APEC 5152 - Handout 3

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Measuring the Macroeconomy

Contents

1 Introduction

Typical macroeconomic thinking begins by assuming households own all factors of production. For our purposes, assume there are two factors – capital and labor.

1. Households let firms use their capital and labor
2. Firms rent capital from households and pay them wages for labor services - income.
3. Firms use the capital and labor services provided by households to produce goods and services.
4. Households purchase the goods and services produced by firms - expenditure.

Every introductory and intermediate macroeconomics text I have read present these four activies in a "circular flow" diagram. In figure 1, the blue curve "Labor" represents the flow of capital and labor services from households to firms, while the green curve "Income ($)" represents the wage and rental payment firms pay households. The blue curve "Goods" represents the goods and services produced by firms for sale to households, while the green curve "Expenditure ($)" represents the expenditures households make to firms to purchase the goods and services.

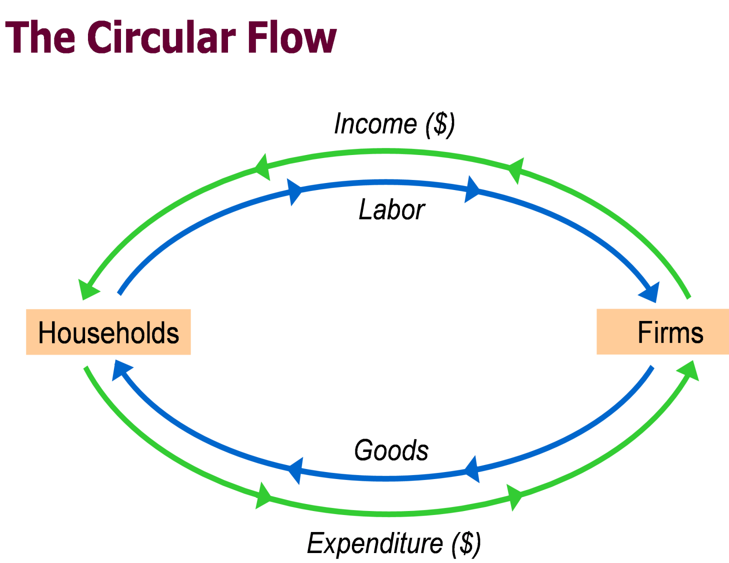

Figure 1. The circular flow diagram

2 The Social Accounting Matrix

The numerical analog of a circular flow diagram is a construct called the social accounting matrix (SAM). A SAM is a double-entry accounting system that owes its origins to the work of Nobel Laureate, Sir Richard Stone, founder of the United Nations' System of National Accounts (SNA).[1] A SAM shows the major flows of income sources and expenditures of an economy over a specific time period, usually one year. It shows the major economic transactions among the various agents of an economy, for the given period of time. Table 1 presents a SAM that would *roughly* correspond to figure 1.[2]

Table 1. A two sector Social Accounting Matrix

	Activity-		Commodity-		Factor		Agent	Accum	Total
	Ag	Non-Ag	Ag	Non-Ag	Labor	Capital	Household		
Activity-									
Ag			Sales_A						Prod_A
Non-Ag				Sales_N					Prod_N
Commodity-									
Ag							Cons_A	Invest	Demand_A
Non-Ag							Cons_N		Demand_N
Factor									
Labor	Wages_A	Wages_N							Lab Inc
Capital	Rent_A	Rent_N							Cap Inc
Agents									
Household					Wages	Rent			Income
Accum							Savings		Savings
Total	Cost_A	Cost_N	Supply_A	Supply_N	Lab Pay	Cap Pay	Expenditure	Invest	

In econ-speak, the SAM in table 1 represents the economic activity of a two-sector, closed, economy, with two productive factors, labor and capital. In this model, there is no government and, being a closed economy, there is no trade. The SAM for this model has five account categories: activity,

[1]See Robinson (1989) for a good discussion of social accounting matrices.

