also consistent with the structures of the two models; that is, given that the Share model is derived from the Massachusetts model, it follows that its forecasts would be less than forecasts from the Boston model.

We show the comparison of the two models for production costs in Table 21. Ratios in this table are well within the acceptance range; many times, they are close to 1. Forecasts from the Share model are less than forecasts from the Boston model, except for durables in 1994; it equals 0.99. This is consistent with our finding in Table 14: the Boston model,

Table 20

Share Model Versus Boston Model for
Private Nonfarm Employment
(thousands of workers)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model				
Durables	274.3	268.9	268.6	267.8
Nondurables	98.4	95.7	93.4	91.5
Mining	1.1	1.1	1.1	1.2
Construction	92.8	93.5	92.7	91.6
Transportation	92.9	93.6	93.9	93.8
Finance	179.2	180.7	179.2	176.5
Retail Trade	372.4	376.7	379.2	379.0
Wholesale Trade	118.1	119.8	120.8	120.8
Services	739.3	751.1	762.3	765.2
Agriculture	9.9	10.0	10.2	10.4
Total	1978.6	1991.1	2001.5	1997.7
Boston Model				
Durables	295.4	293.7	297.2	299.1
Nondurables	103.3	101.8	100.6	99.7
Mining	1.2	1.3	1.3	1.4
Construction	97.2	99.0	99.5	99.4
Transportation	97.7	99.2	100.5	101.1
Finance	185.0	189.3	191.3	192.2
Retail Trade	386.0	393.8	399.8	403.1
Wholesale Trade	129.1	133.8	137.9	140.8
Services	748.1	766.3	785.0	795.2
Agriculture	10.6	10.9	11.3	11.7
Total	2053.6	2089.1	2124.4	2143.7

Table 20 (continued)

Share Model Versus Boston Model for Private Nonfarm Employment (thousands of workers)

Industrial Sector	Year 1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	0.93	0.92	0.90	0.90
Nondurables	0.95	0.94	0.93	0.92
Mining	0.91	0.87	0.87	0.83
Construction	0.96	0.94	0.93	0.92
Transportation	0.95	0.94	0.93	0.93
Finance	0.97	0.95	0.94	0.92
Retail Trade	0.96	0.96	0.95	0.94
Wholesale Trade	0.92	0.90	0.88	0.86
Services	0.99	0.98	0.97	0.96
Agriculture	0.93	0.92	0.90	0.89

Source: Figures for Share model and Share model as a percentage of Boston model are author's calculations based on REMI forecasts. Figures for the Boston model are from REMI forecasts.

Table 21

Share Model Versus the Boston Model for Production Costs

Industrial Sector	Year			
	1991	1992	1993	1994
<u>Share Model</u>				
Durables	2.19	2.19	2.19	2.19
Nondurables	2.20	2.20	2.20	2.20
Mining	4.78	4.83	4.83	4.83
Construction	2.96	2.96	2.96	2.96
Transportation	2.35	2.35	2.35	2.38
Finance	2.37	2.37	2.37	2.37
Retail Trade	2.41	2.41	2.43	2.43
Wholesale Trade	2.39	2.39	2.39	2.39
Services	2.75	2.75	2.75	2.75
Agriculture	2.95	2.95	2.97	2.97
<u>Boston Model</u>				
Durables	2.18	2.19	2.19	2.20
Nondurables	2.18	2.19	2.19	2.19
Mining	4.40	4.36	4.32	4.27
Construction	2.86	2.86	2.87	2.87
Transportation	2.32	2.33	2.33	2.34
Finance	2.33	2.33	2.33	2.34
Retail Trade	2.36	2.36	2.37	2.37
Wholesale Trade	2.33	2.33	2.34	2.34
Services	2.72	2.73	2.74	2.75
Agriculture	2.90	2.91	2.92	2.93

Table 21 (continued)

