Regional Economic Modeling:

A Systematic Approach to Economic Forecasting and Policy Analysis

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CHAPTER 2

ECONOMIC BASE MODELS[1]

Regional models cover a wide range of sizes and employ a variety of techniques in their calibration and estimation. They can be divided into two groups. The first group is composed of *nonstructural models*. Their use includes predictions based on past trends, analysis of regional changes based on national industry changes, and shifts in the local share of these national industries. This group also may employ statistical methods, which search for past regularities in regional data. The second group of models are called *structural models*, because these models include the cause-and-effect relationships in a regional economy. The relationships that explain how participants in the economy respond to changes that affect them, such as the change in consumption that would occur if income changes, are called *behavioral relationships*. Other types of relationships in a structural model would include *definitional* and *technical relationships*.

Since our focus is on how changes in policy, which often involve structural changes, affect a regional economy, we concentrate on structural models. These models range in complexity from those including two or three relationships, to those including thousands of equations. We start with the simplest structural model.

In this chapter, we consider only single-sector models that have fixed prices, wages, and input requirements. These models also assume that all inputs are available in the quantities required. In later chapters, we drop these assumptions in favor of more realistic relationships.

Our first step toward understanding a regional economy is to identify essential economic phenomena that we want to measure and predict. Measured aspects of economic phenomena are called *economic variables*.

We assume that certain variables, called *exogenous* variables, have values that are determined outside of the regional economy. All other variables, called *endogenous* variables, are determined within the economy. We can then develop causal relationships among the variables in the model. To quantify these relationships, we use historical data to estimate *parameters* that are used in the equations of our model to show the magnitude of the causal relationships. The model can then be used to carry out a baseline forecast, as shown in diagram 2-1.

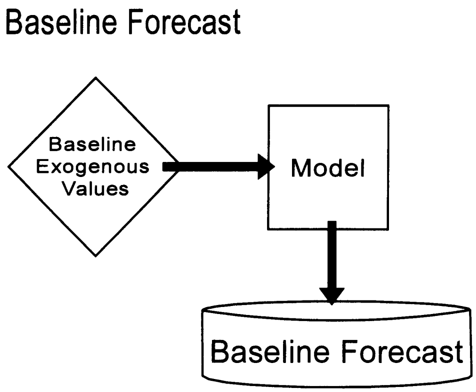


Diagram 2-1

In order to generate the *baseline* or *control* forecast, values for all of the exogenous variables need to be specified. The computer program solves the model to find the unique set of values for the endogenous variables that are consistent with the relationships and parameters in the model, as well as the values of the exogenous variables.

To analyze a particular policy question, the next step is to introduce a change in an exogenous variable or in the structure of the model. This can be accomplished either directly or through *policy variables* that are incorporated in the model program. These policy variables take on a default value of zero in the control forecast if they are additive, or a value of one if they are multiplicative. Thus, at their default values,

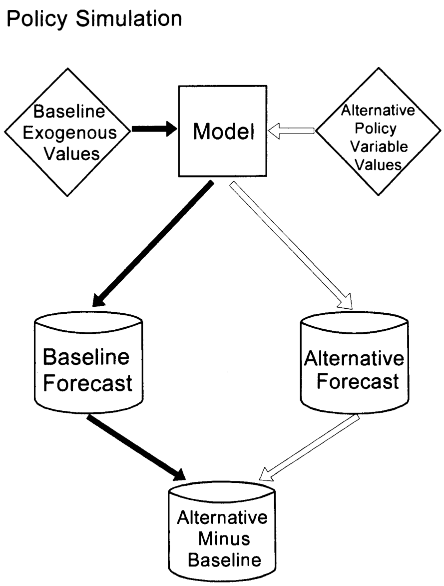


Diagram 2-2

they do not affect the forecast. Alternative values for the policy variables are used as inputs into the alternative forecast. Then, with these new inputs and the baseline exogenous values, the model program generates a complete new set of values for the endogenous variables, as illustrated in diagram 2-2. By subtracting the baseline from the alternative, we find the effect of the policy. This means of producing an alternative forecast is called *policy simulation.*

2-1 ASSUMING INCOME EQUALS OUTPUT

The first task in regional modeling is defining the subnational area to be modeled. Each area is considered to be a point, and spatial location within it is not considered. Thus, each area should be defined to be the smallest geographical area of interest. In the case where a larger geographical entity is also of interest, subareas may be linked in a multi-area model.

A Closed Economy

We begin our model building by defining and showing the accounting relationships among some key economic variables. We start with a simple account for a closed economy that ignores many of the income flows in the real world. As a starting point, we simplify our presentation by assuming that our regional economy is self-sufficient. By way of example, the accounts for a closed economy are shown in table 2-1, although it would be virtually impossible for such an economy to exist.

TABLE 2-1

Income and Product Accounts for a Simplified Closed State Economy

A. State Product Account		**B. Personal and Local Government Income and Outlay Account**	
Uses	*Sources*	*Uses*	*Sources*
Y (output)	**CG** (consumption and local government spending)	**CG** (consumption and local government spending)	**Y** (output)
	IL (local investment)	**S** (personal savings and local government surplus)	
Y	**Y**	**Y**	**Y**

C. Savings and Investment Account

Uses	*Sources*
IL (local investment)	**S** (personal savings and local government surplus)
IL	**S**

Y Total state output of goods and services: gross state product (GSP) or gross regional product (GRP)

CG Total state use of goods and services for consumption, and local (including state) government spending

S Local savings by individuals, and local (including state) government surplus

IL Residential and nonresidential construction, new equipment purchases, and inventory changes within the state.

For the time being, we ignore government taxes and transfers, imports and exports, and other economic flows in the accounts. We will include these as we develop our model. The accounts can be represented in equation form. From account A, we have

$$Y = CG + IL, \tag{2-1}$$

where the income earned in the region (Y) comes from sales to the investment sector (IL) and to consumers and local government (CG). From account B, we have

$$Y = CG + S, \tag{2-2}$$

where income (Y) can be spent by consumers and local government (CG) or can be saved by individuals and local governments (S). Setting equation 2-1 equal to equation 2-2 gives us the equation for account C,

$$IL = S, \tag{2-3}$$

in which all local investment (IL) is equal to savings (S), and all savings are used for local investment. Savings could be negative if individuals and local governments are spending more than is earned in the state (CG > Y). In this case, local investment (IL) would also be negative. This would be possible in a closed economy only if inventory reduction exceeds new fixed investment.

An Open Economy

To convert the closed accounts to an open economy, we include imports and exports in the accounts. Savings and investment can now originate or be used in the rest of the country. We are able to develop an account for the rest of the country that shows the interactions between the state and the outside world.

TABLE 2-2

Income and Product Accounts for a Simplified Open State Economy

A. State Product Account		**B. Personal and Local Government Income and Outlay Account**	
Uses	*Sources*	*Uses*	*Sources*
Y (output)	**CG** (consumption and local government spending)	**CG** (consumption and local government spending)	**Y** (output)
	IL (local investment)	**S** (personal savings and local government surplus)	
	XFG (exports including federal government)		
	- M (imports)		
Y	**Y**	**Y**	**Y**

C. Savings and Investment Account		**D. Rest of Country Account**	
Uses	*Sources*	*Uses*	*Sources*
IL (local investment)	**S** (personal savings and local government surplus)	**XFG** (exports including federal government)	**M** (imports)
IR (investment, rest of country)			**IR** (investment, rest of country)
I	**S**	**XFG**	**XFG**

XFG Sales outside of the state of goods produced within the state. This includes federal government spending in the local area.

M Purchases within the state of goods and services produced outside of the state.

IR Investment in the rest of the country from the state (a negative value indicates a net flow of rest of country investment into the state).

We can see the difference between a closed and an open economy by comparing the accounts in tables 2-1 and 2-2. Account 2-1A gave us the state product equation for a closed economy (Y = CG + IL) in which exports and imports are equal to zero. In an open economy, a state imports part of its consumption and exports part of its production. Thus, account A from table 2-2 gives us

$$Y = CG + IL + XFG - M. \qquad (2\text{-}4)$$

Output in the state is equal to the value of locally produced goods and services. Consumer and local government spending (CG), local investment (IL), and sales outside of the state (XFG) represent the final sales of the state. To find the value of locally produced goods and services, we must subtract imports (M) from this amount, since part of the final sales of the state are produced outside of the state.

Net exports (XFG - M) can have a negative value within the accounts. From this account, we can see that in an open economy output (Y) can be smaller than CG + IL, as long as imports (M) exceed exports (XFG).

The uses of income in account B are the same in the open economy as in the closed economy.

$$Y = CG + S, \qquad (2\text{-}5)$$

or

$$S = Y - CG. \qquad (2\text{-}6)$$

In this account, all output (Y) is assumed to go to households and local government as income (Y).[2] It is then spent for personal or local government use (CG), or it is saved in the form of personal savings and government surpluses (S). Again, federal government taxes, transfers, and spending are implicitly assumed to be zero and are not considered until later in the chapter. Meanwhile, we define all income (Y) that is not used for personal consumption or local government spending (CG) to be equal to savings (S).

In our closed-economy example, all savings are invested locally. In an open economy, savings can be invested locally or in the rest of the country. By including investment in the rest of the country (IR), the closed-economy investment account (IL = S) is converted to the open-economy investment account.

$$I = S = IL + IR, \tag{2-7}$$

or

$$IL = S - IR. \tag{2-8}$$

In an open economy, personal savings and local government surpluses (S) can be invested either locally (IL) or outside of the local area (IR). Local investment (IL) can also exceed local savings (S), if investment in the rest of the country is negative. In other words, if investment in the locality is larger than the amount of local savings, we know that the rest of the country is funding investment in the locality.

We can now develop an account that shows the interactions that the rest of the country has with the region. Account D gives us the equation.

$$XFG = M + IR, \tag{2-9}$$

or

$$IR = XFG - M. \tag{2-10}$$

In this simplified economy, the earnings gained from exports (XFG) are directly or indirectly spent on imports (M) or investment in the rest of the country (IR). The investment in the rest of the country (IR) is therefore equal to the difference between exports (XFG) and imports (M). Regions with positive net exports ($XFG - M > 0$) will be experiencing a flow of their savings to the rest of the country to finance investment outside of the region. On the other hand, regions with more imports than exports will be financed by savings from the rest of the country.[3]

Before continuing, we look at estimated values for the variables in this model for a representative state. Using methods that are covered later, the following accounts are estimated for Michigan.

TABLE 2-3

Estimated Income and Product Accounts for Michigan in 1977

A. State Product Account

Uses		*Sources*	
Y	80.8	**CG**	65.0
		IL	16.2
		XFG	83.7
		- **M**	84.1
	80.8		80.8

B. Personal and Local Government Income and Outlay Account

Uses		*Sources*	
CG	65.0	**Y**	80.8
S	15.8		
	80.8		80.8

C. Savings and Investment Account

Uses		*Sources*	
IL	16.2	**S**	15.8
IR	-0.4		
	15.8		15.8

D. Rest of Country Account

Uses		*Sources*	
XFG	83.7	**M**	84.1
		IR	-0.4
	83.7		83.7

It may surprise you to find that exports (XFG = 83.7) are greater than total gross state product, or GSP (Y = 80.8). The reason that this is possible is that GSP (Y) is a measure of the total value added to production in Michigan. For example, when a car is produced, the value added in Michigan is equal to the sales price of the car minus the intermediate inputs into production. Many of these intermediate inputs are imported into the state. In contrast, exports are valued at their total final sales price.

Account B assumes that all GSP is available for consumption by individuals and local government. The difference between this spending and GSP is savings (S). The savings and investment account (account C) indicates that a small part of local investment (IL) was financed by a net flow from the rest of the country. In any case, these accounts give a simple view of a state economy, which we enhance when we assemble a more comprehensive set of accounts later in the chapter.

Returning to our accounts, we can show the internal consistency of the accounts by substituting equation 2-6 and equation 2-10 into equation 2-8.

$$IL = Y - CG - XFG + M \tag{2-11}$$

Rearranging this gives us

$$Y = IL + CG + XFG - M, \tag{2-12}$$

which is the same as equation 2-4. Therefore, our four basic equations are

$$Y = CG + IL + XFG - M \tag{2-13}$$

$$Y = CG + S \tag{2-14}$$

$$S = IL + IR \tag{2-15}$$

$$XFG = M + IR \tag{2-16}$$

We can now express local investment as planned local investment (IL_p) and unplanned investment (IL_{up}), which are defined as follows:

$$IL = IL_p + IL_{up} \tag{2-17}$$

IL_p local planned investment: local residential and nonresidential construction, new equipment purchases, and planned changes in inventory. Planned inventory changes are equal to zero in steady state.

IL_{up} local unplanned investment: unplanned changes in inventories, usually caused by failure to set output equal to sales.

This distinction will be useful as a way to allow for a difference between output and demand as we develop our model. Our accounting identities can now be shown as

$$Y = CG + IL_p + IL_{up} + XFG - M \quad (2\text{-}18)$$

$$Y = CG + S \quad (2\text{-}19)$$

$$S = IL_p + IL_{up} + IR \quad (2\text{-}120$$

$$XFG = M + IR \quad (2\text{-}21)$$

An Economic Base Model

The accounts give us definitional interrelationships among the variables that we are examining. This, however, does not tell us how a change in one variable affects the other variables. To build a model for simulations and forecasts, we must develop behavioral relationships between the variables.

First, we choose the exogenous variables (i.e., those that are determined outside the model). As explained previously, the remaining variables are the endogenous variables. Each must be explained by an equation in the model. All equations in the model are solved simultaneously; thus, all endogenous variables are interrelated. After we develop the model, we will then be able to make a forecast or carry out a simulation. A simulation is accomplished by changing the exogenous variables or relationships in the model and evaluating the changes in the endogenous variables.

Our task now is to develop a model that includes all of the variables in the economy that are defined by our accounts. We consider IL_p and XFG to be exogenous.[4] It seems reasonable to assume that planned investment and exports depend on factors determined outside of the local economy, at least in the short run. For example, exports may depend on demand in the rest of the country and world for the commodities produced in the region, while local investment may be due to decisions made in the last few years.

The remaining variables in our accounts, Y, CG, IL_{up}, IR, M, and S, are endogenous variables. All endogenous variables of interest must be explained within the model, either by a behavioral relationship or by an accounting identity.

Total planned purchases (PP) of goods and services produced in the area are

$$PP = CG + IL_p + XFG - M \tag{2-22}$$

Note that PP is less than total purchases made in the area because imports are subtracted from total spending. This is due to the fact that some portion of spending by residents and by purchasers of exports is supplied with imported goods. In the case of exports, this occurs because imported intermediate inputs are used in their production.

In the following equation, we assume that the same proportion of all types of purchases are satisfied by imports.

$$M = mCG + mIL_p + mXFG, \tag{2-23}$$

where m is the proportion of export and local demand supplied by imported content.

Substituting equation 2-23 into equation 2-22 and simplifying, we obtain

$$PP = (1 - m)\,CG + (1 - m)\,IL_p + (1 - m)\,XFG. \tag{2-24}$$

If we now define the parameter r as

$$r = 1 - m, \tag{2-25}$$

then r becomes the proportion of local and export planned purchases that is supplied locally. Substituting equation 2-25 into equation 2-24, we obtain

$$PP = rCG + rIL_p + rXFG. \tag{2-26}$$

We further simplify the notation by defining the net economic base (BN) and the gross economic base (BG), as follows:

$$BN = rIL_p + rXFG = rBG, \text{ where} \tag{2-27}$$

$$BG = IL_p + XFG. \tag{2-28}$$

Substituting equation 2-27 into equation 2-26, we obtain

$$PP = rCG + BN \tag{2-29}$$

Next, we assume that local personal and government consumption (CG) is some proportion (b) of total gross state (regional) product.

$$CG = bY \tag{2-30}$$

We can complete the model by assuming that businesses produce what they can sell. This means that they do not have any change in their inventories, so our assumption is equivalent to assuming that they act to keep $IL_{up} = 0$. The equation that represents both of these assumptions is

$$Y = PP. \tag{2-31}$$

The equations of the model can be summarized in the order in which they appear in the computer program. This program is available to accompany this book.

$$Y = PP \tag{2-32}$$

$$CG = bY \tag{2-33}$$

$$BN = rBG \tag{2-34}$$

$$PP = rCG + BN \tag{2-35}$$

$$IL_{up} = Y - PP \tag{2-36}$$

When stated in this form, it is obvious from equation 2-32 and equation 2-36 that, at equilibrium (i.e., a simultaneous solution for all of the equations), unplanned inventory change IL_{up} will equal zero.