[2]Roughly because the SAM includes a savings account (Accumulation), while the circular flow diagram does not include a savings account.

commodity, factor, agent, and accumulation. Activity accounts summarize the economic costs (column entries) and receipts (row entries) for production activities. Commodity accounts summarize the value of market demand (column entries) and supply (row entries) of the goods and non-factor services produced in the economy (activities). Factor accounts summarize the payments to factors (column entries) and income received for the use of capital and labor services (row entries). The agent account gives the sources (row entries) and uses (column entries) of income, while the accum (short for accumulation) account gives the supply (column entries) and demand (row entries) of investment (i.e., invest) income.

Observe that a SAM is a square matrix. Each row in the matrix represents an "account" that has a matching column account. For example, the row "Labor" in table 1 has a corresponding column "Labor," and the row "Activity-Ag" has a corresponding column "Activity-Ag." In the discussion below, we'll let Ag and Non-Ag represent the agricultural and non-agricultural sectors of an economy.

Each cell in the SAM represents the payment from the account of its column to the account of its row. The intersection of accounts "Activity-Ag" and "Labor" in table 1, is the value of exchange between the agricultural sector and labor: the payment from the agricultural sector to households for the flow of labor services provided. The intersection of accounts "Activity-Ag" and "Capital" is the payment from the agricultural sector to households for the use of its capital. The sum of entries along a row account gives the total receipts for that account, while the sum of entries down a column account gives the total expenditures of that account.

The double-entry bookkeeping feature of the SAM requires the row sum of an account to be equal to its corresponding column sum. Hence, a necessary condition for table 1 to represent a correctly constructed SAM is for the following equalities to hold: $\text{Cost}_j = \text{Production}_j$ $\text{Supply}_j = \text{Demand}_j$, $j = A, N$; Lab Pay = Lab Inc, Cap Pay = Cap Inc, Expenditure = Income, and Savings = Investment.

A non-technical description of the two-sector SAM

As noted above, when moving down a column, a column entry represents the value of expenditures paid from one account to another – when moving along a row, a row entry represents the value of receipts one account receives from another. Consider first, the interpretation of a typical cell column entry, where the intersection of an account column (e.g. Activity-Ag) with an account row (e.g., Labor) gives the value of payment made from the row account to the column account. The first account, "Activity," has two columns that identify the production activities Ag and Non-Ag. Each cell down the column "Activity-Ag" records the total payment from the agricultural sector to an account category. For example, the cell entry "Wages_A" is the *value* of wages paid to the flow of labor services used in agricultural production, while the cell entry "Rent_A" is the *value* of rent paid for the flow of capital services used in agricultural production. Thus, in this example, the column sum for Activity-Ag

$$\text{Cost}_A = \text{Wages}_A + \text{Rent}_A$$

is the total cost of labor and capital used to produce agricultural output. Then, the total value of a movement down the "Activity-Ag" column account corresponds to the green curve "Income ($)" in figure 1 (strictly speaking, a movement down both Activity- columns corresponds to the "Income ($)" curve). A similar interpretation of cell entries extends to "Activity 2."

Next, consider the row entries corresponding to activity accounts. Again, there is a row associated with the Ag and Non-Ag activity accounts. The intersection of Activity-Ag's row and Commodity-Ag's column is the value of domestic demand of agricultural output. Hence, "Sales_A" is the value of agricultual demand, while "Sales_N" is the value of Non-Ag demand. The double entry account system requires that total receipts be equal to total costs, and hence the row sum must be equal to the column sum, i.e.,

$$\text{Demand}_A = \text{Supply}_A \quad \text{and} \quad \text{Demand}_N = \text{Supply}_N$$

Commodity accounts summarize the value of market transactions associated with the products generated in activities 1 and 2. With no trade, the column entry for commodity j is simply the value of domestic sales of good j, "Sales_j," where $j = 1, 2$. Here, moving down the column of Commodity 1, "Sales_1" is the market value of payments to producers of good 1. Of course, with constant returns to scale, in a competitive equilibrium and closed economy, "Sales_1" is exactly equal to "Cost_1," the cost of producing good 1. Moving along the row of Commodity j, the entry "Sales_j" is simply the total revenue received by producers of good j.