Share Model Versus the Boston Model for Production Costs

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	1.00	1.00	1.00	0.99
Nondurables	1.01	1.01	1.01	1.01
Mining	1.09	1.11	1.12	1.13
Construction	1.04	1.04	1.03	1.03
Transportation	1.01	1.01	1.01	1.02
Finance	1.02	1.02	1.02	1.01
Retail Trade	1.02	1.02	1.03	1.03
Wholesale Trade	1.03	1.03	1.02	1.02
Services	1.01	1.01	1.00	1.00
Agriculture	1.02	1.01	1.02	1.02

Source: Figures for the Share model and the Share model as a percentage of the Boston model are author's calculations based on REMI forecasts. Figures for the Boston model are from REMI forecasts.

relative to the Massachusetts model, predicts smaller growth in rates for production costs.

In Table 22, we show the comparisons for regional demand. Recall from Table 13 that the Boston model, relative to the Massachusetts model, predicts a large share increase for durables, transportation, and wholesale trade, while it predicts a large share decrease for finance. For these industrial sectors, the Share model does not replicate

Table 22

Share Model Versus Boston Model for Regional Demand
(billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
<u>Share Model</u>				
Durables	22.53	23.49	24.72	25.69
Nondurables	12.57	12.58	12.63	12.61
Mining	1.19	1.20	1.22	1.24
Construction	2.94	2.97	3.00	3.02
Transportation	6.40	6.48	6.59	6.65
Finance	13.52	13.85	14.26	14.57
Retail Trade	7.58	7.69	7.83	7.92
Wholesale Trade	4.39	4.46	4.58	4.65
Services	14.01	14.32	14.73	15.01
Agriculture	0.29	0.30	0.30	0.31
Total	85.4	87.3	89.9	91.7
<u>Boston Model</u>				
Durables	24.79	26.38	28.34	30.02
Nondurables	13.35	13.55	13.79	13.95
Mining	1.27	1.31	1.36	1.40
Construction	3.11	3.18	3.27	3.34
Transportation	7.00	7.22	7.49	7.70
Finance	11.25	11.24	11.32	11.34
Retail Trade	7.83	8.01	8.24	8.41
Wholesale Trade	4.91	5.12	5.39	5.60
Services	14.59	15.08	15.69	16.16
Agriculture	0.29	0.30	0.31	0.32
Total	88.4	91.4	95.2	98.2

Table 22 (continued)

Share Model Versus Boston Model for Regional Demand (billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	0.91	0.89	0.87	0.86
Nondurables	0.94	0.93	0.92	0.90
Mining	0.94	0.92	0.90	0.89
Construction	0.95	0.93	0.92	0.91
Transportation	0.91	0.90	0.88	0.86
Finance	1.20	1.23	1.26	1.29
Retail Trade	0.97	0.96	0.95	0.94
Wholesale Trade	0.89	0.87	0.85	0.83
Services	0.96	0.95	0.94	0.93
Agriculture	1.00	0.98	0.97	0.96

Source: Figures for the Share model and the Share model as a percentage of the Boston model are author's calculations based on REMI forecasts. Figures for the Boston model are from REMI forecasts.

forecasts of the Boston model as well. Forecasts for durables and transportation are generally better than they are for wholesale trade. Forecasts for finance are worse than any of the other three. As we implied earlier, the failure of the Share model to replicate forecasts for certain industrial sectors is a result of the assumptions built into the Boston model relative to the assumptions built into the Massachusetts model. Focusing on the totals for regional demand and not on its components, however, forecasts from the Share model are well within the acceptance region. This is because forecasts from the Share model, for the components, are both larger and smaller than forecasts from the Boston Model. When we aggregate the components, positive and negative differences cancel each other out.

In Table 23, we show the comparison for the remaining variable, regional output. Excluding mining, the Share model is generally within the acceptance region. For the totals of regional output, the Share model is well within the acceptance range. Now that we examined the performance of the Share model absent of any policy changes in Metropolitan Boston, we now compare the two models accounting for the construction expenditure impact of the Third Harbor Tunnel.