Returning to our specific example for Michigan from equation 2-30, we could estimate b as

$$b = \frac{CG}{Y} = \frac{65}{80.8} = .804 \tag{2-37}$$

Likewise, from equations 2-26 and 2-31, we could estimate r as

$$r = \frac{Y}{CG + XFG + IL_p} = \frac{80.8}{65 + 83.7 + 16.2} = .490 \tag{2-38}$$

This would enable us to rewrite equations 2-27, 2-29, and 2-30 in the explicit forms

$$BN = 0.49\ BG \tag{2-39}$$

$$PP = .49\ CG + BN \tag{2-40}$$

$$CG = .804\ Y \tag{2-41}$$

$$Y = PP. \qquad (2\text{-}42)$$

Substituting equation 2-30 into 2-29 and using 2-31, we obtain

$$Y = PP = (rb)\, Y + BN \qquad (2\text{-}43)$$

where *rb* is the fraction of Y that is used for locally produced consumption and local government spending. This is obtained when *b*, the proportion of income Y that is spent, is multiplied by the proportion of this spending that is met by locally produced goods (*r*). Output (Y) is expressed as a function of BN (exports (*r*XFG) + local planned investment (rIL_p)) and the part of Y that is used for local consumption and local government spending [(*rb*)Y]. Note that Y changes if the value of the economic base (BN) changes. When Y increases, (*rb*)Y also increases, further increasing Y, increasing Y again, etc. This is called *induced demand,* or the demand created by the respending of income gained due to changes in output.

We can obtain the explicit form of equation 2-43 by substituting equation 2-41 into equation 2-40.

$$PP = .804\,(.49)\, Y + BN = .394\, Y + BN \qquad (2\text{-}44)$$

Using this equation and equation 2-31, we can also find the value of BN for 1977 in Michigan.

$$BN = 80.8 - 0.394\,(80.8) = 48.96 \qquad (2\text{-}45)$$

From equation 2-39 and the value for BN, we can determine that

$$BG = 48.96/0.49 = 99.92 \qquad (2\text{-}46)$$

A Diagrammatic Representation of the Economic Base Model

The model presented previously is represented graphically in diagram 2-3. The equilibrium output, at which output is equal to planned purchases, is at the intersection of the 45-degree line (Y = PP) and the line showing planned purchases (PP = *rb*Y + BN) at the equilibrium

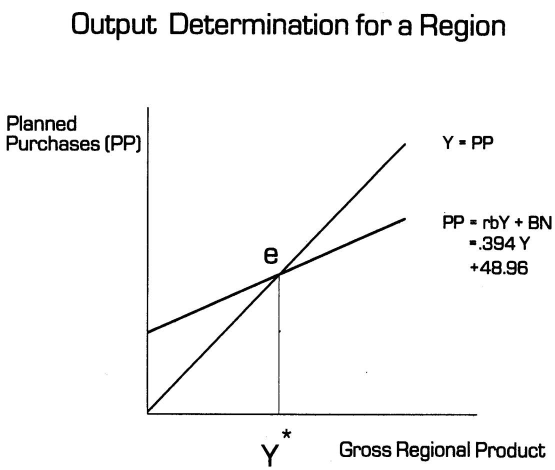


Diagram 2-3

Y*. Since we are only at equilibrium when local output is equal to expenditures on local output, the 45-degree line is used to graphically represent all of the points where the value along the vertical axis is equal to the value along the horizontal axis. The equilibrium is achieved when producers have no reason to increase or decrease their output. Since it is exactly equal to what they can sell (i.e., $IL_{up} = 0$), this must be along the 45-degree line.[5]

The equilibrium must also be on the expenditure on local output line, defined by PP = *rb*Y + BN (from equation 2-43). The points along this line represent the planned purchases of local output that would take place at given levels of output (Y).

The intersection of these two lines gives the actual equilibrium of local output (Y) and of expenditures for local goods and services purchased in the locality (PP). This intersection shows the actual amount of production and expenditure that occurs when all of the behavioral assumptions of the model are fulfilled simultaneously. Diagram 2-4 illustrates how this equilibrium is achieved.

Suppose that the demand were at point *a* with planned purchases PP** and output Y**. Point *b* would represent the rate of output on the vertical axes. Then, we would observe an excess of PP over output of *a-b* at an annual rate. Initially, this causes decreasing inventories ($IL_{up} < 0$). Production is increased by businesses to stem the loss of inventory. This moves output to an equilibrium (*e*) on the 45-degree line, where inventory no longer changes and producers have no incentive to increase or decrease production.

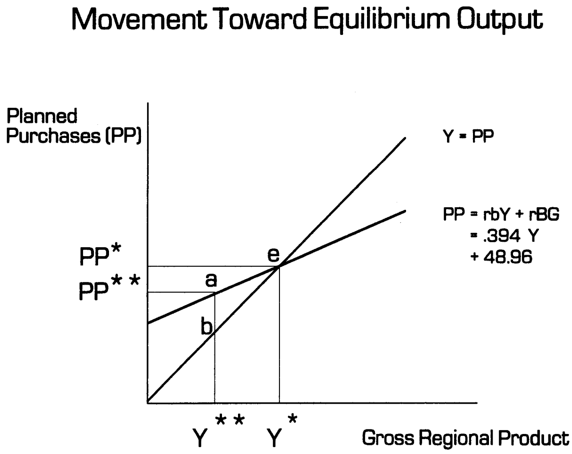


Diagram 2-4

We can represent the situation at Y** by assuming that output (Y) may momentarily be different than planned purchases (PP). This situation can be modeled by assuming that output at this moment (*m*) is set, based on sales rate the moment (or day) before (*m* − 1).

$$Y_m = PP_{m-1} \tag{2-47}$$

In this case, inventory change (IL_{upm}) in moment m can be represented as

$$IL_{up,m} = Y_m - PP_m. \tag{2-48}$$

Using the explicit form of the model, which represents the Michigan economy, we can write the following set of equations:

$$Y_m = PP_{m-1} \tag{2-49}$$

$$CG_m = 0.804\ Y_m \tag{2-50}$$

$$BN_m = 0.49\ BG_m \tag{2-51}$$

$$PP_m = 0.49\ CG_m + BN_m \tag{2-52}$$

$$IL_{up,m} = Y_m - PP_m. \tag{2-53}$$

In this model, the subscript m or $m - 1$ has been added to each variable. It shows that all of the variables depend on the values of the other variables at the same moment, except output (Y), which depends on planned purchase (PP) a moment before. As is shown in diagram 2-4, the only exogenous variable in this model is BG.

We know from equation 2-49 that Y_m^{**} is the output rate that was needed to supply planned purchases (PP_{m-1}) in the previous period. Thus, with PP^*_{m-1} and BG_m, we can solve each of the equations (2-49 through 2-53) above in sequence. Suppose that we select an arbitrary value of PP_{m-1}, say 60. Then, from equation 2-49, we know that Y_m will be equal to 60. We will assign Y_m^{**} the value of 60 for the initial period ($m = 0$). Using equations 2-50, 2-51, 2-52, and 2-53 in sequence, we can calculate values for all four endogenous variables in the initial moment ($m = 1$).

$$Y_1\ (60.0) = PP_0\ (60.0) \tag{2-54}$$

$$CG_1\ (48.24) = 0.804\ Y_1\ (60.0) \tag{2-55}$$

$$BN_1\ (48.96) = 0.49\ BG_1\ (99.92) \tag{2-56}$$

$$PP_1\ (72.60) = 0.49\ CG_1\ (48.24) + BN_1\ (48.96) \tag{2-57}$$

$$IL_{up,1}\ (-12.6) = Y_1\ (60.0) - PP_1\ (72.60) \tag{2-58}$$

These calculations locate a, b, and Y** on diagram 2-4. They show that the change of inventory (a-b) will be an annual rate of -12.6. Now, we can find PP* and Y* at point e on diagram 2-4, if we can find a way to calculate values of Y** and PP** that get closer and closer to the Y* and PP* values indicated as e on the graph. This can be accomplished by starting the set of calculations again for iteration $m = 2$ at equation 2-59. This time we use the PP_1 value (72.60). The calculations for $m = 2$ are

$$Y_2\ (72.60) = PP_1\ (72.60) \tag{2-59}$$

$$CG_2\,(58.37) = 0.804\,Y_2\,(72.60) \tag{2-60}$$

$$BN_2\,(48.96) = 0.49\,BG_2\,(99.92) \tag{2-61}$$

$$PP_2\,(77.56) = 0.49\,CG_2\,(58.37) + BN_2\,(48.96) \tag{2-62}$$

$$IL_{up,\,2}\,(-4.96) = Y_2\,(72.60) - PP_2\,(77.56). \tag{2-63}$$

We note that at the end of iteration 2, the value of inventory loss has decreased. This means that we have moved closer to Y*, as shown in diagram 2-5. In this diagram, note how the difference between PP and Y gets smaller after each iteration. By checking this difference, which is also IL_{up} (unplanned inventory change), we can see how close we are to the equilibrium point. When IL_{up} reaches an arbitrary small number, we say we are at the equilibrium point.

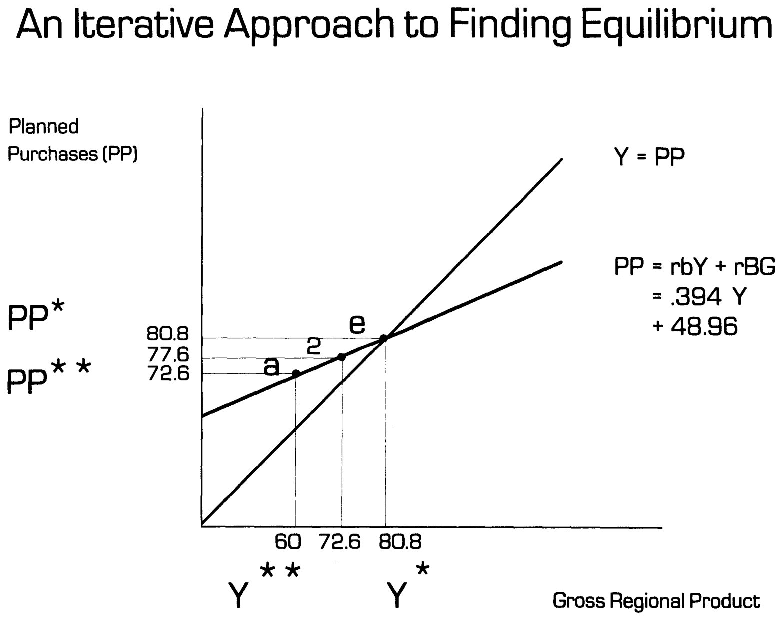


Diagram 2-5

In table 2-4, we show the results of the iteration process at the end of each iteration, as generated with the Regional Economic Modeling System (REMS) computer program that is available with this book. It is clear that IL_{up} gets smaller in absolute value after each iteration, as does the change in Y_m from the previous iteration ($Y_m - Y_{m-1}$). Thus, we can use the size of the change in Y or the size of IL_{up} to decide when we have gotten near enough to the *e* value. If we had started with PP_0, which was larger than P*, the value of *e* would still be the final result, because the absolute value of inventory accumulation at every point above *e* will become smaller after each iteration. The results from a solution using 100 as the starting value are shown on table 2-5. In this case, you will note that IL_{up} is positive, and Y** decreases with each iteration. This table can be reproduced by setting the 1977 initial value of PP at 100 in the "data prep" section in the REMS software.

The iterative process is the algorithm that we use to find the simultaneous solution to all of the equations (i.e., the *e*-value) for each year. It is sometimes called the Gauss-Sidel solution method. The degree of accuracy of the solution can be increased by increasing the number of iterations arbitrarily. It can also be increased by reducing the size of the convergence criteria that is used to test when the difference between PP_{m-1} and Y_m (i.e., the value of IL_{up}) is small enough to assume that equilibrium (*e*) has been reached.

TABLE 2-4

Iterative Solution for an Economic Base Model for 1977

Iteration	Y	PP	CG	BN	IL_{up}
0	60.00000	60.00000	0.00000	0.00000	0.00000
1	60.00000	72.59840	48.24000	48.96080	-12.59840
2	72.59840	77.56167	58.36911	48.96080	-4.96327
3	77.56167	79.51699	62.35958	48.96080	-1.95533
4	79.51699	80.28731	63.93166	48.96080	-0.77032
5	80.28731	80.59079	64.55100	48.96080	-0.30348
6	80.59079	80.71035	64.79500	48.96080	-0.11956
7	80.71035	80.75745	64.89112	48.96080	-0.04710
8	80.75745	80.77600	64.92899	48.96080	-0.01856
9	80.77600	80.78331	64.94391	48.96080	-0.00731
10	80.78331	80.78619	64.94979	48.96080	-0.00288
11	80.78619	80.78733	64.95210	48.96080	-0.00113
12	80.78733	80.78778	64.95301	48.96080	-0.00045

TABLE 2-5

Iterative Solution for an Economic Base Model for 1977

Iteration	Y	PP	CG	BN	IL_{up}
0	100.00000	100.00000	0.00000	0.00000	0.00000
1	100.00000	88.35680	80.40000	48.96080	11.64320
2	88.35680	83.76984	71.03887	48.96080	4.58696
3	83.76984	81.96277	67.35096	48.96080	1.80708
4	81.96277	81.25085	65.89807	48.96080	0.71192
5	81.25085	80.97039	65.32569	48.96080	0.28047
6	80.97039	80.85989	65.10019	48.96080	0.11049
7	80.85989	80.81636	65.01135	48.96080	0.04353
8	80.81636	80.79921	64.97636	48.96080	0.01715
9	80.79921	80.79246	64.96257	48.96080	0.00676
10	80.79246	80.78980	64.95714	48.96080	0.00266
11	80.78980	80.78875	64.95500	48.96080	0.00105
12	80.78875	80.78834	64.95415	48.96080	0.00041

Baseline and Alternative Forecasts

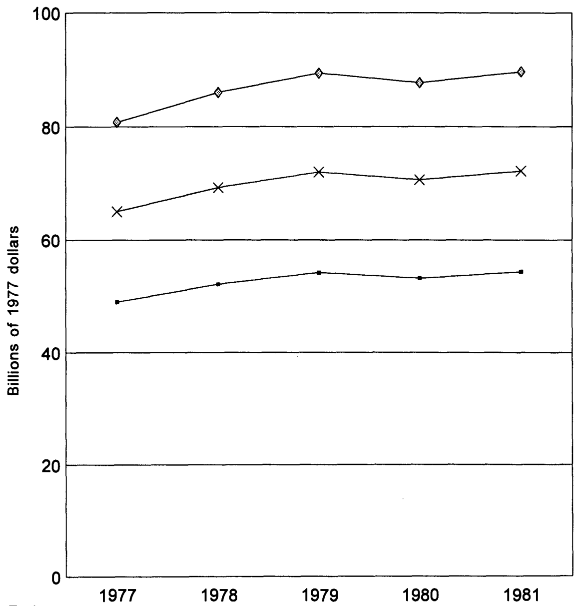
To obtain a baseline forecast covering a number of years, the values of BG_t (where *t* indicates the year) need to be predicted. In the program to solve this model, it is most convenient to use the values of the last year as the starting point for the next year's solution. A computer program to carry this out, as well as other programs shown in this book, are available from the author on a diskette for an IBM-compatible PC. You should try these out on your computer. We extend the exogenous variable (BG_t) forward. In this case, we use changes given in the United States Index of Durable Goods production, since Michigan exports depend heavily on durable goods, to "predict" the changes in the Michigan BG value from 1977 through 1982. This index[6] and the values of BG, if it had moved as the United States durable goods industrial production index did, are shown on table 2-6.

TABLE 2-6

"Prediction" of Michigan's Economic Base Using United States Durable Goods Industrial Production Rates of Change

Durable Goods	1977	1978	1979	1980	1981	1982
U.S. Industrial Production Index	100	106.5	110.7	108.6	111.0	103.1
Michigan Predicted BG	99.92	106.4	110.6	108.5	110.9	103.0

A Simple Michigan Economic Base Model Control Forecast



Endogenous	1977	1978	1979	1980	1981
Y -◇-	80.787	86.026	89.422	87.726	89.665
PP	80.788	86.027	89.423	87.726	89.665
CG -✳-	64.953	69.165	71.896	70.532	72.09
BN -▪-	48.961	52.136	54.194	53.165	54.341
ILu	0	-0.001	0	0.001	-0.001

Diagram 2-6

Using these projected values, the model can generate the baseline "forecast" shown on diagram 2-6. Note that behind the equilibrium values for each year was an iterative process to find these values. The iterations required and the values of the variables for each iteration are available through your program.

To carry out a policy simulation, we need to consider how a proposed change will alter an exogenous variable or a parameter of the model. Then, we need to make this change and rerun the forecast. The result, obtained by subtracting the control from the alternative forecast, shows the effect of the policy or external change on the local economy. Policy variables can be either multiplicative or additive. The simple economic base model for Michigan can be rewritten to include policy variables as follows:

$$BN = (0.49 \times PVrBGM \times PVrM)(BG + PVBGA) \qquad (2\text{-}64)$$

$$PP = (0.49 \times PVrCGM \times PVrM)\, CG + BN \qquad (2\text{-}65)$$

$$CG = (0.804 \times PVbM)\, Y, \qquad (2\text{-}66)$$

where

Variable	*Default Values*	*Definition*
PVrBGM	= 1	Policy variable for changing the share of gross economic base exports that come from local inputs;
PVrM	= 1	Policy variable for changing the share of gross exports and of local CG that are produced locally;
PVrCGM	= 1	Policy variables for changing the proportions of local CG supplied locally
PVbM	= 1	Policy variable for changing the average and marginal propensity to consume; and
PVBGA	= 0	Policy variable for changing gross exports (BG).