Consider next the two factor columns, labor and capital. The income from factors accrue to households. In the "Labor" column, the entry "Wages" is the value of wages paid to households in return for their labor services. In the "Capital" column, "Rent" is the value of rent paid to households for use of their capital stock. In the factor rows, "Wages_A" ("Wages_N") is the value of wages paid for labor services rendered to agriculture (non-agriculture), while "Rent_A" ("Rent_A") is the value of rental payments for capital services rendered to agriculture (non-agriculture). As with the activity and commodity accounts, the SAM's double entry nature requires that

$$\text{Lab Pay} = \text{Lab Inc}$$

i.e., the value of labor payments from firms to households is exactly equal to the value of income households receive for their labor services. Similar arguments hold for capital rental payments and rental income.

Moving down the Household column, we have total expenditures on the agricultural and non-agricultural goods, A and N, and the non-consumption income diverted to savings. Here, "Cons_j" is the domestic household expenditure on good $j = A, N$. "Savings" is the amount of its income the household makes available (payment) to the capital market. Notice the savings of domestic households appears in a separate row referred to as "Accumulation." The household column entries shows that income is spent on consumption goods and savings. Moving along the Household row we find the total factor payments to households for the use of their labor and capital services. Here, "Wages" is the total value of wages received by households in exchange for labor service flows, while "Rent" is the total value of capital rent received by households in exchange for capital services flows.

The SAM alone does not specify or depict any behavioral and institutional characteristics of a market economy. Instead, the SAM is a collection of identities over economic objects. For example, if it is not yet obvious,

$$\text{Cost}_A + \text{Cost}_N = \text{Demand}_A + \text{Demand}_N = \text{Lab Inc} + \text{Capital Inc}$$

where the first sum is valued added GDP, the second sum is the expenditure measure of GDP, and the last sum is the income measure of GDP. This income is used for consumption or savings. In other words, the SAM organizes data based on economic identities which, in turn, we link to a model that exploits the myriad relationships among economic variables.

Value-added

Intermediate macro texts typically give an example of calculating the value-added of a production chain. The example goes like this: Yang produces ice cream. Each quart of ice cream requires 3 cups of cream, one teaspoon of vanilla extract, and one cup of honey. Yang buys these ingredients from John at 50 cents per cup of cream, 10 cents per teaspoon of vanilla extracts and 40 cents per cup of honey. If the ice cream sells for three dollars per quart, value-added is one dollar. What's sometimes left unsaid, is Yang needs to combine labor and machinery (capital) with the cream, vanilla and honey to produce ice cream. So, value-added, the part that remains after paying John for her ingredients, is paid out to capital and labor. In this case, the cream, vanilla extract and honey are *intermediate inputs* used to produce ice cream.

How does value-added enter into a SAM? Table 2 introduces number entries into the rows for "Commodity" A and N. The value 12561.4 is the amount the agricultural sector pays to itself for intermediate inputs like cream and butter. The value 9156.5 in the Commodity A row is the amount the agricultural sector pays to the non-agricultural sector for intermediate inputs like fertilizer and energy. The value 9156.5 in the Commodity N row is the amount the non-agricultural sector pays to the agricultural sector for intermediate inputs like cowhide used to produce leather shoes and jackets. Now, the total cost of agricultural production is 121347 and the total cost of non-agricultural production is 73894. These values, which include the cost of labor and capital along with the cost of intermediate goods is called *gross value.* In the ice cream example, this gross value is equivalent to the $4 per quart of ice cream. As in the above example, value-added is calculated as the difference between gross value and the cost of intermediate inputs.