We set up this analysis in an analogous way to the previous one. In Tables 24 through 27, we show the comparison between the Share model and the Boston model for the same variables and for the same time periods. Accounting for the impact of the project, the relative performance of the Share model is fundamentally the same as it was without the policy changes. We can speculate why this is the case. We believe that it is related to the absolute size of the differences relative to the absolute size of the levels. Given that the Share model predicts levels that are close to levels predicted by the Boston model, resulting differences from the impact

Table 23

Share Model Versus Boston Model for Regional Output (billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
<u>Share Model</u>				
Durables	27.23	28.40	29.92	31.10
Nondurables	7.68	7.69	7.74	7.75
Mining	0.37	0.37	0.37	0.38
Construction	2.74	2.77	2.80	2.82
Transportation	6.02	6.09	6.21	6.28
Finance	10.94	11.19	11.51	11.76
Retail Trade	6.97	7.08	7.23	7.32
Wholesale Trade	5.34	5.44	5.57	5.66
Services	17.05	17.44	17.95	18.29
Agriculture	0.33	0.34	0.35	0.36
Total	84.7	86.8	89.7	91.7
<u>Boston Model</u>				
Durables	29.48	31.24	33.42	35.17
Nondurables	8.04	8.13	8.26	8.34
Mining	0.42	0.44	0.45	0.47
Construction	2.91	2.98	3.06	3.13
Transportation	6.47	6.64	6.86	7.02
Finance	10.66	10.95	11.32	11.61
Retail Trade	7.18	7.35	7.57	7.73
Wholesale Trade	5.79	6.01	6.29	6.51
Services	17.62	18.18	18.88	19.41
Agriculture	0.35	0.36	0.38	0.39
Total	88.9	92.3	96.5	99.8

Table 23 (continued)

Share Model Versus Boston Model for
Regional Output
(billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of the Boston Model</u>				
Durables	0.92	0.91	0.90	0.88
Nondurables	0.95	0.95	0.94	0.93
Mining	0.88	0.84	0.82	0.81
Construction	0.94	0.93	0.91	0.90
Transportation	0.93	0.92	0.91	0.89
Finance	1.03	1.02	1.02	1.01
Retail Trade	0.97	0.96	0.96	0.95
Wholesale Trade	0.92	0.90	0.89	0.87
Services	0.97	0.96	0.95	0.94
Agriculture	0.95	0.95	0.93	0.92

Source: Figures for the Share model and for the Share model as a percentage of the Boston model are the author's calculations based on REMI forecasts. Figures for the Boston model are from REMI.

Table 24
Third Harbor Tunnel Impact: Share Model Versus Boston Model for Private Nonfarm Employment
(thousands of workers)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model				
Durables	274.4	269.1	268.7	267.8
Nondurables	98.5	95.7	93.5	91.5
Mining	1.1	1.1	1.1	1.2
Construction	92.9	93.6	92.8	91.6
Transportation	92.9	93.6	94.0	93.7
Finance	179.3	180.7	179.2	176.5
Retail Trade	372.5	376.8	379.2	379.0
Wholesale Trade	118.2	119.8	120.9	120.9
Services	739.5	751.3	762.4	765.2
Agriculture	9.9	10.0	10.2	10.3
Total	1979.2	1991.8	2001.9	1997.7
Boston Model				
Durables	295.5	293.8	297.2	299.1
Nondurables	103.3	101.8	100.6	99.7
Mining	1.2	1.3	1.3	1.4
Construction	97.4	99.4	99.6	99.4
Transportation	97.7	99.2	100.5	101.1
Finance	185.0	189.4	191.3	192.2
Retail Trade	386.1	393.9	399.9	403.1
Wholesale Trade	129.1	133.8	137.9	140.8
Services	748.2	766.5	785.2	795.2
Agriculture	10.6	10.9	11.3	11.7
Total	2054.2	2090.1	2124.9	2143.9