The policy variables ending in M are multiplicative, and the policy variables ending in A are additive. This is reflected in their default values. It is easy to see that when all of the policy variables are at their default values, we have the economic base model that was used to generate the control forecast. However, if we increase the default value for a multiplicative policy variable to 1.02, we will increase the parameter (or exogenous variable) by 2 percent. Likewise, if an additive policy variable is increased by 2, it will have the same effect as increasing the parameter or exogenous variable to which it is attached by 2. Much of the work in performing a policy study involves translating the change caused by a policy into appropriate policy variable changes.

The most common change made is to assume that a policy is successful in increasing economic base activity by enough to generate an amount (say 1) of net economic base output. Thus, to increase the gross economic base output (BG) by this amount, we divide the desired change in BN (1) by r (0.49, in this case) to obtain the change in BG required to produce this change in BN (2.04; i.e., 1.00/0.49 = 2.04). In table 2-7, we show the baseline values, and then alternative values with PVBGA equal to 2.04 from 1977 to 1981. We also show the difference between the control and the alternative for each of the years, indicating our predicted policy effect. The results of this simulation are also shown in diagram 2-7.

A Simple Michigan Economic Base Model Simulation

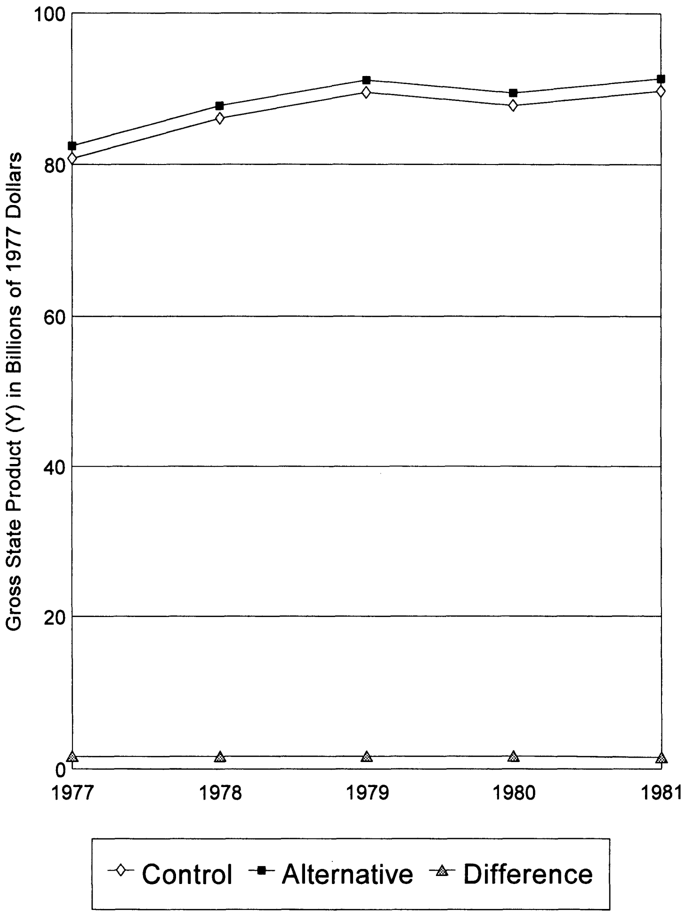


Diagram 2-7

TABLE 2-7

A Forecast and Simulation Using the Michigan Economic Base Model

CONTROL FORECAST

	1977	1978	1979	1980	1981
Policies					
PVbM	1.000	1.000	1.000	1.000	1.000
PVrM	1.000	1.000	1.000	1.000	1.000
PVrBGM	1.000	1.000	1.000	1.000	1.000
PVrCGM	1.000	1.000	1.000	1.000	1.000
PVBGA	0.000	0.000	0.000	0.000	0.000
Endogenous					
Y	80.787	86.026	89.422	87.726	89.665
PP	80.788	86.027	89.423	87.726	89.665
CG	64.953	69.165	71.896	70.532	72.090
BN	48.961	52.136	54.194	53.165	54.341
IL_{up}	0.000	-0.001	0.000	0.001	-0.001

POLICY SIMULATION

	1977	1978	1979	1980	1981
Policies					
PVbM	1.000	1.000	1.000	1.000	1.000
PVrM	1.000	1.000	1.000	1.000	1.000
PVrBGM	1.000	1.000	1.000	1.000	1.000
PVrCGM	1.000	1.000	1.000	1.000	1.000
PVBGA	2.040	2.040	2.040	2.040	2.040
Endogenous					
Y	82.437	87.676	91.072	89.376	91.314
PP	82.437	87.676	91.072	89.375	91.315
CG	66.279	70.491	73.222	71.858	73.416
BN	49.960	53.136	55.194	54.165	55.341
IL_{up}	0.000	-0.001	0.000	0.001	-0.001

EFFECTS OF POLICY CHANGES
(Alternative Minus the Control)

Policies						Endogenous					
PVbM	0.000	0.000	0.000	0.000	0.000	Y	1.650	1.650	1.650	1.650	1.649
PVrM	0.000	0.000	0.000	0.000	0.000	PP	1.649	1.649	1.649	1.649	1.650
PVrBGM	0.000	0.000	0.000	0.000	0.000	CG	1.326	1.326	1.326	1.326	1.326
PVrCGM	0.000	0.000	0.000	0.000	0.000	BN	0.999	1.000	1.000	1.000	1.000
PVBGA	2.040	2.040	2.040	2.040	2.040	IL_{up}	0.000	0.000	0.000	0.000	0.000

We find that if we divide the change in the endogenous variables Y, PP, and CG by the change in BN (i.e., 0.49 × BG), then we obtain the ratio 1.65, 1.65, and 1.32, respectively. These values are the same for each year of the simulation. This ratio of Y to BN is called the *multiplier* and is constant due to the simple linear nature of the model at hand. The value of *r* (.49) times the consumption multiplier (1.32) is .65, or the amount of extra local production per dollar of increase in BN. This value plus 1 is the Y multiplier.

Returning to our equation 2-43, we represent the baseline or control values as C and the alternative as A. When we subtract the control from the alternative, equation 2-69 expressed in changes is obtained.

$$Y_A = rb\ Y_A + BN_A \quad \textit{Alternative} \tag{2-67}$$

$$-Y_C = -rb\ Y_C - BN_C \quad \textit{Control (Baseline)} \tag{2-68}$$

$$Y_A - Y_C = rb\ (Y_A - Y_C) + BN_A - BN_C \tag{2-69}$$

$$\Delta Y = rb\ \Delta Y + \Delta BN \tag{2-70}$$

Output Determination After an Exogenous Change

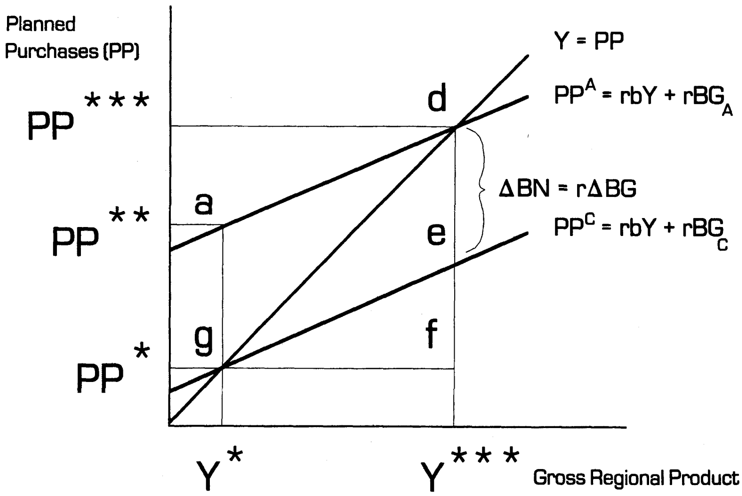


Diagram 2-8

Diagram 2-8 illustrates the effects of such a change. In this diagram, the demand curve shifts up from PP^C to PP^A due to an increase in the exogenous variable BG. The equilibrium expenditure and output, determined by the intersection of the demand curve and the 45-degree line, moves from *g* to *d*. The total equilibrium demand moves from PP* to PP***, corresponding to the equal rise in output from Y* to Y***. Although *r*BG increased by the distance PP** – PP* (*d-e* or *a-g*), the expenditure increased by PP*** – PP* (*d-f*), which is significantly larger than just the exogenous change in *r*BG. The vertical difference PP*** – PP** (*d-a* or *e-f*) is equal to the induced demand caused by increases in Y ($rb\Delta Y$). If *rb* were equal to zero, the PP line would be horizontal, and the vertical distance PP** to PP*** (*d-a*) would be equal to zero.

The Multiplier (K)

A very important distinction in model building is the difference between structural equations in a model and equations in the model's *reduced form*. The structural equations of a model show causality. They set forth the behavioral assumptions and identities in the model. The reduced-form equations simply have one of the endogenous variables on the left and all of the exogenous variables on the right.

In model building, there is a distinction between *parameters* and exogenous variables in the model. In general, the distinction is that parameters of a model are fixed, whereas exogenous variables take on different values during the sample periods.[7] We illustrate these concepts using the economic base model that we have developed up to this point. The model can be restated as follows:

$$BN = rBG \qquad (2\text{-}71)$$

$$Y = rCG + BN \qquad (2\text{-}72)$$

$$CG = bY \qquad (2\text{-}73)$$

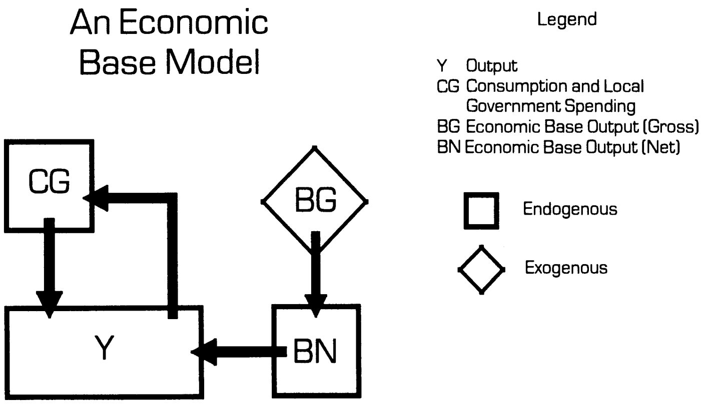


Diagram 2-9

Using equations 2-71, 2-72, and 2-73 as our structural equations, we can identify *r* and *b* as the parameters of the model. Y, BN, and CG are the endogenous variables, and BG is an exogenous variable. A causal arrow diagram of the model might be drawn as represented in diagram 2-9.

From diagram 2-9, we can see how a change in the exogenous variable, the economic base (BG and then BN), changes output (Y), which in turn changes individual spending (CG). This circle of causality continues to be repeated until a new equilibrium is reached.

A way to find the value of Y directly for any given BG for the simple economic base model is to find the reduced form of the model, where Y is on the left and only BG is on the right. This approach cannot be generalized to work with the more complicated models, which we will consider later, in the same way that the iterative approach works for almost all economic models. We obtain equation 2-74 by substituting equations 2-71 and 2-73 into equation 2-72.

$$Y = (rb)Y + rBG, \tag{2-74}$$

in which the endogenous variable Y is on both sides of the equation. The similarity between this equation and equation 2-69 should be noted.

We arrange equation 2-74 so that

$$Y = \left[\frac{1}{1-rb}\right] rBG \tag{2-75}$$

This is a reduced-form equation. It shows the endogenous variable (Y) as a function of model parameters (*r* and *b*, which would be values estimated from data in an actual model) and the model's exogenous variable (BG). By using the reduced-form equation, we can estimate the effects on output (Y) of a change in the exogenous variable BG.

We use 1977 values from Michigan to develop an economic base estimate.

$$\begin{aligned} Y &= \left[\frac{1}{1-(.49)\,(.804)}\right](.49\,BG) \\ &= 1.65\,(.49\,BG) \end{aligned} \tag{2-76}$$

Equation 2-75 can also be expressed in the form

$$\frac{Y}{rBG} = \frac{Y}{BN} = \frac{1}{1-rb} \tag{2-77}$$

If we take the derivative of equation 2-75 with respect to BN, or if we apply the same procedure that we used to derive equation 2-70, we obtain

$$\frac{\Delta Y}{\Delta BN} = \frac{dY}{dBN} = \frac{1}{1 - rb} = K \qquad (2\text{-}78)$$

This gives us the multiplier K. Using the same operations on equation 2-76 for Michigan, we obtain

$$\frac{\Delta Y}{\Delta BN} = \frac{\Delta Y}{\Delta (rBG)} = \frac{dY}{d(rBG)}$$
$$= \frac{dY}{dBN} = \frac{1}{1 - (.49)\,(0.804)} = 1.65 \qquad (2\text{-}79)$$

This multiplier shows the change that is required in equilibrium output in response to a change in the BN variable. It confirms the result that we obtained with the iterative approach for each year by subtracting the baseline from the alternative.

The Effect of the Parameter Changes

While *r* and *b* are regarded as parameters of our model, it would be interesting to see what would happen to the local economy if *r* or *b* were changed. The easiest way to do this is to use the framework that we have set up for an iterative approach to model solution. For example, suppose we undertook policies to increase the local content (*r*) of goods and services purchased locally (CG) and of gross economic base exports (BG). This can be accomplished by increasing *r* in the alternative forecast, using the PVrM policy variable. If we wanted to compare increasing BG by 2.04 with a policy to encourage increased local content by enough to raise net demand by 1.00 (e.g., by subsidizing a local person to become a brewer for a local tavern in an area where no beer is currently brewed), we would have to calculate the change in r that is required to accomplish this increase in the base period.

$$\Delta Y = 1.00 = 0.49\,(PVrM)\,(BG + CG) \qquad (2\text{-}80)$$

$$PVrM = \frac{1.00}{0.49\,(BG + CG)} = \frac{1.00}{0.49\,(99.92 + 65)} = 0.012375 \qquad (2\text{-}81)$$

Thus, the value for PVrM in the alternative would be set at 1.012375. The results from this simulation are shown on table 2-8. Comparing this table with table 2-7, we see that raising *r* (i.e., import substitution) is as effective as expanding BG (the economic base) as a way to stimulate Y (output).

TABLE 2-8

Michigan Economic Base Model

Effects of Increasing *r* by .012

	1977	1978	1979	1980	1981
PVrM	0.012	0.012	0.012	0.012	0.012
Y	1.612	1.717	1.785	1.751	1.789
CG	1.296	1.380	1.434	1.408	1.439
BN	0.587	0.626	0.650	0.638	0.652

At this point, it might be instructive to do a number of policy simulations using the policy variables in the simple economic base model. In doing these simulations, remember that you need to think of a policy that will lead to an exogenous variable or parameter change. Then, you represent it quantitatively in the model. You must be sure to include all of the effects not shown in the model. For example, increasing spending on local schools or financing a new industrial park with local taxes may change PVbM, PVBGA, and PVrM.

Converting Output (Y) to Employment (E)

Regional economic models are used to make predictions of the changes in economic activity in a local area for the purpose of planning and public policy making. Employment data is the primary source of data for subnational areas, and employment is usually the greatest concern in public policy making. To predict changes in employment, the model is converted from dollar terms to employment terms.

To do this, four new definitions are presented:

E — total employment

EXFG — employment dependent on exports, including the federal government

EIL_p — employment dependent on local planned investment

ECG — employment dependent on local consumer and government spending

EBN employment dependent on local investment and exports, including federal government

Algebraically, the terms are defined as

$$E = ECG + EXFG + EIL_p \tag{2-82}$$

$$E = ECG + EBN, \tag{2-83}$$

where

$$EBN = EIL_p + EXFG \tag{2-84}$$

Note that, in employment units, EIL_p and EXFG are already net (not gross) variables, because, by measuring employment input, we capture that portion of investment and exports (BG) that is supplied locally.

To convert the dollar amounts to employment, we must make an assumption about the relationship of value added to employment. We assume that employees per unit of value added in producing Y is equal to the average number of employees per unit of value added. The employees per unit of value added (E/Y) is called *epv*, which produces

$$epv = \frac{E}{Y} \tag{2-85}$$

By expressing output in terms of employment and the number of employees per dollar of value added, we obtain

$$Y = \frac{E}{epv} \tag{2-86}$$

Thus, the number of employees per unit of value added is assumed to be fixed and the same for all types of production in this simple model.