Table 2. Two-sector SAM for Turkey (trillion of 2001 Turkish lira)

	Activity		Commodity		Factor		Agents	Accumulation	Total
	A	N	A	N	Capital	Labor	Household		
Activity									
A			121347.0						121347.0
N				73894.0					73894.0
Commodity									
A	12561.4	9156.5					99629.1		121347.0
N	9156.5	7530.4					52511.6	4695.5	73894.0
Factor									
Capital	46895.7	29672.0							76567.7
Labor	52733.4	27535.1							80268.5
Agents									
Household					76567.7	80268.5			156836.2
Accumulation							4695.5		4695.5
Gross value	121347.0	73894.0	121347.0	73894.0	76567.7	80268.5	156836.2	4695.5	

3 Additional Details on SAMs

We now turn to a more technical discussion of the SAM. Here we give a precise definition of prices and cell entries, and show the conditions that ensure the sum of row account entries are equal to the sum of corresponding column account entries. This section is not required reading.

The most important assumption typically imposed on the data is that it was generated by a market clearing - equilibrium process. The existence of an equilibrium not only implies the data organized in the SAM are balanced, but also that they are derived from the outcomes satisfying the rationality assumption of agents in the economy, i.e., consumers maximize utility and firms maximize profit. In table 3, the following two market clearing conditions are exploited

$$Y_A = Q_A \tag{1}$$

$$Y_N = Q_N + S \tag{2}$$

Here, Q_A is aggregate quantity of agriculture demanded by the household, Q_N is aggregate quantity of non-agricultural output demand by the household, and S is the quantity of non-ag output saved.

The value of total investment is equal to $p_N S$, while the value of total consumption is equal to $p_A Q_A + p_N Q_N$. Production technologies satisfy constant returns to scale. It follows that the total value of production received by producers is equal to the payments to all factors of production (discussed later). Also, one advantage of these units is we can set each output price p_j equal to unity in the base case equilibrium. Professor Tim Kehoe of the U of M's Economics Department suggests we can think of these variables as price indices, which are naturally set equal to one in the base period. In practice, we index the inital labor supply to unity so that w is total wage payments. Table 3 presents a two-sector SAM with these more technical formulations as cell entries.

Table 3. A more technical two-sector SAM

	Activity		Commodity		Factor		Agents	Accum	Total
	A	N	A	N	Labor	Capital	Household		
Activity									
A			Y_A						Y_A
N				pY_N					pY_N
Commodity									
A							Q_A		Q_A
N							pQ_N	S	$pQ_N + S$
Factor									
Labor	wL_A	wL_N							wL
Capital	rK_A	rK_N							rK
Agents									
Household					wL	rK			GDP
Accumulation							S		S
Total	$C^A(w, r, Y_A)$	$C^N(w, r, Y_N)$	Y_A	pY_N	wL	rK	$TotExp$	S	

The sum of all Activity j column entries is $C^j(\cdot) = wL_j + r^k K_j$, the total cost of producing Y_j units of good j. The sum of all Activity j row entries is $p_j Y_j$. One can show that with constant returns to scale, $C^j(w, r, Y_j) = p_j Y_j$. In other words, the market value of sector j output is exactly equal to the cost of producing that output. The sum of all Commodity j column entries is simply $p_j Y_j$, the market value of good j supply. The sum of all Commodity j rows is equal to the receipts from the sale of commodity j, i.e., the value of consumption, or in the case of commodity 1, the value of consumption plus investment.

4 Production of National Income

Economists typically view the process of generating gross domestic product as one where inputs are combined to produce goods and services. Inputs are often called *factors of production*, and a most basic categorization of these factors is capital assets and labor. Capital and labor are *stock* variables (meaning they are measured at a point in time), which can provide a *flow* of services to firms. Households own the stocks of capital and labor and rent these assets to firms for a specified period of time. In turn, the assets generate a flow of services for the firms.

Economists typically represent the production process with a production function

$$Y = f(K, L)$$

where K represents capital and L represents labor. An economy will have a limited stock of each factor (i.e., a limited stock of capital and labor), and this limited stock is referred to as the economy's *factor endowment*. For our purposes, let Y represent the real value of goods and services produced by the economy.