Table 24 (continued)
Third Harbor Tunnel Impact: Share Model Versus Boston Model for Private Nonfarm Employment
(thousands of workers)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	0.93	0.92	0.90	0.90
Nondurables	0.95	0.94	0.93	0.92
Mining	0.89	0.87	0.86	0.85
Construction	0.95	0.94	0.93	0.92
Transportation	0.95	0.94	0.94	0.93
Finance	0.97	0.95	0.94	0.92
Retail Trade	0.96	0.96	0.95	0.94
Wholesale Trade	0.92	0.90	0.88	0.86
Services	0.99	0.98	0.97	0.96
Agriculture	0.93	0.92	0.90	0.88

Source: Figures for the Share model and for the Share as a percentage of the Boston Model are author's calculations based on REMI forecasts. Figures for the Boston model are from REMI forecasts.

Table 25

Impact of the Third Harbor Tunnel: Share Model Versus the Boston Model for Production Cost

Industrial Sector	Year			
	1991	1992	1993	1994
<u>Share Model</u>				
Durables	2.19	2.19	2.20	2.20
Nondurables	2.20	2.21	2.21	2.21
Mining	4.80	4.81	4.82	4.83
Construction	2.97	2.96	2.96	2.95
Transportation	2.36	2.36	2.36	2.37
Finance	2.37	2.38	2.38	2.38
Retail Trade	2.42	2.42	2.43	2.43
Wholesale Trade	2.39	2.39	2.40	2.40
Services	2.74	2.74	2.75	2.75
Agriculture	2.95	2.96	2.96	2.96
<u>Boston Model</u>				
Durables	2.18	2.19	2.19	2.20
Nondurables	2.18	2.19	2.19	2.19
Mining	4.40	4.36	4.32	4.27
Construction	2.86	2.86	2.87	2.87
Transportation	2.32	2.33	2.33	2.34
Finance	2.33	2.33	2.34	2.34
Retail Trade	2.36	2.36	2.37	2.37
Wholesale Trade	2.33	2.33	2.34	2.34
Services	2.72	2.73	2.74	2.75
Agriculture	2.90	2.91	2.92	2.93

Table 25 (continued)

Impact of the Third Harbor Tunnel: Share Model Versus the Boston Model for Production Cost

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	1.00	1.00	1.00	1.00
Nondurables	1.01	1.01	1.01	1.01
Mining	1.09	1.10	1.12	1.13
Construction	1.04	1.04	1.03	1.03
Transportation	1.02	1.01	1.01	1.01
Finance	1.02	1.02	1.02	1.02
Retail Trade	1.03	1.03	1.02	1.02
Wholesale Trade	1.03	1.03	1.02	1.02
Services	1.01	1.01	1.00	1.00
Agriculture	1.02	1.02	1.01	1.01

Source: Figures for the Share model and for the Share model as a percentage of the Boston model are author's calculations based on REMI forecasts. Figures for the Boston model are from REMI.

Table 26

Impact of the Third Harbor Tunnel: Share Model versus the Boston Model for Regional Demand (billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
<u>Share Model</u>				
Durables	22.53	23.50	24.72	25.69
Nondurables	12.57	12.58	12.64	12.61
Mining	1.19	1.20	1.22	1.24
Construction	2.94	2.97	3.00	3.02
Transportation	6.40	6.48	6.59	6.65
Finance	13.54	13.85	14.26	14.57
Retail Trade	7.58	7.69	7.83	7.92
Wholesale Trade	4.39	4.46	4.58	4.64
Services	14.02	14.32	14.74	15.01
Agriculture	0.29	0.29	0.30	0.31
Total	85.4	87.4	89.9	91.7
<u>Boston Model</u>				
Durables	24.79	26.39	28.34	30.02
Nondurables	13.35	13.55	13.79	13.95
Mining	1.27	1.31	1.36	1.40
Construction	3.11	3.18	3.27	3.34
Transportation	7.00	7.23	7.50	7.70
Finance	11.26	11.24	11.33	11.34
Retail Trade	7.83	8.01	8.24	8.41
Wholesale Trade	4.91	5.12	5.39	5.60
Services	14.60	15.08	15.69	16.16
Agriculture	0.29	0.30	0.31	0.32
Total	88.4	91.4	95.2	98.2