This means that *epv* is assumed to be the average employment per dollar of local value added in the export sector (EXFG/*r*XFG), in the investment sector (EIL_p/rIL_p), and in the local consumption and government spending sector (ECG/*r*CG), producing the equalities

$$rXFG = EXFG/epv \tag{2-87}$$

$$rIL_p = EIL_p/epv \tag{2-88}$$

$$rCG = ECG/epv \tag{2-89}$$

$$rBG = EBN/epv \tag{2-90}$$

which implies that

$$EBN = epv \times BN \tag{2-91}$$

We restate the causal arrow diagram in employment terms in diagram 2-10.

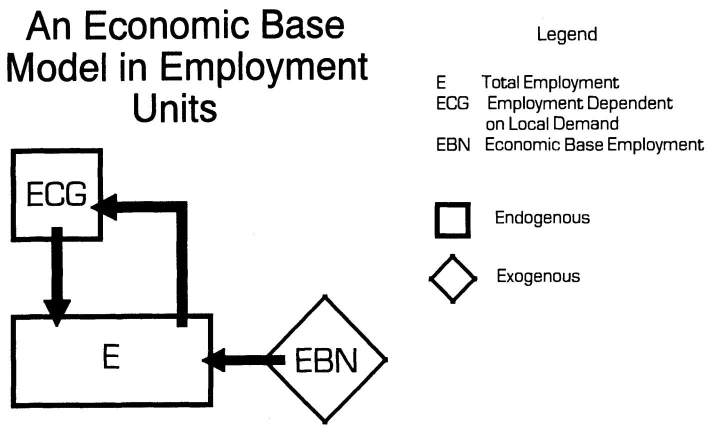


Diagram 2-10

Economic base employment (EBN) is assumed to be the production for export, multiplied by the average number of employees per dollar of value added in all sectors (*epv*). Using equation 2-43,

$$Y = rbY + BN, \tag{2-92}$$

we can substitute for Y and BN to obtain

$$\frac{E}{epv} = rb\frac{E}{epv} + \frac{EXFG}{epv} + \frac{EIL_p}{epv} = rb\frac{E}{epv} + \frac{EBN}{epv} \tag{2-93}$$

We can find the reduced form from equation 2-93, as follows:

$$\frac{E}{epv} = \frac{1}{1 - rb}\left[\frac{EBN}{epv}\right] \tag{2-94}$$

or

$$E = \frac{1}{1 - rb} EBN \tag{2-95}$$

We divide equation 2-95 by ($EXFG + EIL_p = EBN$) to obtain

$$\frac{E}{EBN} = \frac{1}{1 - rb} \tag{2-96}$$

This is the employment counterpart to equation 2-77, which is in output units. To predict the change in total employment, based on the change in exogenous employment (EBN), we take the derivative of E with respect to EBN, or perform the same operation we used to obtain equation 2-70, which yields

$$\frac{\Delta E}{\Delta EBN} = \frac{d(E)}{d(EBN)} = \frac{1}{1 - rb} = K \tag{2-97}$$

This is the same multiplier (K) in employment units that we previously estimated in output units in equation 2-78.

While the multiplier can be obtained from equation 2-96, the value of r cannot be determined from the reduced form unless the value of b can be found from a different source. This illustrates the problem, in general, with the reduced form relative to the structural approach. When we know K but not r and b, we cannot do simulations that involve changes in r or b. This is especially important in this case, because changing r may be key to stimulating the local economy.

2-2 EMPIRICAL IMPLEMENTATION OF THE ECONOMIC BASE MODEL

We estimated the parameters for the Michigan model, as shown previously, using regional income and product account data developed for a full-scale forecasting and simulation model. An economic base model can also be estimated using primary data sources published by the U.S. government. However, none of the available data explicitly separates employment into basic and nonbasic sectors. Therefore, we must find a way to derive the numbers needed for our economic base model from the published data. To do this, we first develop an adequate database. Then, we determine which employees are economic base employees for each industry. Finally, we add these employees together to find the total number of economic base employees. This becomes a key input into the process of estimating the parameters for all of the single sector models in this book. Our focus here is on United States data. However, similar data issues are likely to exist in other countries.

Using Available Data

Employment data, based on place of employment for states and counties, is tied to either social security records for employees or records from the unemployment insurance program. Data from the Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA) are based on unemployment insurance data, often called *ES-202 data.* County Business Patterns (CBP) data, published by the Census Bureau, is drawn from social security records. The BLS also conducts the 790 program, which samples firms and gives current estimates of employment that are benchmarked annually to the ES-202 data. BEA uses some other data sources, including income tax returns, to estimate self-employment and to supplement the ES-202 wage and salary employment data. The other major sources of employment data are the decennial Census Data and the Current Population Survey.

The BLS and the BEA data lack detail. The Census does not provide annual information, and the population sample of the Current Population Survey is too small to yield reliable regional data. For our current purpose, the best data source, due both to its detail and frequency, is County Business Patterns.

County Business Patterns reports March employment figures by industry for every county in the United States. At the detailed level of about 1,400 industries, the annual data gives the number of employees, the first quarter and annual payroll, the total number of establishments, and the number of establishments by employment-size class. Due to their reliance on social security records, CBP tables do not show employment figures for government or self-employed workers.

TABLE 2-9[8]

1987 Employment by Major Sector
Adams County, Colorado

Total	97,009
Agricultural services	365
Mining	550
Contract construction	6,545
Manufacturing	12,807
Transportation and other public utilities	11,643
Wholesale trade	19,940
Finance, insurance, and real estate	3,721
Services	14,041
Unclassified establishments	222
Federal government employment	6,254
State and local government employment	11,059

Total employment in each county is divided into ten major, private nonfarm sectors, as shown by the Adams County, Colorado data in table 2-9.[9] Total wage and salary employment reported by CBP is equal to the sum of the employment in each of the aggregate sectors. The number of government workers is available from the Bureau of Economic Analysis (BEA) Regional Economic Information Systems (REIS). The number of self-employed people in nongovernment sectors is also available in the BEA data, but it is not used in this chapter.

Unlike the BEA county data, CBP reports employment in progressively more detailed levels. This is illustrated by an excerpt from the Adams County data shown in table 2-10. Some detail is left in this table to show the specificity with which CBP defines sectors.

TABLE 2-10[10]

Excerpt from the Construction Sector of County Business Patterns (CBP) Adams County, Colorado

SIC	*Industry*	*No. of Employees for the Week Including March 12*
CONTRACT CONSTRUCTION		
15	GENERAL CONTRACTORS AND OPERATIVE BUILDERS	6,545
16	HEAVY CONSTRUCTION CONTRACTORS	856
	161 Highway and street construction	207
	162 Heavy construction, except highway	350
17	SPECIAL TRADE CONTRACTORS	5,065
	171 Plumbing, heating, air conditioning	1,049
	172 Painting, paper hanging, decorating	116
	173 Electrical work	864
	174 Masonry, stonework, and plastering	513
	175 Carpentry and flooring	224
	1751 Carpentry	153
	1752 Floor laying and floor work, not elsewhere classified	71
	176 Roofing and sheet metal work	367
	177 Concrete work	935
	179 Misc. special trade contractors	852

Each detailed industry is defined by a number. This is the *standard industrial classification* (SIC) code, in which sectors are categorized at the two-, three-, or four-digit level. The relationship is hierarchical. In other words, two-digit sectors are subcategories of the aggregate sectors, three-digit sectors are components of two-digit sectors, and four-digit sectors are classified as part of three-digit sectors. For example, contract construction in Adams County consists of SIC-15, general contractors and operative builders; SIC-16, heavy construction contractors; and SIC-17, special trade contractors. At the four-digit level, we see that carpentry (SIC-1751) and floor laying and floor work not elsewhere classified (SIC-1752) are components of carpentry and flooring (SIC-175).

If each worker were classified at a detailed level, the sum of subsectors would equal the aggregate sector. However, CBP is sometimes unable to classify employees. For example, the sum of employment in SIC-161 and SIC-162 is 557 (207 + 350). This is less than the total of 604 employees reported at the respective two-digit sector (SIC-16). In this example, 47 workers are reported at the two-digit level but not at the three-digit level. To have a working model, we must somehow classify unidentified employees. Our solution to this problem is, by its nature, somewhat arbitrary. One possible approach would be to allocate unclassified employees among the subcategories in the same proportion as those who are classified.

A further problem that we encounter is CBP data suppression, which is done to protect the confidentiality of individual companies. Thus, for an industry with a small number of firms or a few firms that employ a large percentage of the total workers, CBP reports the *employment-size class* of the sector rather than the exact number of employees. When data is suppressed in the CBP tables, you will find letters representing employment ranges. In table 2-11, for example, the letters B and C in the employment column represent ranges of 20 to 99 and 100 to 249, respectively.

TABLE 2-11[11]

Grain Mill Products (CBP Data)
Adams County, Colorado

SIC	*Industry*	*No. of Employees (for the week including March 12)*	*Payroll in Thousands of Dollars*		*Total No. of Establishments*	*No. of Establishments by Employment-Size Class*							
			1st Qtr.	Annual		1-4	5-9	10-19	20-49	50-99	100-249	250-499	550-999
204	Grain Mill Products	193	1,539	6,668	5	-	2	-	2	-	1	-	-
2041	Flour and other grain mill products	(C)	(D)	(D)	1	-	-	-	-	-	1	-	-
2048	Prepared foods, n.e.c.	(B)	(D)	(D)	3	-	1	-	2	-	-	-	-

Note: Employment-size classes are indicated as follows:

A = 0 to 19
B = 20 to 99
C = 100 to 249
E = 250 to 499
F = 500 to 999
G = 1,000 to 2,499
H = 2,500 to 4,999
I = 5,000 to 10,000
J = 10,000 to 24,999
K = 25,000 to 49,999
L = 50,000 to 99,999
M = 100,000 or more

D = Disclosure Suppression

These employment-size classes can help us approximate employment numbers for suppressed data. We could assume, for example, that employment is equal to the midpoint of the range given for an industry. Accordingly, we would estimate employment in prepared feeds not elsewhere classified (n.e.c.)[12] (SIC-2048) as being equal to 60, which is the midpoint of employment class B. We would also estimate employment in flour and grain mill products (SIC-2041) as being equal to 175, the midpoint of employment class C. These estimates would then need to be adjusted downward, since the sum of estimated employment at the four-digit level (60 + 175 = 235) would exceed the 193 employees reported for SIC-204.

We could also estimate suppressed data as the sum of the employment in individual establishments. The right-hand columns in CBP show the number of establishments in each employment class. In table 2-11, we see that SIC-2048 includes one establishment employing five to nine workers and two others each employing twenty to forty-nine workers. Assuming that the midpoint of the employment-size range is equal to the employment in the establishment, we would estimate SIC-2048 employment as $[(1 \times 7) + (2 \times 35)]$, or 77 workers, and SIC-2041 employment as 175, for a total of 252 workers. Again, we would need to adjust the four-digit level estimates downward to reflect the total SIC-204 employment given as 193 above.

A final limitation of the CBP data arises because it is first-quarter rather than full-year employment. For an industry that has a large seasonal change in employment, March data could overreport or underreport average annual employment. We could use first-quarter and annual payroll figures to estimate seasonal employment changes. For example, the first-quarter payroll rate in Adams County for grain mill products is less than the total payroll rate for the year. To obtain a seasonally-adjusted annual employment estimate, we might scale up the seasonal employment to reflect the seasonal payroll differences.

Having obtained figures for all types of employment and having compensated for unclassified workers, suppressed data, and seasonal variations in employment, we would like to obtain a numerical solution for the economic base model. The multiplier (K) is given as

$$K = \frac{E}{EBN} , \tag{2-98}$$

where E is total employment, and EBN is economic base employment.

Estimating Economic Base Employment

The first step in measuring economic base employment is to find employment by disaggregated industry, as we did previously. Next, we refer back to the behavioral assumption of the model to define the difference between ECG and EBN. Consumption and local government spending (CG) is dependent on local output, as a proxy for income. The values of rXFG and $r\mathrm{IL}_p$ are determined exogenously. The activity associated with local output, assuming a uniform employment-to-output ratio in all sectors, is ECG, while that associated with exogenous activity is EXFG and EIL_p, or simply economic base employment EBN (where EBN = EXFG + EIL_p). Employment directly dependent on consumption by local consumers and government goes in the ECG category, while a commodity produced locally for the national or international market goes into exports, and is, therefore, counted in the EBN category. Employment for a commodity that is produced locally, as an intermediate input for a product that will be sold nationally or internationally, is also in the EBN category because it depends on sales from the area to national and international markets. Having established these definitions, we need a method to divide employment into ECG and EBN. The standard methods used to estimate this economic base are (1) the judgmental approach, (2) the location quotient, and (3) the minimum requirements technique. We present these three approaches in turn.

Judgmental Approach

The first approach is labeled judgmental, because it relies on the judgment of the analyst. He or she simply looks over the industries and categorizes them based on a subjective assessment of whether they are producing for the local market or for direct or indirect export out of the local area. For example, employment in grocery stores or regular dental services is almost certainly for the local market, while employment for the production of guided missiles or airplanes is almost certainly for export. However, other industries present more difficult choices. A printing company, for example, may be printing the local newspaper or it may be printing encyclopedias. In the former case, the industry is local; in the latter, it is almost all export. The classification is also difficult for industries that supply other industries. Here, one must know what industries they serve and what market is served by the industries that use their inputs.

The judgmental approach is a somewhat ad hoc process, and the results may vary from one analyst to another. In many cases, the approach benefits substantially from the analyst's knowledge about the specific area. In this case, we illustrate how we might proceed in a case where we have only the information contained in the CBP publication.

We use an example to illustrate the judgmental method. Table 2-12 shows our division of employment in the mining industry.

TABLE 2-12[13]

Mining Sector
Economic Base and Local Employment
Adams County, Colorado

				ET	*EBN*	*ECG*
MINING				550	524	26
	13	OIL AND GAS EXTRACTION		278	278	0
		138 Oil and gas field services		278	278	0
			1381 Drilling oil and gas wells	198	198	0
			1398 Oil and gas field services, n.e.c.	80	80	0
	14	NONMETALLIC MINERALS, EXCEPT FUELS		132	106	26
		144 Sand and gravel		132	106	26
			1442 Administrative and auxiliary	140	140	0

Most of the employees are economic base employees in the mining sector. We assume that the local consumption of locally produced oil is insignificant, and therefore assign this sector's 278 employees to EBN. Sand and gravel is difficult to transport, so we assume that at least some of the workers in this industry are supplying noninvestment local demand.

The last category, administrative and auxiliary, often refers to employees working in a headquarters office, rather than working directly on the production of the commodity or service in question. We also classify them as EBN employees. On a more aggregated level, table 2-13 shows our complete ECG and EBN assignments.

TABLE 2-13[14]

Major Sector
Economic Base and Local Employment
Adams County, Colorado

	ET	*EBN*	*ECG*
Total	97,009	24,573	72,436
Agricultural services, forestry and fisheries	365	65	300
Mining	550	524	26
Contract construction	6,545	4,860	1,685
Manufacturing	12,807	11,847	960
Transportation and other public utilities	11,643	0	11,643
Wholesale trade	9,862	0	9,862
Retail trade	19,940	0	19,940
Finance, insurance and real estate	3,721	0	3,721
Services	14,041	972	13,069
Unclassified establishments	222	51	171
Federal government	6,254	6,254	0
State and local government	11,059	0	11,059

Total economic base employment is 24,573. Total local employment is 72,436. Most economic base employees work in mining, construction, federal government, and manufacturing. Since we are counting investment-dependent employment (IL_p) as EBN, workers involved in building new roads and houses are considered EBN. In the construction sectors, only maintenance and repair workers are classified as ECG.

From examining the detailed sectors, we guess that while some service employees are exporting their production, most are supplying the local market. We divided unclassified establishments to match the proportion of employment found in EBN and ECG among the classified industries. A preponderance of employees work to supply the local market, including some in every large category of industry. ECG workers include all of those working in transportation, wholesale trade, and retail trade.

Location Quotient

The next approach that we present for estimating EBN is called the *location quotient (LQ) method.* This is used to find the EXFG portion of EBN. The location quotient is a measure of the concentration of an industry in a region. This approach assumes that an industry in a region that has a proportion of employment in that industry that is greater than the national average, exports all of the output produced by the employees who are in excess of the national proportion. Local investment, such as contract construction, is still determined judgmentally. We use the following definitions to calculate the location quotient:

LQ(*i*)	the location quotient for industry *i* in the local region
E(*i*)	employment in industry *i* in the local region
E	total employment in the local region, and
EU	total employment in the United States

LQ(*i*) is calculated as

$$LQ(i) = \frac{E(i)/E}{EU(i)/EU} \tag{2-99}$$

The location quotient is the proportion of employment in industry *i* relative to the United States proportion of employment in industry *i*. If two out of one hundred employees in a region are involved in furniture manufacture, for example, and two million out of one hundred million employees in the United States make furniture, then

$$E(i)/E = 2/100 = .02 \tag{2-100}$$

$$EU(i)/EU = 2 \text{ million}/100 \text{ million} = .02 \tag{2-101}$$

In other words, both the region and the nation employ 2 percent of their workers in the furniture business. Our location quotient is calculated as follows:

$$LQ(i) = \frac{E(i)/E}{EU(i)/EU} = \frac{.02}{.02} = 1 \tag{2-102}$$

A location quotient of 1 indicates that the region employs the same proportion of people in industry *i* that we find in that industry nationwide. If there is a proportionally high amount of employment in a particular industry within the region, then the location quotient is greater than 1. If there is a proportionally low amount of employment in a particular industry within the region, then the location quotient is less than 1.