Table 4. National Income for Turkey (trillion, real Turkish lira, 2001)

	Activities	Commod	Factors		Agents	Accum	Col Sum
			Capital	Labor	HH		
Activities		156836.2					156836.2
Commod					125469	31367.2	156836.2
Factors							
Capital $(r \cdot K)$	76567.7						76567.7
Labor $(w \cdot L)$	80268.5						80268.5
Agents							
HH			76567.7	80268.4			156836.1
Accum					31367.2		31367.2
Row Sum	156836.2	156836.2	76567.7	80268.4	156836.2	31367.2	

Table 4 presents the SAM for Turkey. As suggested above, the SAM is convenient for several reasons. One reason is it tells us how national income is distributed across capital and labor. In this case, owners of capital received 76567.7 (trillion) lira for the use of their capital, while labor received 80268.5 (trillion) lira. In the discussion below we will drop the unit designator (trillion). Note, this is a specific example of what Mankiw means by "the division of national income."

Another use of the SAM is it provides us with a reasonably simple way to derive/calculate parameters of a Cobb-Douglas or constant-elasticity-of-substitution aggregate production function. By *aggregate production function* we mean a function that tells us how much GDP the economy can produce with a given amount of capital and labor. We assume the aggregate production function satisfies constant returns to scale, i.e., for any $\lambda > 0$

$$f(\lambda K, \lambda L) = \lambda f(K, L)$$

Of course, for a Cobb-Douglas technology

$$Y = BK^{\alpha_1} L^{\alpha_2}$$

under constant returns to scale, $\alpha_1 + \alpha_2 = 1$. For the moment, to keep our notation simpler, let $\alpha_1 = \alpha$ and $\alpha_2 = 1 - \alpha$, and write the production function as

$$Y = BK^{\alpha} L^{1-\alpha}$$

5 The Economics of National Income Distribution

We now take up the issue of factor price determination. Recall, that the SAM entries for capital and labor give us the value of payments from firms to households (when moving down the Activity account) for the use of their capital and labor services. This means, the value 76567.7 is equal to the product of the capital rental rate, denoted r, and the capital stock, K. Similarly, the value 80268.5 is equal to the product of the wage rate, denoted w, and the stock of labor, L.

"Estimating" the production function

To determine factor prices, we first need to have an estimate of the production function. To begin, consider the input choice decision facing competitive firms: we assume they either maximize profit or minimize cost. Here, let's consider profit maximization. The representative firm maximizes the following expression

$$\pi = pf(K, L) - rK - wL$$

which is simply profit defined as the difference between total revenue, $pf(\cdot)$, and total cost, $rK+wL$. The profit maximizing firm chooses K and L to solve the following two first-order-conditions

$$\frac{\partial \pi}{\partial K} = pf_K(K, L) - r = 0$$
$$\frac{\partial \pi}{\partial K} = pf_L(K, L) - w = 0$$

Here, $f_K(K, L)$ is the marginal product of capital and $f_L(K, L)$ is the marginal product of labor. Let $p = 1$. In the Cobb-Douglas case, we have

$$\frac{\partial \pi}{\partial K} = \alpha B K^{\alpha-1} L^{1-\alpha} - r = 0 \quad (3)$$
$$\frac{\partial \pi}{\partial L} = (1-\alpha) B K^{\alpha} L^{1-\alpha-1} - w = 0 \quad (4)$$

We can rearrange terms in (3) and (4) to get

$$\frac{\alpha B K^{\alpha} L^{1-\alpha}}{K} - r = 0 \Longrightarrow \alpha = \frac{rK}{BK^{\alpha}L^{1-\alpha}} = \frac{rK}{Y} \quad (5)$$
$$\frac{(1-\alpha) B K^{\alpha} L^{-\alpha}}{L} - w = 0 \Longrightarrow 1-\alpha = \frac{wL}{BK^{\alpha}L^{1-\alpha}} = \frac{wL}{Y} \quad (6)$$

If we add $\alpha + 1 - \alpha$ we get

$$\alpha + 1 - \alpha = \frac{rK}{Y} + \frac{wL}{Y} = \frac{rK + wL}{Y} = 1$$

or $Y = rK + wL$. The implication of this is: the total value of output is exactly equal to the cost of producing that output. There is another implication embedded in expressions (6) and (5): α is equal to the share of aggregate production cost received by owners of capital, $\frac{rK}{Y}$, while $1-\alpha$ is equal to the share of aggregate production cost received by labor, $\frac{wL}{Y}$.