Table 26 (continued)

Impact of the Third Harbor Tunnel: Share Model versus the Boston Model for Regional Demand
(billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	0.91	0.89	0.87	0.86
Nondurables	0.94	0.93	0.92	0.90
Mining	0.93	0.92	0.90	0.89
Construction	0.95	0.93	0.92	0.91
Transportation	0.91	0.90	0.88	0.86
Finance	1.20	1.23	1.26	1.29
Retail Trade	0.97	0.96	0.95	0.94
Wholesale Trade	0.89	0.87	0.85	0.83
Services	0.96	0.95	0.94	0.93
Agriculture	0.98	0.97	0.96	0.95

Source: Figures for the Share model and for the Share model as a percentage of the Boston model are author's calculations based on REMI forecasts. Figures for the Boston model are from the REMI forecasts.

Table 27

Impact of the Third Harbor Tunnel: Share Model Versus the Boston Model for Regional Output (billions of 1977 dollars)

Industrial Sector	Year 1991	1992	1993	1994
<u>Share Model</u>				
Durables	27.24	28.41	29.92	31.10
Nondurables	7.67	7.69	7.74	7.74
Mining	0.36	0.37	0.37	0.38
Construction	2.74	2.77	2.80	2.82
Transportation	6.00	6.08	6.19	6.26
Finance	10.94	11.20	11.52	11.75
Retail Trade	6.97	7.08	7.23	7.33
Wholesale Trade	5.34	5.43	5.57	5.66
Services	17.06	17.44	17.95	18.29
Agriculture	0.33	0.34	0.35	0.36
Total	84.6	86.8	89.7	91.7
<u>Boston Model</u>				
Durables	29.48	31.25	33.42	35.17
Nondurables	8.04	8.13	8.26	8.34
Mining	0.42	0.44	0.45	0.47
Construction	2.91	2.99	3.06	3.13
Transportation	6.48	6.65	6.86	7.02
Finance	10.66	10.96	11.32	11.61
Retail Trade	7.18	7.35	7.57	7.73
Wholesale Trade	5.79	6.01	6.29	6.51
Services	17.62	18.19	18.88	19.41
Agriculture	0.35	0.36	0.38	0.39
Total	88.9	92.3	96.5	99.8

Table 27 (continued)

Impact of the Third Harbor Tunnel: Share Model Versus the Boston Model for Regional Output (billions of 1977 dollars)

Industrial Sector	Year			
	1991	1992	1993	1994
Share Model as a <u>Percentage of Boston Model</u>				
Durables	0.92	0.91	0.90	0.88
Nondurables	0.95	0.95	0.94	0.93
Mining	0.85	0.84	0.82	0.81
Construction	0.94	0.93	0.91	0.90
Transportation	0.93	0.91	0.90	0.89
Finance	1.03	1.02	1.02	1.01
Retail Trade	0.97	0.96	0.96	0.95
Wholesale Trade	0.92	0.90	0.89	0.87
Services	0.97	0.96	0.95	0.94
Agriculture	0.96	0.95	0.94	0.92

Source: Figures for the Share models and for the Share model as a percentage of the Boston model are author's calculations based on REMI forecasts. Figures for the Boston model are from the REMI forecasts.

would have to be huge to affect the relative differences of levels. We do not have time to investigate this point further; however, our present results indicate that the simple share model forecasts nearly the same levels as the Boston model.

To summarize our findings in a more compact way, we will use three difference measures. They are the mean absolute difference (MAD), the root mean square difference (RMSD), and the mean absolute percentage difference (MAPD).[4] The MAD is the average of the absolute values of the differences. It is defined mathematically as follows:

$$MAD = sum[abs(A - B)]/n \qquad (12)$$

where

sum = the summation operator (we sum across years);

abs = the absolute value operator;

A = value from model A;

B = value from model B; and

n = number of years.