Location quotients are calculated at the most detailed level for which data is available. In the mining sector, for example, Adams County data is reported for SIC-1381, SIC-1389, SIC-1442, and administrative and auxiliary employees. We compute a separate location quotient for each of these sectors. Table 2-14 shows Adams County, Colorado and United States employment figures and our computation of the EXFG employment using the location quotient approach for the mining sector.

TABLE 2-14[15]

Mining Sector Location Quotient Determined Local and Economic Base Employment

		Adams County	*United States*	*Location Quotient LQ(i)*	*Export Employment (EXFG)*	*Local Employment (ECG)*
Total Employment		79696	85483804			
	MINING	550	724967		233	327
13	OIL AND GAS EXTRACTION	278	428303		128	150
	131 Crude petroleum and natural gas	0	158913	0.00	0	0
	132 Natural gas liquids	0	16369	0.00	0	0
	138 Oil and gas field services	278	253020		128	150
	1381 Drilling oil and gas wells	198	75464	2.81	128	70
	1382 Oil and gas exploration services	0	25198	0.00	0	0
	1389 Oil and gas field services, n.e.c.	80	152357	0.56	0	80
14	NONMETALLIC MINERALS, EXCEPT FUELS	132	141030		95	37
	141 Dimension stone	0	3378	0.00	0	0
	142 Crushed and broken stone	0	49264	0.00	0	0
	144 Sand and gravel	132	44316		95	37
	1442 Construction sand and gravel	132	39210	3.61	95	37
	1446 Industrial sand	0	5106	0.00	0	0

	Adams County	*United States*	*Location Quotient LQ(i)*	*Export Employment (EXFG)*	*Local Employment (ECG)*
14 NONMETALLIC MINERALS, EXCEPT FUELS, cont.					
145 Clay, ceramic and refractory materials	0	11592	0.00	0	0
147 Chemical and fertilizer materials	0	21984	0.00	0	0
148 Nonmetallic minerals services	0	1860	0.00	0	0
149 Miscellaneous nonmetallic minerals	0	8636	0.00	0	0
ADMINISTRATIVE AND AUXILIARY	140	155634	0.96	0	140

We see that Adams County mining employment is proportionally high in drilling oil and gas wells (LQ = 2.81) and in construction sand and gravel (LQ = 3.61). The relative proportion of employment in administrative and auxiliary jobs (0.96) is about the same as found in the rest of the United States, while the relative employment in oil and gas field services n.e.c. (0.56) is lower than in the United States. Location quotients for all four-digit sectors other than those mentioned is zero. We report location quotients of zero at the three-digit level when all of the corresponding four-digit location quotients are zero. The amount [E × (EU(*i*)/EU)] is the number of employees we assume a region would need in a particular industry to supply itself. If employment is proportionally low compared to the United States, then we assume that there are no exports. If employment in an industry is proportionally high, then the region has employment above the national average for this industry, which is equal to the total employment minus that needed for local supply. We assume that the product of these employees is exported, giving us EXFG(*i*). Algebraically, we have

$$EXFG(i) \begin{cases} EXFG(i) = 0 \text{ if } LQ(i) \leq 1 \\ EXFG(i) = \left[\dfrac{LQ(i) - 1}{LQ(i)}\right] \times E(i) \text{ if } LQ(i) > 1 \end{cases} \tag{2-103}$$

Thus, in SIC-1442, LQ = 3.61; so

$$EXFG(i) = \left[\frac{3.61 - 1}{3.61}\right] 132 = 95 \tag{2-104}$$

The location quotient method of calculating export-dependent employment would only be accurate if several very restrictive assumptions were met: (1) no cross hauling of goods and services; (2) uniform consumption patterns; (3) equal labor productivity across regions; and (4) no international trade. To help focus our discussion of these four assumptions, we use the location quotients for mining in Adams County on table 2-14.

(1) No Cross Hauling

A region may simultaneously import and export a commodity in what is known as cross hauling. The calculation of the location quotient, however, assumes that this never occurs. This assumption is not realistic, particularly at high levels of aggregation. In the Adams County oil-and-gas-wells drilling industry, for example, we find that nearly two-thirds of employees would be classified as EXFG at the four-digit level. At the three-digit level, SIC-1381 employees would not be distinguished from other SIC-138 workers, and their collective location quotient (1.18) would lead us to classify less than one-fifth of the workers as economic base. Classified at the two-digit level (LQ = 0.70) or in the mining sector (LQ = 0.81), we would assume that all of the drilling oil and gas workers are supplying local consumption.

We would be mistaken to assume that no cross hauling occurs in aggregate industries. Even at the four-digit level, this assumption could be unrealistic. While Adams County oil and gas drilling may all be done by Exxon, residents can still buy some of their gasoline at Mobil and Chevron.

(2) Uniform Consumption Patterns

When we assume that relatively high employment in an industry implies the production of export goods, we are implying that all regions consume equal proportions of every good. However, consumption patterns may differ across regions. In the real world, for instance, we might expect Californians to buy proportionally more hot tubs than Iowans.

(3) Equal Labor Productivity

We assume that excess employment creates goods and services that are then exported. In an actual economy, however, the number of employees needed to satisfy local demand depends on their productivity. Regional labor could be more or less productive than the national average, affecting the accuracy of our economic base estimation.

(4) No International Trade

We compare employment in a local industry to the percentage of employment in that industry for the country as a whole to infer export employment. Implicitly, we assume that there are no international imports or exports. However, United States employment in the industry could be higher or lower than the amount needed to supply the total demand of the nation. If the United States exports college educational services to foreign students, for example, a state that has a location quotient of 1 might appear to be satisfying only local demand when, in fact, it is exporting by teaching an average proportion of foreign students. Conversely, a state with a location quotient of 1 for video equipment could in fact be importing this equipment, since no VCRs are made in the United States.

Despite these drawbacks, the location quotient is a frequently used measure of local and export production. In comparison to the ad hoc determination of exports in the judgmental approach, the location quotient is straightforward and well documented. Before extending the economic base model, we will discuss a third method of estimating EBN, called minimum requirements.

Minimum Requirements

The minimum requirements (MR) approach sets the least amount of production needed to meet local demand. Everything else is assumed to be exported. Unlike the LQ, this approach allows for cross hauling. The MR approach assumes that the region having the lowest location quotient for any given industry can be used as an estimate of the proportion of that industry that is used to satisfy local markets. For example, there are some states that do not produce any oil and gas. Thus, the minimum requirement of oil and gas production is zero, and all oil and gas production (in any region in the country) is assumed to be for national markets. If banking services for any state are as low as one-half of the national average of banking to total employment, then we assume that only one-half of the banking industry in a state with the average proportion of banking services is tied to the local market.

The minimum requirements approach bases an industry's exports on the concentration of the sector in the *minimum requirements region*. This is in contrast to the location quotient, which bases exports on an industry's concentration in the Unites States as a whole. We use the following equation to calculate MR exports:

$$EXFG(i) = E(i) - \left[\frac{EM(i)}{EM} \times E \right] \qquad (2\text{-}105)$$

EM(i) the employment in industry (i) in the state with the minimum LQ(i) (i.e., the minimum E(i)/E)

EM the total employment in the minimum-requirement region

The difference between this approach and the LQ approach can be more easily seen if we rearrange the location quotient equation 2-103. We start by repeating and rearranging equation 2-103,

$$EXFG(i) = \left[\frac{LQ(i) - 1}{LQ(i)} \right] \times E(i) = \left[E(i) - \frac{E(i)}{LQ(i)} \right] \tag{2-106}$$

We then substitute equation 2-99 for LQ(i) to obtain

$$EXFG(i) = E(i) - \left[\frac{EU(i)}{EU} \times E \right] . \tag{2-107}$$

In the LQ approach, we assume that the proportion of local employment required to supply local demand is the same proportion of total employment that is devoted to this industry nationally. By comparing equation 2-107 with equation 2-105, we can see that the only difference between the LQ approach and the MR approach is that the United States ratio in equation 2-107 is replaced by the ratio of that industry in the minimum requirement region in equation 2-105.

In the MR approach, the proportion of employment in industry i in the state with the lowest proportion of any state in the country EM(i)/EM is multiplied by the employment (E) for the state in question. This gives us the amount of employment used to satisfy local demand in that region. We assume that any employment over this amount is equal to the exports for that state. The most surprising feature of the minimum requirements is that the ratio of E to EXFG is the same for every area. The reason for this can be deduced by starting with equation 2-105 and setting the minimum requirement for each industry in a particular year equal to its proportion p(i).

$$p(i) = \frac{EM(i)}{EM} \tag{2-108}$$

We restate equation 2-105 as

$$EXFG(i) = E(i) - [p(i) \times E] , \tag{2-109}$$

where p(i) is the same in every region. Now, summing over all industries for any region, we obtain

$$\sum_{i=1}^{n} EXFG(i) = \sum_{i=1}^{n} E(i) - \left[\left(\sum_{i=1}^{n} p(i) \right) \times E \right] \tag{2-110}$$

Next, let $\sum_{i=1}^{n} EXFG(i)$ equal EXFG, $\sum_{i=1}^{n} E(i)$ equal E, and $\sum_{i=1} p(i)$ equal p. Over all, we find

$$EXFG = E - (p \times E) = (1 - p) \times E \tag{2-111}$$

Solving this equation for E/EXFG, we find that

$$\frac{E}{EXFG} = \frac{1}{1 - p} \tag{2-112}$$

Since the summation of p(*i*) over all *i* is the same for each region, the multiplier, if it is based only on EXFG rather than on EBN, is the same for each region.

Another way to see why E/EXFG is the same for all regions is to imagine moving an employee from one industry to the next. Equation 2-111 shows that unless this region is the one used to define EM(*i*)/EM in that year, this transfer does not change the total export employment for that year. Thus, E/EXFG remains at a fixed value for all areas in a given year.

Calculating the Multiplier

Once the EBN (EXFG + EIL_p) and ECG values have been determined, we can calculate the multiplier (K). We do this using the equation for the economic base model,

$$K = \frac{EBN + ECG}{EBN} = \frac{E}{EBN} \tag{2-113}$$

For example, we can estimate K using the judgmental numbers from Adams County. We obtain

$$K = \frac{97{,}009}{24{,}573} = 3.95 \tag{2-114}$$

The multiplier 3.95 is high compared to the Michigan multiplier of 1.65 that we estimated in equation 2-79. This is especially surprising because, in general, we would expect a large state to have a larger multiplier than a small county. In this case, the judgmental approach gives us a high multiplier compared to one derived from the data that was constructed in the process of building a fully operational model (explained in chapter 7). More importantly, this K could be used to find the structural parameters of the employment economic base model, if we can estimate b. Using United States data for consumption (3,052) plus state and local government spending (497) and dividing by gross domestic product (4,540)[16], we calculate $b = 3549/4540 = .78$.

$$\frac{1}{1 - r(.78)} = 3.95 \quad as \tag{2-115}$$

$$1 = 3.95 - r \times .78 \times 3.95 \tag{2-116}$$

$$\frac{1 - 3.95}{.78 \times 3.95} = -r \tag{2-117}$$

$$r = \frac{3.95 - 1}{.78 \times 3.95} = .96 \tag{2-118}$$

This value of r is obviously unrealistically high. The economic base may be incorrectly estimated. As we find in the next section, it is due to a problem with the specification of the model, which happens to be important for this county. We return to estimating this model using an extended and more accurate economic base model in section 2-4. In this section, we extend our economic base model to incorporate the fact that output by place of work is not the same as income by place of residence. Before proceeding to extending the model, we first consider the forecasting accuracy of the simple economic base model, expressed in employment units, in the next section.

2-3 FORECASTING WITH AN ECONOMIC BASE MODEL

If a model is an accurate representation of the system being modeled, it should replicate the observed values of the endogenous variables providing that it uses the observed values of the exogenous variables. If the model is accurate and complete, we should also find evidence that the values of the parameters of the model have remained constant.

Making a Forecast

While we need to know the structural equations in the model for most policy simulations, it is possible to make economic forecasts based on the reduced form model. From equation 2-97, we find that the reduced form for the economic base model stated in employment terms is

$$\Delta E = K \times \Delta EBN, \tag{2-119}$$

where

$$K = \frac{1}{1 - rb} \qquad (2\text{-}120)$$

Providing that r and b are parameters that remain constant, equation 2-119 can be used as our forecasting equation. If we use this equation on historical data and there is evidence that K changes or that ΔE is not accurately forecast, then this would be evidence that the model is not an accurate representation of the local economy being modeled.

Here, we present two versions of a forecasting model using the employment version of the simple economic base model. We start by restating equation 2-97 as equation 2-121.

$$E_{t+1} - E_t = K_t \times (EBN_{t+1} - EBN_t) \qquad (2\text{-}121)$$

The subscripts t and $t + 1$ indicate the present year and the following year, respectively. The change in employment from one year to the next ($E_{t+1} - E_t$) is the multiplier for year t (K_t), which is multiplied by the change in economic base employment ($EBN_{t+1} - EBN_t$). Forecasted employment in this model, which we will call model A1, is given by equation 2-122.

$$F1_{t+1} = \left[K_t \times (EBN_{t+1} - EBN_t)\right] + E_t \qquad (2\text{-}122)$$

Predicted employment in forecasting model A1 ($F1_{t+1}$) is equal to the change in employment given in equation 2-121 plus the initial employment in year t.

The accuracy for past years of the model (equation 2-122) can be tested using historical data. To test the validity of the model in 1968, for example, we use values for K_{1967}, EBN_{1967}, EBN_{1968}, and E_{1967} and compare the model ($F1_{1968}$) results to actual 1968 employment. If we wish to forecast future employment, however, we find that no regional data can help us estimate future economic base employment (EBN_{t+1}). Thus, we need to adjust our model to create a forecasting model, which will be named model A2.

Model A2 uses model A1, but it also assumes that some regional variables are a fixed proportion of national variables. A number of national economic models can provide us with predictions of national employment for sectors in the CBP and BEA data. We can then use these national forecasts to derive our regional forecasting model.

This type of model can also be called the *share t model*, where exogenous regional variables are assumed to be a fixed share of national variables. The economic base employment for each industry (*i*) in each time period (*t*) can be calculated using the following formula:

$$EBN_{i,t} = S_{i,t} \times E^{u}_{i,t} \,, \tag{2-123}$$

in which the employment in the economic base industries ($EBN_{i,t}$) is given as a proportion ($S_{i,t}$) of United States employment in the same industries $E^{u}_{i,t}$. The share coefficient is computed for industry *i* in year *t* as

$$S_{i,t} = EBN_{i,t} / E^{u}_{i,t} \,, \tag{2-124}$$

which follows directly from equation 2-123. The change in employment in industry *i* is given by

$$EBN_{i,t+1} - EBN_{i,t} = S_{i,t} \left[E^{u}_{i,t+1} - E^{u}_{i,t} \right] , \tag{2-125}$$

in which we use the share coefficient, regional employment, and national employment values for year *t*. We obtain an estimate of the increase in United States employment in industry *i* from a national economic forecast. To estimate the change in aggregate economic base employment, we sum across all industries.

$$EBN_{t+1} - EBN_{t} = \sum_{i=1}^{n} S_{i,t} \left[E^{u}_{i,t+1} - E^{u}_{i,t} \right] \tag{2-126}$$

The complete A2 model, corresponding to the A1 model shown in equation 2-122, is given by

$$FA2_{t+1} = K_t \sum_{i=1}^{n} S_{i,t} \left[E^{u}_{i,t+1} - E^{u}_{i,t} \right] + E_t \,, \tag{2-127}$$

in which we multiply the change in economic base employment by K_t and add baseline employment E_t to derive our forecast of employment in year $t + 1$.

Measuring Forecast Error

The purpose of this book is to present a comprehensive approach to regional policy analysis and forecasting models. A key part of evaluating a model is assessing its validity. Therefore, we want to test the validity of forecasting Models A1 and A2.

One way to evaluate the accuracy of a model is to test it using historical data.

We obtain data from past years and run an *ex post forecast* for an historical year. The predictions from our models are compared against the actual change in economic activity. We can measure the error of the models in terms of percentage, mean percentage, or absolute percentage.