Returning to the SAM in table 4, straightforward calculations yield

$$\alpha = \frac{76567.7}{156836.2} = 0.488202$$

and

$$1 - \alpha = 0.511798$$

It follows then, that the aggregate Cobb-Douglas production function for Turkey is $Y = BK^{0.4882}L^{0.51179}$. Note, we still have a parameter to determine, which is B. To get the value of B we need information on the stock of capital and labor in 2001. From an earlier study, an estimate of Turkey's stock of capital in 2001, denoted K_{2001}, is $K_{2001} = 621938$ (in billions). We can use $L_{2001} = 0.02311$, where L_{2001} denotes the stock of labor in 2001 (in billions). To get B, we simply use the Cobb-Douglas function above and rearrange terms to get

$$B = \frac{Y}{K^{0.4882}L^{0.51179}} = \frac{156836.2}{621938^{0.4882}0.02311^{0.51179}} = 1600.8$$

Then we used $L_{2001} = 2.311$ and ended up with

$$\frac{156836.2}{621938^{0.488}2.311^{0.512}} = 152)$$

Factor prices

To get (equilibrium) factor prices, we return to equations (3) and (4). Rearranging terms slightly gives us

$$r = \alpha B \left(\frac{L}{K}\right)^{1-\alpha} \tag{7}$$

$$w = (1-\alpha) B \left(\frac{K}{L}\right)^{\alpha} \tag{8}$$

The downward sloping curve in figure 2 is a graph of equation (7). Given the stock of labor $L = 0.02311$, the marginal product of capital function is

$$r = \alpha B \left(\frac{L}{K}\right)^{1-\alpha} = 0.4882 * 1600.8 * \left(\frac{0.02311}{K}\right)^{0.51179} = \frac{113.639}{K^{0.51179}}$$

In figure 2, the stock of capital is represented by the vertical line slightly to the left of 622,000. Figure 2 is a graphical depiction of the market for capital services.