We use the term "penalize" to represent the cost of the size of the difference. This measure, therefore, penalizes proportional to the absolute size of the difference. In other words, we are weighing differences equally.

The RMSD is the square root of the average of the squared values of the differences. Mathematically, it is defined as follows:

$$RMSD = \{[sum(A - B)^2]/n\}^{0.5}. \qquad (13)$$

Appropriate definitions from equation (12) apply here. This

[4] In econometric literature, difference measures are referred to as forecast error measures. Forecast error measures are a special case of difference measures; they quantify the difference between actual values and forecasted values. Econometricians refer to this difference as the error. The principles for measuring differences are the same, but the interpretation of the difference is not. In this section and in the next, we reference an econometric text for general information. The reader should remember that we are not using the econometrician's interpretation of the difference.

measure penalizes more for larger differences. It weights large differences more heavily than small ones. This measure is also known as the "quadratic loss function," and it is the most popular measure used when measuring differences accuracy (Kennedy, 1981, p. 206).

Finally, the MAPD is the average of the absolute values of the percentage differences. Its mathematical definition follows:

$$MAPD = sum[abs(A - F)/A]/n. \qquad (14)$$

Likewise, appropriate definitions from equation (12) apply here. This measure penalizes relative to the percentage difference as opposed to the numerical size of the difference. This measure, thus, has the advantage of being dimensionless. In the next section, we will use these measure to analyze differences between two sets of forecast results.

These measures summarize across years. Recall that a distinction between the MAD and the RMSD is that the RMSD penalizes for individually large differences, while the MAD does not. When the value of the RMSD is larger than the value of the MAD, this implies that differences across years are not uniform. In Table 28, we list the MAD and the RMSD for the variables. For the totals of the variables, the MAD and the RMSD are approximately equal except for employment. The difference between the two measures for employment is approximately 2; this is small. Thus, the MAD and the RMSD show that differences between forecasts from the Share model and forecasts from the Boston model are uniform.

Focusing now on the last measure, recall that the MAPD quantifies average differences in terms of percentages. Using the MAPD, we show that the average percentage differences for the totals of the variables are less than 10, implying that forecasts from the Share model are close in value to forecasts from the Boston model. Looking across industrial sectors, however, it is clear that the average percentage difference is sometimes greater than 10. This occurs for all variables expect production costs. It occurs most for regional demand.

To reiterate our basic findings, the ratios of the forecasts for the totals of the variables are well within the acceptance region. Across industrial sectors, the ratios are mostly within the acceptance region for total private nonfarm employment, production costs, and regional output. The Share model does not perform as well, by sector, for regional demand. We could improve the performance of the Share model if we account for the expected shifts in Metropolitan Boston's share in the state economy. In conclusion, using a simple method to convert the forecasts from the Massachusetts model to Boston equivalents produces forecasts that are close in value to figures predicted by the Boston model; therefore, if the analyst is under a budget constraint or is unable to purchase a substate model, then, in the case of Massachusetts, the analyst could scale the forecasts from the Massachusetts

Table 28

Difference Measures

Industrial Sector	MAD	RMSD	MAPD
<u>Total Private Nonfarm Employment</u>			
Durables	26.4	26.7	8
Nondurables	6.5	6.7	6
Mining	0.2	0.2	13
Construction	6.2	6.3	6
Transportation	6.1	6.1	6
Finance	10.6	11.2	5
Retail Trade	18.9	19.3	4
Wholesale Trade	15.5	15.8	10
Services	19.2	20.8	2
Agriculture	1.0	1.1	8
Total	110.6	113.7	5
<u>Production Costs</u>			
Durables	0.0	0.0	0
Nondurables	0.0	0.0	1
Mining	0.5	0.5	9
Construction	0.1	0.1	3
Transportation	0.0	0.0	1
Finance	0.0	0.0	2
Retail Trade	0.1	0.1	3
Wholesale Trade	0.1	0.1	2
Services	0.0	0.0	1
Agriculture	0.0	0.0	2
Total	0.8	0.8	3