The *percent error (PE)* is calculated as

$$PE_{(t+1)} = \frac{F_{(t+1)} - E_{(t+1)}}{E_{(t+1)}} \times 100 \qquad (2\text{-}128)$$

The forecast error in year $t + 1$ is equal to the forecasted employment F, minus the actual employment found in historical data (E). The result is expressed as a percentage by dividing it by the actual employment, and multiplying the result by 100. If the forecasted employment in year $t + 1$ is 103 and the actual employment in year $t + 1$ is 100, we would have

$$PE_{(t+1)} = \frac{103 - 100}{100} \times 100 = 3 , \qquad (2\text{-}129)$$

where the error in the employment is 3 percent.

To develop a procedure for estimating the *mean percent error (MPE)* over a number of years, we use the following definition: MPE is the mean percent error of the model in predicting employment. We compute the MPE by taking the summation of the percent error over the n-year span. Algebraically, we have

$$MPE = \sum_{1}^{n} \frac{F_{(t+1)} - E_{(t+1)}}{E_{(t+1)}} \times \frac{100}{n} = \sum_{1}^{n} \frac{PE_{(t+1)}}{n} \qquad (2\text{-}130)$$

In a three-year period where the percent error of the forecast are PE (year 1) = 2.2%, PE (year 2) = -1.8%, and PE (year 3) = 3.2%, the MPE would be

$$MPE = \frac{2.2\% - 1.8\% + 3.2\%}{3} = 1.2\% \qquad (2\text{-}131)$$

In this example, the mean percent error (MPE) of the model is 1.2%, which shows a tendency of the model to overpredict employment by 1.2%.

The *absolute percent error* is the absolute value of the percent error. Thus, a 2% error and a -2% error would both have an absolute percent error of 2%. The *mean absolute percent error (MAPE)* is the average of the absolute percent error over a given period of time. Algebraically, we have

$$MAPE = \frac{1}{n} \times \sum_{t+1=1}^{n} \left[\frac{|F1_{(t+1)} - E_{(t+1)}|}{E_{(t+1)}} \times 100 \right] \tag{2-132}$$

Using the values PE (year 1) = 2.2, PE (year 2) = -1.8, and PE (year 3) = 3.2, the MAPE would be

$$MAPE = \frac{|\,2.2\%\,| + |\,-1.8\%\,| + |\,3.2\%\,|}{3} = 2.4\% \tag{2-133}$$

The MAPE shows the average percentage error per year, but it does not show the direction (positive or negative) of the error. Thus, the MAPE is always at least as large in absolute value as the MPE. The MAPE is larger if errors are made in both the positive and negative direction.

To evaluate our forecasting models using these error measurements, we need a basis of comparison. For this, we use a *naive no-change forecasting model.* We compare the economic base model forecast to the simple prediction that employment in a given year is equal to that of the previous year. The naive model can be represented as

$$FN_{t+1} = E_t \, . \tag{2-134}$$

Table 2-15 allows us to examine the change in multipliers over time and to compare the errors of the forecasting models with those of the no-change model.

While model estimation should be applied at the most disaggregate level available, we illustrate error measurements using data derived from a two-digit judgmental approach. All employment in construction, durable and nondurable manufacturing, mining, farming, the federal government, military, and hotel sectors is EBN. All other employment is assumed to be ECG. Models and errors are calculated from 1967–1983. Table 2-15 shows selected states and United States averages based on fifty states plus Washington, D.C.

TABLE 2-15

Ex Post Forecasting Information 1967–1983

				Mean % Error			*Mean Absolute % Error*		
	K1967	***K1972***	***K1983***	*Model A1*	*Model A2*	*No-Change Model*	*Model A1*	*Model A2*	*No-Change Model*
Connecticut	2.0	2.4	2.9	-2.2	-1.5	-1.4	2.2	2.0	2.3
District of Columbia	2.1	2.3	2.4	-0.7	0.5	0.3	1.3	41.1	11.2
Maryland	2.4	2.8	3.4	-2.2	-1.8	-1.7	2.2	1.8	2.1
New York	2.8	3.4	4.0	-2.2	-0.1	-0.2	2.2	2.1	1.2
Illinois	2.3	2.6	3.4	-2.3	-0.2	-0.3	2.3	1.7	1.8
Michigan	2.1	2.4	3.0	-2.0	-0.7	-0.6	2.7	1.4	3.2
Nebraska	3.0	3.2	3.8	-1.5	-1.8	-1.9	1.6	1.9	2.2
Florida	2.9	3.2	3.8	-1.6	-3.9	-4.3	2.2	4.0	4.7
South Carolina	1.8	1.9	2.2	-1.4	-2.6	-2.2	1.4	2.6	2.8
Colorado	2.7	2.9	3.2	-1.0	-3.8	-4.1	1.4	3.8	4.1
Wyoming	2.6	2.5	2.9	-0.7	-2.6	-3.9	1.9	2.7	4.9
Alaska	1.7	2.1	2.7	-2.8	-4.3	-4.6	2.9	5.9	5.3
U.S. Average	2.4	2.6	3.0	-1.5	-1.9	-2.0	1.9	2.3	2.8

In forecasting model A1, we use past figures for K_t to forecast K_{t+1}. For economic base model A2, we use an estimate of $S_{i,t+1}$, introducing a second potential source of error. Since we use the actual value of past employment, any error in models must originate in either changes in the K values for model A1 or in the K and the S values in model A2.

The first three columns in table 2-15 show the value for each state in 1967, 1972, and 1983, respectively. The K value for Connecticut in 1967 is 2.0. This means that

$$2.0 = \frac{E\ (1967)}{EXFG\ (1967) + EIL\ (1967)} = K \tag{2-135}$$

In Michigan, in 1972, the value of K was 2.4. Using an estimate from the United States of 0.8 for CG/Y (b = 0.78) and equation 2-46, we would infer that

$$2.4 = \frac{1}{1 - r \times b} \tag{2-136}$$

$$2.4 - 2.4 \times r \times 0.78 = 1 \tag{2-137}$$

$$r = (1 - 2.4)/[-(2.4)\ (0.78)]$$

$$= -(1 - 2.4)/-1.872 = .75 \tag{2-138}$$

The r value (the percentage of local consumption and exports supplied locally) is equal to .75 for Michigan. If this estimate were accurate, it would mean that for every dollar spent in or exported from this state, 75¢ goes to locally produced goods. It should be contrasted with our estimate of .49 for r in 1977, using data from the regional accounts that were derived from an operational model of the Michigan economy.

From equation 2-119, we have

$$\Delta E = 2.4\ \Delta EBN \tag{2-139}$$

This means that for each export or investment employee (EBN) in Michigan, there are also 1.4 employees whose jobs depend on local demand.

The average multiplier across all states increased from 2.4 in 1967 to 3.0 in 1983. This value increased fastest for northeastern and midwestern states, and slowest for southern and western states. Because the change in our multiplier is our source of error in forecasting, it deserves some discussion.

The K value is calculated as [(ECG + EBN)/EBN], in which we have judgmentally decided that most services are ECG, while most manufacturing is EBN. Service employment relative to manufacturing employment increased over the 1967 – 1983 period across the country and especially in northern and midwestern states. This sectoral shift from manufacturing to services might be explained by

- a decline in manufacturing without a corresponding decline in use of services, because the existing population increasingly uses savings, social security payments, etc., to buy local services;
- growth in services, such as banking and education, which are assumed by our judgmental model to be entirely for local use, yet may in fact include export services; or
- an increase in workers earning income outside of the state, which is then spent within the state.

The slowest growing K values in western and southern states could be explained by

- a decline in residents' spending of savings and social security payments for local services;
- a low amount or decline in exports of services such as banking and education; or
- an increase in workers' earning income in basic industries in these states that is then spent for services in other states.

The high value of K (3.8) for Florida in 1983 could be explained by a large number of retirees spending savings and social security payments on local services. Other high K values might be explained differently. Nebraska's high value, for instance, could be due to the high amount of sales per export employee. The high K value in New York could be due to services exported from New York, which we did not include in EBN. Wyoming was the only state over this period that showed only a small increase in its K value. This was possibly caused by an increase in workers' earnings in mining that were then spent outside of the state. The lowest K values were 1.7 (Alaska) and 1.8 (South Carolina) in 1967. Only 0.7 jobs in Alaska and 0.8 jobs in South Carolina were dependent on local demand for every one job dependent on exogenous demand. In the case of South Carolina, this might have been due to low wages for employees in manufacturing, which would lead to a high EBN value, but a low ECG value, since workers in manufacturing would have little to spend. The low K value of Alaska can be explained by looking at one of the unique characteristics of its economy — a high percentage of its consumption is supplied by imports.

The percentage error in the models shows the difference between predicted and actual employment. In the naive model, percentage error shows the rate of economic growth. Thus, the growth rate over the 1967 – 1983 period ranges from -0.3 in Washington, D.C., to 4.6% in Alaska. On average, the state and district economies expanded at a rate of 2% per year over the period.

The percentage error in economic base models A1 and A2 is somewhat lower than that of the naive model. As expected, model A1 produces more accurate forecasts than A2 because shifts in the multiplier account for all error in model A1, while changes in shares are an additional source of error in model A2. Although A1 produces better forecasts, we can only estimate this model if we know EBN_{t+1}. To project employment into the future, we must rely on model A2, for which we can obtain the necessary data from historical records and national forecasts.

In either case, the underprediction of employment is caused by sectoral shifts. We use multipliers estimated in year t to develop forecasts for year $t + 1$. Since the older multipliers are smaller than the actual multipliers, employment is systematically underestimated. In addition to this multiplier shift, the share of total United States employment changed in each state over the period of the forecast.

Model A2 underestimated employment by a great deal for states with high growth levels, such as Florida, Wyoming, and Alaska. We can infer that the use of the year t share coefficient led to a systematic underestimation of economic growth. If we observe that multipliers were growing quickly in these same states, we can see that the underestimation of the share coefficient and the multiplier would interact in our model, leading to a large underestimation of economic growth. On average, model A2 underestimated growth by 1.9%, which is only slightly better than the 2% error in our naive, no-change forecast.

The MAPE is the average of the absolute value of the percentage errors for each year of the forecast period. Colorado shows the same magnitude MAPE and MPE for the naive forecast. This indicates that all the errors were in the same direction. In this case, the no-growth forecast underestimated employment change in each of the years from 1967 to 1983. For almost all of the states and all forecasting models, however, the magnitude of the MAPE is greater than the MPE, indicating that errors of overprediction, as well as those of underprediction, occur.

Measured by the MAPE, forecasting models A1 and A2 both represented an improvement over the naive forecast. The MAPE is 2.8% for the naive model, 2.3% for model A2, and 1.9% for model A1. Again, we see that model A1 produces the least error. Unfortunately, it cannot be used for actual forecasts because we do not know the EBN values. However, it can be used for what-if scenarios if we hypothesize changes in EBN.

2-4 RECOGNIZING THAT REGIONAL OUTPUT AND INCOME DIFFER

The model developed in section 2-3 is designated as economic base model A hereafter. In that model, we consider income to be equal to output in an area. Yet, the income generated by production in a local area may often go to residents outside of the area. Conversely, the income of an area's residents may come from outside of the area. In making an economic prediction or carrying out a simulation for a region, it is vital that we take this distinction into account. For example, many people earn income in a city and live in the suburbs in a different county or state. Thus, when the economy of the city is stimulated, a high proportion of the generated income is respent in the suburbs and does not lead to further induced spending in the city. In the suburbs, induced demand using economic base model A would overestimate induced spending because a high proportion of spending depends on income earned outside of the region. This income is mainly exogenous instead of local, as assumed in economic base model A.

The amount of economic activity that is generated may be overestimated because we have the wrong model. In economic base model B, we separate income by place of work (Y) from income by place of residence (YP), recognizing the following three reasons for the discrepancy: 1) government transfers, 2) income earned from capital invested outside the place of residence, and 3) income earned by working outside of the place of residence. In this model, consumption and local government spending (CG) are a function of exogenous income (RDV), as well as output (Y). This allows for the differentiation between output and income.

Accounts

The accounts for economic base model B are built on economic base model A, with place-of-work income separated from place-of-residence income and with some additional flow variables added. In the accounts for model B, account A is defined on a place-of-work basis, while account B is defined on a place-of-residence basis. We show both the simple account A for economic base model A and the parallel account for economic base model B.

TABLE 2-16

Comparison of Account A for Models A and B

Account for Model A		Account for Model B	
A. State Product Account		A. State Product Account (Place of work)	
Uses	*Sources*	*Uses*	*Sources*
Y (output)	CG (consumption and local government spending)	YLPL (local earnings by local residents)	CG (consumption and local government spending)
	IL (local investment)	YLPU (earnings locally by nonresidents)	IL (local investment)
	XFG (exports, including federal government)	H (profits)	XFG (exports, including federal government)
	- M (imports)		- M (imports)
Y	Y	Y(gross state product)	Y(gross state product)

YLPL	Labor and proprietors' income earned in the state that stays in the state
YLPU	Labor and proprietors' income earned in the state by nonresidents of the state
H	Profits earned in the state

The source of local output (Y), i.e., gross state or gross regional product, is consumer and local government spending (CG), plus local investment (IL), plus exports including federal government spending (XFG), minus imports (M). The use of local income is now divided into laborers' and proprietors' income earned by residents (YLPL) and nonresidents (YLPU) of the state and the residual profits (H = Y - YLPL - YLPU).

TABLE 2-17

Comparison of Account B for Models A and B

Account for Model A		Account for Model B	
B. Personal and Local Government Income and Outlay Account		B. Personal and Local Government Income and Outlay Account (Place of residence)	
Uses	*Sources*	*Uses*	*Sources*
CG (consumer and local government spending)	Y (output)	CG (consumer and local government spending)	YLPL (local earnings by local residents)
S (personal savings and local government surplus)		SETC (residual, Account B)	UYLP (income earned rest of country by local residents)
			DIR (dividends, interest, rent)
			V (transfer payments)
Y	Y	YP (Personal Income)	YP (Personal Income)

UYLP	Labor and proprietors' income earned outside of the state by residents of the state
DIR	Dividends, interest, and rent received by residents of the state
SETC	Personal income not spent for consumption or state and local government expenditures. SETC includes federal taxes.
V	Net transfer payments including payments to and from the social security system

In table 2-17, account B for model B is a place-of-residence account, and both sides of the account are equal to the income of residents of the state. Output (Y) from our simple account is replaced by all sources of income for residents of the region: labor and proprietors' income earned within the state (YLPL) and outside of the state (UYLP); dividends, interest, and rent received by residents of the state (DIR); and net government transfers to residents of the state (V). The uses for the income are consumer and regional government spending (CG) and the residual (SETC), which includes federal taxes and local savings. The sum of both sides of the equation gives us the personal income of the residents of the state (YP). In account CD shown in table 2-18, we combine accounts C and D for model A into a residual account for model B. This catch-all account shows the uses and sources of funds for savings and investment and the rest the country. We show the residual account (CD) to complete the accounting system, but we do not enter it into our models directly.

TABLE 2-18

Comparison of Accounts C and D for Model A to Account CD for Model B

Accounts for Model A

C. Savings and Investment Account

Uses	*Sources*
IL (local investment)	S (personal savings and local government surplus)
IR (investment, rest of country)	
I	S

D. Rest of Country Account

Uses	*Sources*
XFG (exports including federal government)	M (imports)
	IR (investment, rest of country)
XFG	XFG

Account for Model B

CD. Residual Account

Uses	*Sources*
XFG (exports including federal government)	M (imports)
UYLP (income earned rest of country by local residents)	YLPU (earnings locally by nonresidents)
	H (profits)
DIR (dividends, interest, rent)	SETC (residual Account B)
V (government transfers)	
IL (local investment)	

The complete accounts for economic base model B are shown in table 2-19.

TABLE 2-19

Social Accounts for a State or Other Local Area

A. State Product Account (Place of work)

Uses	*Sources*
YLPL	CG
YLPU	IL
H	XFG
	− M
Y	Y

B. Personal Income and Outlay Account (Place of Residence)

Uses	*Sources*
CG	YLPL
SETC	UYLP
	DIR
	V
YP	YP

CD. Residual Account

Uses	*Sources*
XFG	M
UYLP	YLPU
DIR	H
V	SETC
IL	

The New Equations

The equations behind these accounts can be used as part of the basis for building regional economic base model type B. To assign values to the equations for economic base model B, we must use the available data, which is in the following form:

YLP *earned income by place of work.* The income earned in a region; and

RA *residence adjustment.* The net amount of the excess of earnings by local residents outside of the local area (UYLP) and earnings of out-of-area residents in the local area (YLPU).

Algebraically, these are

$$YLP = YLPL + YLPU \qquad (2\text{-}140)$$

and

$$RA = UYLP - YLPU \tag{2-141}$$

Adding equations 2-140 and 2-141, we obtain

$$YLP + RA = YLPL + UYLP, \tag{2-142}$$

which we substitute into account B. By also substituting equation 2-141 into account CD, we have a slightly altered set of accounts so that we can use the existing data. These accounts and their measured values for Michigan in 1977 are shown in table 2-20.

TABLE 2-20

Social Accounts for Any Region with Specific Estimates for Michigan in 1977

A. State Product Account (Place of Work) | B. Personal Income and Outlay Account (Place of Residence)

Uses		*Sources*		*Uses*		*Sources*	
YLP	55.0	CG	65.0	CG	65.0	YLP	55.0
		IL	16.2			RA	0.3
H	25.8	XFG	83.7			DIR	8.1
		-M	84.1	SETC	4.2	V	5.8
Y	80.8	Y	80.8	YP	69.2	YP	69.2

CD. Residual Account

Uses		*Sources*	
XFG	83.7	M	84.1
RA	0.3	H	25.8
DIR	8.1	SETC	4.2
V	5.8		
IL	16.2		
	114.1		114.1

YLP Labor and proprietor's income earned in the state.

RA Residential adjustment (UYLP-YLPU): The net of income earned in the rest of the country by state residents and the earnings in the state of nonresidents.

Using these accounts, we develop model B as an alternative to model A. We first recall the equations for model A, where equation 2-27 becomes equation 2-143, equations 2-35 and 2-40 are combined with equation 2-31 to become equation 2-144, and equations 2-33 and 2-41 are modified to become equation 2-145

$$BN = rXFG + rIL_p \qquad (2\text{-}143)$$

$$Y = rCG + BN = 0.49\ CG + BN \qquad (2\text{-}144)$$

$$CG = bY = 0.804\ Y \qquad (2\text{-}145)$$

For our type-B model, the equations for BN and Y remain the same. However, the equation for CG must be changed, since the determinant (Y) of local spending does not differentiate between local output and local income. It is much more appropriate to make local personal consumption and local government spending (CG) depend on local personal income (YP) rather than on local output. Thus, for model B, we use the relationship

$$CG = cYP \qquad (2\text{-}146)$$

The equation for YP can be written from account B as

$$\begin{aligned} YP &= YLPL + UYPL + DIR + V \qquad (2\text{-}147) \\ &= YLP + RA + DIR + V \\ &= YLP + RDV, \end{aligned}$$

where

$$RDV = RA + DIR + V \qquad (2\text{-}148)$$

To obtain the equation for YLP, we must assume that labor and proprietors' income remains at a constant proportion (p) of output (Y). Then, we can represent YLP ÷ Y = p as a constant. Thus,

$$YLP = p\ Y \qquad (2\text{-}149)$$

This makes the model complete, or more formerly closed, assuming that RDV is exogenous. We would not assume that the RA components of RDV in equation 2-148 are exogenous if the residential adjustment (RA) is negative. In that case, changes in Y would be expected to lead to changes in local earnings by workers who live outside of the region. In the case of a negative RA, it should be removed from equation 2-148 and included with YLP in equation 2-149. Other components of RDV are made endogenous in later models but offset each other somewhat, since V increases when Y decreases.

The New Multiplier

By substitution, we now write

$$BN = rXFG + rIL_p \tag{2-150}$$

$$Y = rCG + BN \tag{2-151}$$

$$CG = c(YLP + RDV) \tag{2-152}$$

To solve economic base model B, we can derive the multiplier. Alternatively, we can incorporate the new equations in an extended economic base model and solve it using an iterative solution method, as is shown at the end of this chapter. For the interested reader, we present a derivation of the multiplier for model B. We start by substituting equation 2-152 into equation 2-151.

$$Y = r \times c\ (YLP + RDV) + BN \tag{2-153}$$

Next, we substitute equation 2-149 into equation 2-153 to obtain

$$Y = r \times c(pY + RDV) + BN \tag{2-154}$$

Solving for Y gives us

$$Y - r \times c \times pY = (r \times c \times RDV) + BN \tag{2-155}$$

$$Y = \frac{(r \times c \times RDV) + BN}{1 - (r \times c \times p)} \tag{2-156}$$

The multiplier shows the change in output that occurs due to a change in exogenous variables. In economic base model B, we have an exogenous income multiplier (K_{RDV}) and an economic base multiplier (K_B). To determine K_{RDV}, we take the partial derivative of Y with respect to RDV or perform the same operations that we carried out for equation 2-70 with BN = 0, which yields

$$\frac{\Delta Y}{\Delta RDV} = \frac{\partial Y}{\partial RDV} = \frac{r \times c}{1 - (r \times c \times p)} = K_{RDV} \tag{2-157}$$

Similarly, the economic base multiplier is found by taking the partial derivative of Y with respect to BN or by performing the equation 2-70 operations with RDV = 0. This is

$$\frac{\Delta Y}{\Delta BN} = \frac{\partial Y}{\partial BN} = \frac{1}{1 - (r \times c \times p)} = K_B \tag{2-158}$$

The equation for Y is then

$$Y = (K_{RDV} \times RDV) + (K_B \times BN) \tag{2-159}$$

This equation shows that if RDV = 0, then Y = $K_B \times$ BN. If we note that, from equations 2-157 and 2-158, $K_{RDV} = r \times c \times K_B$, then we can express equation 2-159 as

$$Y = K_B\,[(r \times c \times RDV) + BN] \tag{2-160}$$

Substituting the parameters used to estimate K_B from equation 2-158 into equation 2-160, we solve the model for the reduced form in equation 2-161.

$$Y = \frac{1}{1 - (r \times c \times p)}\,[(r \times c \times RDV) + BN]\ , \tag{2-161}$$

where

$$r = \frac{Y}{CG + IL + XFG} = 0.49 \textit{ as before} \tag{2-162}$$

$$c = \frac{CG}{YP} = \frac{65}{69.2} = 0.94 \tag{2-163}$$

$$p = \frac{YLP}{Y} = \frac{55}{80.8} = 0.68 \tag{2-164}$$

We now determine the Michigan economic base model B multiplier.

$$K_B = \frac{1}{1 - r \times c \times p} = \frac{1}{1 - 0.313} = \frac{1}{0.686} = 1.46 \tag{2-165}$$

The exogenous income multiplier is calculated as

$$\begin{aligned} K_{RDV} &= K_B \times r \times c \\ &= 1.46 \times 0.49 \times 0.94 \\ &= 0.67 \end{aligned} \tag{2-166}$$

Note that both of the multipliers are lower than the model A multiplier of 1.65. We can infer that using 1.65 as the K multiplier would substantially overestimate the impact of a change in the economic base.

The smaller economic base multiplier estimated in economic base model B recognizes that some local spending is supported by income that is not related to local output. This lower multiplier also reflects that a portion of locally generated value added goes to outside owners of local capital (e.g., the shareholders of General Motors who live outside of Michigan and who, therefore, own part of that state's capital).

Even when we do not have the values in the accounts in table 2-16, we can still estimate the K_B value in terms of the data available for every state and county in the United States. We determine K_B in terms of RDV, YLP, and the K value in economic base model A. We begin by solving equation 2-153 for $r \times c$.

$$r \times c = \frac{Y - BN}{YLP + RDV} \tag{2-167}$$

Next, we substitute this expression into the model B economic base multiplier equation 2-158 and simplify.

$$K_B = \frac{1}{1 - \left[\frac{Y - BN}{YLP + RDV}\right] \times p} = \frac{1}{\frac{YLP + RDV - Y \times p + BN \times p}{YLP + RDV}} = \frac{YLP + RDV}{YLP + RDV - Y \times p + BN \times p} \tag{2-168}$$

Since p = YLP/Y from equation 2-149,

$$K_B = \frac{YLP + RDV}{YLP + RDV - Y\left[\frac{YLP}{Y}\right] + BN\left[\frac{YLP}{Y}\right]} = \frac{YLP + RDV}{RDV + (BN/Y)\ (YLP)} \tag{2-169}$$

Multiplying through by Y/BN, we obtain

$$K_B = \frac{(YLP + RDV)\ Y/BN}{RDV\ (Y/BN) + YLP} \tag{2-170}$$

Recognizing from equation 2-77 that Y/BN = K, we simplify this expression to

$$K_B = \frac{(YLP + RDV)\,K}{RDV \times K + YLP} \tag{2-171}$$

In the case of Michigan where RDV = 14.2 and YLP = 55.0 and K = 1.65, this yields

$$K_B = \frac{(55.0 + 14.2)\,1.65}{(14.2)\,(1.65) + 55.0} = 1.46\ , \tag{2-172}$$

which confirms our results from direct calculation in equation 2-165.

Thus, even for simple economic base studies, we can use RDV and YLP data that is publicly available from the Bureau of Economic Analysis (BEA) to improve the accuracy of the multiplier. Note that only in the case where RDV equals zero are K and K_B identical. We can apply this to the Adams County, Colorado multiplier above. Referring to the personal income table for Adams County, we find that for 1986 RDV = 730 (Residence Adjustment) + 306 (Dividends, Interest, and Rent) + 390 (Transfer payments of 519 less Social Insurance Contributions of 129) = 1,426 and YLP = 2,231. Therefore,

$$KB = \frac{(2{,}231 + 1{,}426)\,3.95}{(1{,}426)\,3.95 + 2{,}231} = 1.84 \tag{2-173}$$

This dramatic reduction in the multiplier from 3.95 to 1.84 indicates how important it may be to use model B in some situations. In this case, from the size of the residential adjustment (730), it is clear that many Adams County residents work outside of the county.

2-5 REPRESENTING AN EXTENDED ECONOMIC BASE MODEL

We conclude this chapter by summarizing economic base model B and extending this model to show the determination of personal income, employment, and the economic base. We also undertake to estimate values for the parameters of the model, the exogenous variables, and initial starting values for the endogenous variables. With these estimates in place and projected values for the exogenous variables, we have calibrated a model for forecasting and policy analysis. The model represented in the flow chart in diagram 2-11, in which arrows indicate causality, is a version of the model before we include employment explicitly.

Output (Y) is determined by the economic base (BN), consumption and local government spending (CG), and the local share of local sales (*r*). Local consumption and local government spending (CG) depend on personal income (YP) and the marginal propensity to consume (*c*). Output (Y), along with the proportion of output in income (*p*), and exogenous income (RDV) determine consumption and local government spending (CG).

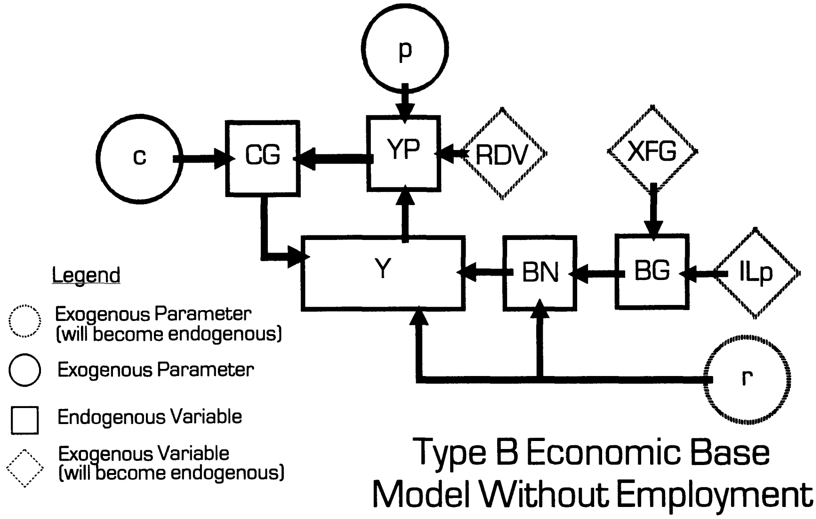


Diagram 2-11

We begin with the output equation shown earlier in this chapter. Here, output (Y) is equal to the sum of locally produced local consumption and government spending (*r*CG), plus the economic base (BN) in equation 2-144, which we repeat here.

$$Y = rCG + BN \tag{2-174}$$

Consumer and government spending (CG) are shown as a proportion of personal income (*c*YP) in

$$CG = cYP \tag{2-175}$$

The determinants of personal income (YP) can now be shown by substituting equation 2-149 into equation 2-147, giving us

$$YP = pY + RDV \tag{2-176}$$

in which personal income is a proportion of output (*p*Y) plus the residence adjustment; dividends, interest, and rent; and transfer payments (RDV). This concludes the model in diagram 2-11.

Next, we extend this model by showing personal income (YP) as a function of employment (E) and earned income per employee (*w*). We also extend it by determining employment endogenously. This complete economic base model B is shown in diagram 2-12, which shows the complete linkages. As in diagram 2-11, output is shown as a function of the local share of local sales (*r*), consumption and government spending (CG), and economic base (BN). Local government spending and consumption (CG) depend on personal income (YP) and the marginal propensity to consume (*c*). This measure of income is determined by the earnings rate (*w*), by employment (E), and by exogenous income (RDV). Employment is calculated with the labor per unit of output parameter (*epv*) in combination with endogenously determined output (Y). The economic base (BN) is shown as a function of United States interregional and international trade (XFG^u), local planned investment (IL_p), and their respective share coefficients (*s* and *r*).

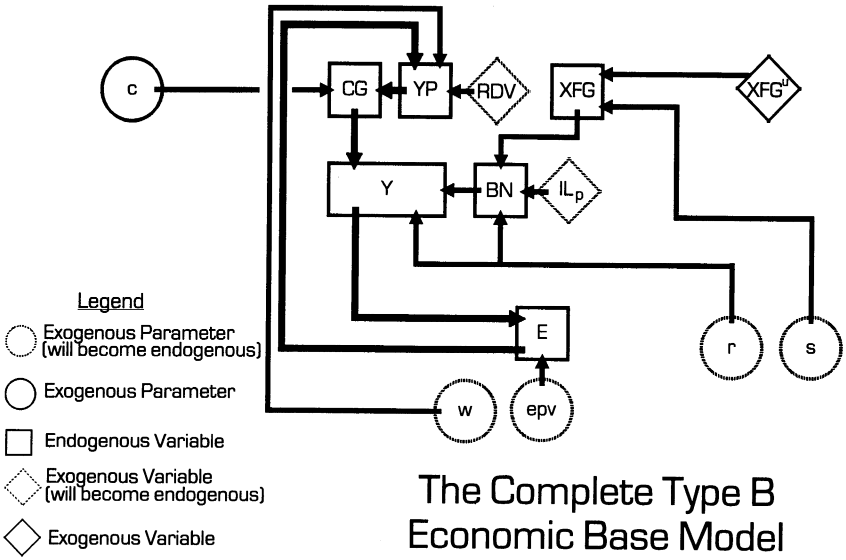


Diagram 2-12

The equation for output is the same as that given previously.

$$Y = rCG + BN \tag{2-177}$$

Consumer and government spending is determined by

$$CG = cYP, \tag{2-178}$$

and YP is found by substituting for YLP in equation 2-147. It is given in the following equation:

$$YP = (E \times w) + RDV, \tag{2-179}$$

where w = YLP/E (annual earnings (w) per employee are equal to labor and proprietors' income divided by employment in the last year for which data is available). Employment is endogenously determined as

$$E = epv \times Y, \tag{2-180}$$

where *epv* was also determined in the last year of data as $epv = E/Y$.

We show the economic base (BN) in terms of United States interregional and international trade and planned local investment.

$$BG = XFG + IL_p \qquad (2\text{-}181)$$

$$BN = rBG, \qquad (2\text{-}182)$$

where we show the economic base (BN) as the sum of the locally produced share of exports and federal government spending (*r*XFG) and local investment spending (rIL_p). To derive an expression for exports in terms of total United States international and interregional trade, we show the following relationship:

$$XFG = s \times XFG^u \qquad (2\text{-}183)$$

s regional share of interregional and international trade
XFG^u total United States interregional and international trade and federal government spending.

The value of *s* is also determined with the latest available data as $s = XFG/XFG^u$. We can then substitute equations 2-183 into equation 2-28 to give us

$$BG = (s \times XFG^u + IL_p) \qquad (2\text{-}184)$$

Thus, the gross economic base (BG) is equal to the region's exports ($s \times XFG^u$) plus planned local investment (IL_p).

The link between one area and the rest of the nation in this economic base model is through demand for interregional and international trade in the rest of the country and federal government spending (XFG^u) and through investment (IL_p), as it affects the local area's economic base (BG). It also depends on direct income payments from the rest of the country to households in the local area (RDV). Employment and output, as well as consumption and local government spending, are all determined within the local system. Therefore, a change in the economy is the result of changes in interregional trade, investment, or exogenous income.

This model will produce exactly the same results as economic base model B. When *w* is substituted into the YP equation (2-179), $E \times w$ becomes $E \times (YLP \div E) = YLP$, as it was originally in equation 2-147. The purpose for breaking out *w*, *epv*, and E is to present the economic base model in a way that integrates the employment and dollar units in the same model. It also allows us to see what parts of the economic base model may be unduly rigid. With explicit parameters and exogenous variables, it is possible to closely examine the assumptions that led to the choice of the endogenous variables for the model.