Table 28 (continued)

Difference Measures

Industrial Sector	MAD	RMSD	MAPD
<u>Regional Demand</u>			
Durables	3.3	3.4	11
Nondurables	1.1	1.1	7
Mining	0.1	0.1	8
Construction	0.2	0.2	7
Transportation	0.8	0.8	10
Finance	2.8	2.8	23
Retail Trade	0.4	0.4	4
Wholesale Trade	0.7	0.8	13
Services	0.9	0.9	5
Agriculture	0.0	0.0	3
Total	4.7	4.9	4
<u>Regional Output</u>			
Durables	3.2	3.2	9
Nondurables	0.5	0.5	5
Mining	0.1	0.1	16
Construction	0.2	0.2	7
Transportation	0.6	0.6	9
Finance	0.2	0.2	2
Retail Trade	0.3	0.3	4
Wholesale Trade	0.7	0.7	10
Services	0.8	0.9	4
Agriculture	0.0	0.0	5
Total	6.2	6.3	6

Source: Author´s calculations, based on REMI forecasts.

model to represent Boston´s share in the state economy and obtain figures that are close in value to figures predicted by the Boston model.

Chapter 6

Conclusions

In this thesis, we investigated the differences in forecasts from the Share model and the Boston model. Given the high cost of the Boston model and the unavailability of this type of substate model in other states, we wanted to investigate how different are the forecasts from a simple share model (derived from the Massachusetts model) versus the forecasts from a more sophisticated substate model that is specifically designed for the substate. We began by considering two cases. In both cases the analyst already owned the state model. In the first case, however, the issue for the analyst was the cost of the model and in the second case the issue for the analyst was the availability of the model.

To make the comparison between the two sets of forecasts, we selected a construction project that would have major impacts on the Metropolitan Boston economy (the Third Harbor Tunnel). Before using the Massachusetts and Boston models to predict the impacts, we adjusted the control forecasts for each model. We carefully documented our procedure in Chapter 4. After making the adjustments, we ran the models to predict the impacts of the project. Then, we scaled the forecasts from the Massachusetts model to represent Boston's share. Using this representation, we compared it to forecasts from the Boston model. In comparing the two sets of forecasts, we found that the differences for the totals of the variables were less than 7 percent. Across the industrial sectors for the variables, we found that the differences were less than or equal to 10 percent. For regional demand, however, some differences were larger than 10 percent: Finance (23 percent), wholesale trade (13 percent), and durables (11 percent). Where large forecast differences occurred, they, primarily, were a result of the assumptions built into the Boston model relative to the assumptions built into the Massachusetts model, as we noted earlier. In using the Massachusetts model, we cannot derive anticipated shifts in Boston's share of Massachusetts because the Massachusetts model does not give information about subregions within the state; its predictions are for the state economy as a whole. Therefore, the simple Share model will not predict shifts in Boston's share of Massachusetts.

In light of the Share model's inability to predict shifts, its performance, in general, is good. Therefore, for the case of Massachusetts and for other states that have similar economic, political, and geographic structures, if the analyst could not obtain the substate model either due to a financial constraint or due to the unavailability of the model, this analyst could use the state model to predict the impacts and, then, convert the predictions to Metropolitan Boston equivalents. The analyst could improve the predictions of the impacts for the substate by incorporating additional information about anticipated shifts in the substate's share of the state economy.

There are still other areas of the analysis that need further investigation. To extend the analysis of this thesis, we would first adjust the policy forecasts for exogenous employment creation in construction and in engineering to employment targets. Second, we would account for the expected shifts in Boston's share of Massachusetts. We would essentially form a Shift-Share model. Third, we would compare forecasts from the Shift-Share model to forecasts from the Boston model in terms of differences, that is, the forecasts of the policy impact minus the control forecasts; in the analysis, we only compared the two sets of forecasts in terms of levels. Finally, we would include other variables to broaden the analysis.

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