A variable should not be classified as an exogenous variable or parameter instead of an endogenous variable if it is influenced by the values of endogenous variables. There are many cases where this situation exists in this model. Investment (IL_p) is influenced by local activity and relative factor costs. Both the share of national markets (*s*) and the region's share of goods and services purchased in the region (*r*) are influenced by cost and profitability conditions, and (*r*) may also be influenced by the size of the local market. The employees per unit of value added (*epv*) are affected by relative factor costs and productivity changes. The residence adjustment, property income, and transfer payments (RDV) change as the size of the population and economic conditions change. Finally, the earnings rate (*w*) is sensitive to the supply-and-demand conditions for labor in the area. When we further extend modeling in the following chapter, we explain more variables endogenously.

We can see that there are inherent shortcomings in the economic base model that must be overcome before we can do realistic forecasting or policy analysis. On the other hand, the economic base model serves as a good starting point. It is the simplest regional economic model possible. It can be stated in its structural form and in its reduced form. The reduced-form multiplier K can be measured using available data for any county or state in the United States. Finally, we can build on the economic base model by developing equations to explain some of the exogenous variables and parameters in the model, making them into endogenous variables. We undertake this task in the next chapter.

The final tasks in this chapter are to gather the equations for the model, to find the values for the parameters, exogenous variables, and initial values of the endogenous variables, and then to use them in a program to create a baseline forecast and a simulation. The equations are

$$Y = PP \quad (2\text{-}185)$$

$$XFG = sXFG^u \quad (2\text{-}186)$$

$$BG = XFG + IL_p \quad (2\text{-}187)$$

$$BN = rBG \quad (2\text{-}188)$$

$$E = epv\, Y \quad (2\text{-}189)$$

$$YP = YLP + RDV \quad (2\text{-}190)$$

$$YLP = E \times w \quad (2\text{-}191)$$

$$CG = cYP \quad (2\text{-}192)$$

$$IL_{up} = Y - PP \quad (2\text{-}193)$$

$$PP = rCG + BN \quad (2\text{-}194)$$

Parameters	Exogenous Variables	Endogenous Variables	
s		Y	E
r	XFG^u	PP	YP
epv	IL_p	XFG	YLP
w	RDV	BG	CG
c		BN	IL_{up}

To have a complete model, we need to find values for the parameters and for the exogenous variables. In general, for an iterative approach to model solution, it facilitates matters to have starting values for the endogenous variables as well. The best way to find the values for the parameters, the exogenous and initial endogenous variables is to look first for values that are key and that we can find easily. We then use these values to determine more values, and so on, until all the necessary values have been obtained.

A key value to find is the employee (E) to output (Y) ratio (*epv*), because this will make it possible to estimate the values for many of the other variables. Since output is only measured for states and not for counties, we turn to Colorado data. To be consistent with the way in which data was obtained for Adams County in 1987, we find 1,169 thousand Colorado private employees from the 1987 CBP for Colorado and add 323 thousand government employees in 1987 from the BEA Regional Economic Information System for Colorado (REIS) data set (table CA 5, 6/22/92) to obtain total Colorado employment of 1,492 thousand. The gross state product (Y) for 1987 for Colorado is 59.630 billion dollars.[17] Thus,

$$\mathit{epv} = 1{,}492 \text{ thousand employees}/59.630 \text{ billion dollars}$$
$$= 25.0 \text{ thousand employees per billion dollars of output}$$
(or 25 employees per million dollars of output).

Since the same *epv* is used for all types of output in this model, we can use this to convert employment numbers from table 2-13 into value added output numbers using equations 2-87 – 2-90.

$$Y = E/epv = 97.009/25.0 = 3.880 \textbf{ billion dollars} \quad (2\text{-}195)$$

$$BN = EBN/epv = 24.573/25.0 = .983 \textbf{ billion dollars} \quad (2\text{-}196)$$

$$rIL_p = EIL_p/epv = 4.860/25.0 = .194 \textbf{ billion dollars} \quad (2\text{-}197)$$

$$rXFG = EXFG/epv = (24.573 - 4.860)/25.0 = .789 \text{ billion dollars} \quad (2\text{-}198)$$

$$rCG = ECG/epv = 72.436/25.0 = 2.897 \text{ billion dollars} \quad (2\text{-}199)$$

$$PP = Y = 3.880 \text{ billion dollars} \quad (2\text{-}200)$$

$$rBG = BN = .983 \text{ billion dollars} \quad (2\text{-}201)$$

Next, if we can estimate the value of r the other values will be easy to find. First, we find c and YP in order to calculate CG with equation 2-192. After finding CG, we can then calculate r from the equation rCG = 2.897 above.

The value of c can be observed at the United States level by taking the ratio of consumption ($3,052[18]) plus state and local government spending ($497[19]) divided by personal income ($3,802[20]).

$$c = (3,052 + 497)/3,802 = .93 \quad (2\text{-}202)$$

The values for YP and RDV are found from the REIS, BEA data set and are the values used at the end of section 2-4.

$$RDV = 1.426$$

$$YP = RDV + YLP$$

$$= 1.426 + 2.231 = 3.657 \quad (2\text{-}203)$$

Thus,

$$CG = .93 \times 3,657 = 3,401, \quad (2\text{-}204)$$

and

$$rCG = 2.897$$

$$\therefore r = 2.897/3.401 = .85 \quad (2\text{-}205)$$

From the above, we can also find

$$IL_p = .262/.85 = .308 \quad (2\text{-}206)$$

$$XFG = .721/.85 = .848 \quad (2\text{-}207)$$

$$BG = .983/.85 = 1.156 \quad (2\text{-}208)$$

Note that r = .85 is lower than our previous estimate of r = .96. However, it still seems high for a county.

We have now completed all of the values for the endogenous variables, except inventory change (IL_{up}), which we assume to be zero. The exogenous values for IL_p and RDV are established for the base year.

For the value of XFG^u, we will use the fraction of nonfederal government U.S. output going to interstate and international trade, estimated as 43.7% using a model of the type presented in chapter 7 for all states plus federal government expenditures. For 1987 through 1991 in 1987 dollars, this is[21]

1987 $\quad$ **2,200 = .437 × (4540 − 385) + 385**

1988 $\quad$ **2,275 = .437 × (4719 − 377) + 377**

1989 $\quad$ **2,325 = .437 × (4837 − 375) + 375**

1990 $\quad$ **2,349 = .437 × (4885 − 381) + 381**

1991 $\quad$ **2,336 = .437 × (4850 − 385) + 385**

Using the 1987 value and equation 2-186, the value of the parameter s is established as

$$s = XFG/XFG^u = .848/2{,}200 = .000385 \qquad (2\text{-}209)$$

The parameter value w is calculated from equation 2-191 as

$$w = YLP/E = 2.231 \text{ billion}/97.009 \text{ thousand} \qquad (2\text{-}210)$$

$$= .0230 \text{ billion per thousand}$$

(or million per employee)
(i.e., $23,000 per employee).

To make a five year forecast, it is necessary to project all of the exogenous variables forward for five years. If we use United States growth proportions in lines 1 and 3 in table 2-21 to project IL_p and RDV in lines 2 and 4 of the same table over the period, we would project the following:

TABLE 2-21[22]

"Projections" of IL_p and RDV based on United States Data

	1987	1988	1989	1990	1991
I^u_t/I^u_{1987}	1.00	1.032	1.053	.994	.900
IL_p (in 1987 dollars)	.308	.318	.324	.306	.277
RDV^u/RDV^u_{1987}	1.00	1.035	1.055	1.076	1.074
RDV (in 1987 dollars)	1.426	1.476	1.504	1.534	1.532

This completes that calibration of the model.

To facilitate policy simulations with the model, we introduce multiplicative and additive policy variables. The model with these policy variables is as follows:

$$Y = PP \qquad (2\text{-}211)$$

$$XFG = (s \times PVsM)(XFG^u + PVXFGUA) \qquad (2\text{-}212)$$

$$BG = XFG + (IL_p + PVILPA) \qquad (2\text{-}213)$$

$$BN = r(PVrM \times PVrBGM)(BG + PVBGA) \qquad (2\text{-}214)$$

$$PP = r(1 + PVvM)\ CG + BN \qquad (2\text{-}215)$$

$$E = (epv \times PVeM) \times Y \qquad (2\text{-}216)$$

$$YLP = E \times (w \times PVwM) \qquad (2\text{-}217)$$

$$YP = YLP + (RDV + PVRDVA) \qquad (2\text{-}218)$$

$$CG = c(PVcM)YP + PVCGA \qquad (2\text{-}219)$$

$$IL_{up} = Y - PP \qquad (2\text{-}220)$$

The default values for the policy variables and the baseline forecasts using these values is shown in table 2-22.

TABLE 2-22

Policy Variables
Baseline Values

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
PVrM	1	1	1	1	1
PVrBGM	1	1	1	1	1
PVsM	1	1	1	1	1
PVeM	1	1	1	1	1
PVwM	1	1	1	1	1
PVcM	1	1	1	1	1
PVBGA	0	0	0	0	1
PVCGA	0	0	0	0	0
PVILPA	0	0	0	0	0
PVRDVA	0	0	0	0	0
PVXFGUA	0	0	0		0
Y	3.868	3.998	4.078	4.108	4.054
PP	3.867	3.999	4.079	4.109	4.054
XFG	0.847	0.876	0.895	0.904	0.899
BG	1.155	1.194	1.219	1.210	1.176
BN	0.982	1.015	1.036	1.029	1.000
E	96.693	99.958	101.946	102.698	101.361
YP	3.650	3.775	3.849	3.896	3.863
CG	3.394	3.511	3.579	3.623	3.593
ILup	0.001	-0.001	-0.001	-0.001	0.001
YLP	2.224	2.299	2.345	2.362	2.331

Table 2-23 shows the alternative less the baseline (or control) forecast with policy variable PVBGA increased by 1.176 (1.00/.85) in the alternative, which increases BN by 1.00. This shows the effect of increasing BN by one, which increases Y by approximately 1.84 and confirms the multiplier calculated in section 2-4. Table 2-24 shows the effects of increasing PVRDVA by 1.00 in each forecast year. This gives us the multiplier for increased exogenous income.

TABLE 2-23

Adams County Extended Economic Base Model

Effects of Increasing BN by Approximately 1.00

	1987	1988	1989	1990	1991
PVBGA	1.176	1.176	1.176	1.176	1.176
Y	1.830	1.833	1.832	1.833	1.833
PP	1.831	1.833	1.832	1.832	1.832
XFG	0.000	0.000	0.000	0.000	0.000
BG	0.000	0.000	0.000	0.000	0.000
BN	0.999	0.999	1.000	0.999	1.000
E	45.745	45.814	45.815	45.815	45.814
YP	1.052	1.054	1.053	1.054	1.054
CG	0.979	0.980	0.980	0.980	0.980
IL_{up}	-0.002	0.000	0.000	0.000	0.000
YLP	1.052	1.054	1.053	1.054	1.054

TABLE 2-24

Adams County Extended Economic Base Model

Effects of Increasing RDV (Exogenous Income) by 1.00

	1987	1988	1989	1990	1991
PVRDVA	1.000	1.000	1.000	1.000	1.000
Y	1.446	1.450	1.449	1.449	1.450
PP	1.448	1.449	1.449	1.449	1.449
XFG	0.000	0.000	0.000	0.000	0.000
BG	0.000	0.000	0.000	0.000	0.000
BN	0.000	0.000	0.000	0.000	0.000
E	36.169	36.231	36.231	36.231	36.230
YP	1.832	1.833	1.833	1.833	1.834
CG	1.704	1.705	1.705	1.705	1.705
IL_{up}	-0.002	0.000	0.000	0.000	0.000
YLP	0.832	0.833	0.833	0.833	0.834

Comparing the two simulations, we find that the output multiplier for changes in net exports (BN) is 1.83, while the multiplier for exogenous income (RDV) is 1.45. The main effect of the RDV increase shows up in increased YP and CG. This demonstrates that extra exogenous income can be as important as an increase in exports in expanding the size of the local economy and the number of jobs in that economy.

Note that both of the simulations show the same effect each year. This is because the model is entirely linear and does not reflect any of the dynamic elements that are almost certainly a part of regional economies.

The extended economic base model in this chapter is our starting point in the next chapter. All of the key elements of model building have been presented in the context of this model. Even though the extended economic base model is not realistic enough to be of much value for policy analysis, it provides a framework on which to build. It also allows us to show how a model can be specified, calibrated, and used for forecasting and policy analysis. The reader is encouraged to try out other policy analysis experiments with this model and to develop interpretations of the resulting predicted effects.

APPENDIX: Chapter 2

The Regional Economic Modeling System (REMS): Information on Installation and Execution

Installation Procedures

The REMS system is available from the author, as noted previously. It includes models for the chapters in part I. The REMS is on 1 high-density floppy disk and, depending on the size of the diskette drive, is either 1.2MB (5' inch) or 1.44MB (3' inch) capacity. The REMS can only be executed on the hard-drive, so it should be installed on the hard-drive first. Approximately 2MB of hard-disk space is required, and 4MB is recommended. To install the REMS, please follow these steps:

1. Make a working copy of the master REMS floppy disk, using either a 1.2MB or a 1.44MB empty diskette.
2. Insert the working copy disk in either drive A: or B:. Switch the system prompt to "A:" or "B:" where the floppy disk is inserted, then type INSTALL <Enter>.
3. Indicate the drive and directory on the hard disk where the REMS is to be installed when the REMS Installation dialogue box is shown on the screen. For example, an answer would look like the following:

   Target Drive and Directory: C:\REMS<Enter>
4. It should take three to five minutes for the installation process to be completed. The program indicates when the REMS is completely installed. Call Regional Economic Models, Inc. (REMI) at 413-549-1169 if the installation takes more than fifteen minutes.
5. Changes to the **CONFIG.SYS** (the system configuration file) may be necessary to properly run the model. The REMS runs best with **FILES=30** and **BUFFERS=20** or greater. Please refer to your DOS manual for more information about how to change the **CONFIG.SYS**.

Using the REMS

Move to the target drive and directory where the program has already been installed, and type **REMS<Enter>** to execute the software. The REMS is menu-driven and easy to use. Once the REMS is executed, use the arrow keys to move the cursor bar to select a choice. Press **<Enter>** to run the selection. The instruction menu should be read for an introduction to REMS, its models, data, tables, and other utilities before executing any other functions.

NOTES ON CHAPTER 2

1. This chapter is adapted in part from George I. Treyz (1986). The chapter was also written in part by Frederick Treyz.

2. The identity output = income assumes that all value added by local production (wages, profits, rents, etc.) is paid out to households or to local governments (through local taxes). This assumption is dropped later in the chapter.

3. Note that net inflows to the state could be used to finance CG rather than IL, if they exceed the value of local investment (IL).

4. In the traditional economic base model, IL_p is combined with CG and considered endogenous. We do not combine them because it is difficult to envision IL_p, which includes investment to build new capital stock, to be a fraction of a flow variable, such as income.

5. Any points off the 45-degree line imply that output exceeds expenditure or expenditure exceeds output. If this were the case, we would observe an unplanned inventory increase (or decrease), which would lead businesses to lower (or raise) output until output reached the equilibrium point.

6. *Business Statistics 1961-88* (December 1989), page 3.

7. For a more complete treatment of this subject see Marschack, J. (1953).

8. The source for this table (2-9) is 1987 County Business Patterns, Bureau of the Census, U.S. Department of Commerce for the first ten sectors and Regional Economic Information Systems (REIS) from the Bureau of Economic Analysis (BEA) for the last two sectors.

9. The complete data for any county or state are available in university libraries and directly from the Bureau of the Census by calling (202) 763-4100 or writing Customer Service Branch, Data Users Service Division (DUSD), Washington Plaza, Bureau of the Census, Washington, D.C. 20233.

10. Source for table 2-10: 1987 County Business Patterns, Bureau of the Census, U.S. Department of Commerce.

11. Source for table 2-11: same as 10 *supra*.

12. Hereafter, the abbreviation *n.e.c.* will appear in place of the phrase "not elsewhere classified."

13. Source for table 2-12: 1987 County Business Patterns, Bureau of the Census, U.S. Department of Commerce.

14. Source for table 2-13: 1987 County Business Patterns.

15. Source for table 2-14: 1987 County Business Patterns.

16. All from the *Survey of Current Business* (SCB) Vol. 72, No. 1, table 1.1, January, 1992, p. 25.

17. *Survey of Current Business*, Vol. 71, No. 12, December 1991, table 4, p. 50.

18. *Survey of Current Business*, Vol. 72, No. 1, table 1.1, p. 25.

19. Idem.

20. Ibid, Table 2.1, p. 33.

21. All data from *Survey of Current Business*, Vol. 72, No. 1, January 1992, p. 5 and 25.

22. Ibid, table 1.2, p. 25; 2.1, p. 33; 1.1, p. 5.