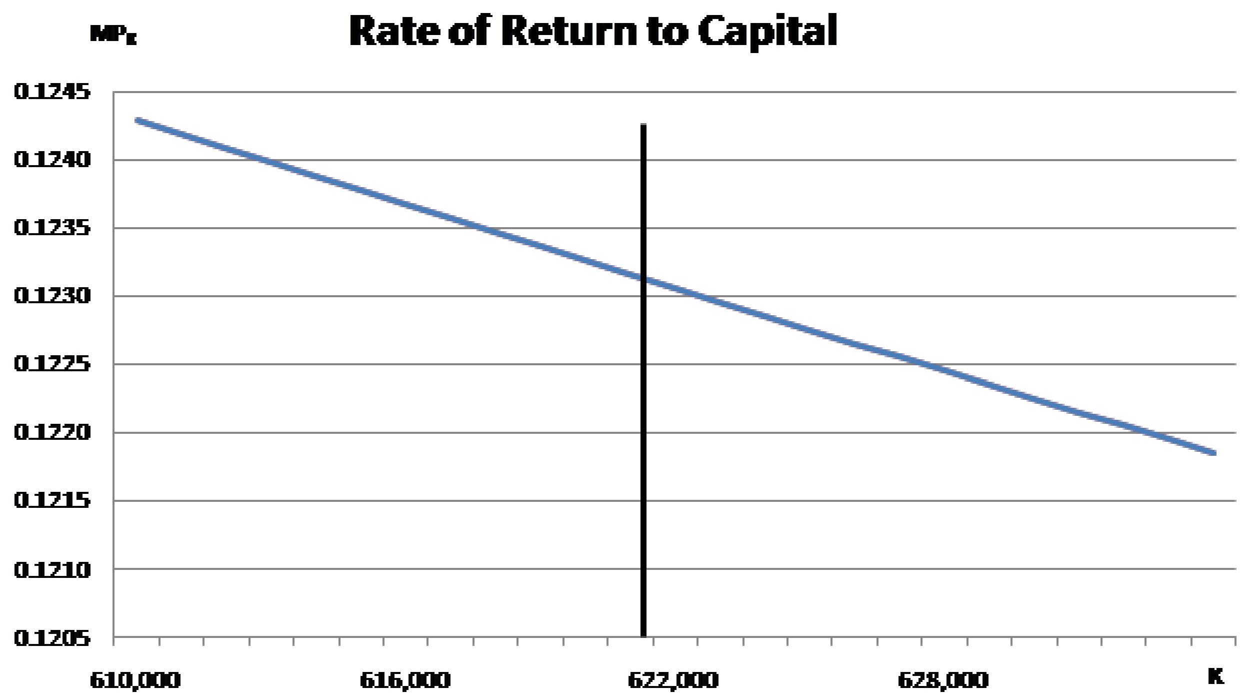

Figure 2. Capital market equilibrium

We omit a figure of the labor market, but similar substitutions yield a marginal product of labor function

$$w = (1 - \alpha)\, B \left(\frac{K}{L}\right)^{\alpha} = 0.51179 * 1600.8 * \left(\frac{621938}{L}\right)^{0.4882} = \frac{552013.308}{L^{0.4882}}$$

In the case of Turkey, our estimate of the equilibrium rate of return to capital and wages are:

$$r^* = \frac{113.639}{621938^{0.51179}} = 0.123111 \tag{9}$$

$$w^* = \frac{552013.308}{0.02311^{0.4882}} = 3,473,323 \tag{10}$$

To verify the results in (9) and (10) are consistent with theory (and with the SAM), calculate r^*K and w^*L. These values are

$$r^*K = 0.123111 * 621938.1 = 76567.7$$

and

$$w^*L = 3473323 * 0.02311 = 80268.5$$

Both of these values are consistent with the entries in the SAM.

To summarize, we have used the data in the SAM to derive a rough measure of how national income is divided between capital and labor services. The value of α gives the share of income paid to capital services and $1-\alpha$ gives the share of income paid to labor services. The parameter α is also the coefficient on capital stock levels in the Cobb-Douglas production function, $Y = BK^{\alpha}L^{1-\alpha}$. We also showed that with a constant returns to scale technology, the economy realized zero economic profit: i.e., $Y = r^*K + w^*L$ – the cost of producing goods and services is exactly equal to the market value of those goods and services.

If we add to this information, data on the capital stock and labor force levels, we can "estimate" a Cobb-Douglas specification of Turkey's aggregate production function. The factor stock levels helped us identify the value of B, where B is called a *scaling parameter*.

With the aggregate production function, we can form a profit function and calculate the first-order conditions for profit maximization. Doing so gives us the marginal marginal value product functions for capital, $\alpha B\left(\frac{L}{K}\right)^{\alpha}$, and labor, $(1-\alpha)\,B\left(\frac{K}{L}\right)^{1-\alpha}$, which we then set equal to r and w respectively. If we substitute the economy's factor endowment levels into the marginal value product functions we'll get the equilibrium rate of return to capital and equilibrium wage rate, r^* and w^*.

If you, then return to the SAM, you should observe the values r^*K and w^*L match the entries in the SAM. In a sense, this takes us on a journey around the circular flow diagram: households are paid for the use of their capital and labor services, firms produce goods and service with the rented factors, and the payment to factors is equal to the market value of goods produced.

6 Problems

Problem 1 *What does the sum Demand*$_A$*+ Demand*$_N$ *correspond to in figure 1?*

Problem 2 *Using the two-setor SAM for Turkey in table 5.a, construct the corresponding single-sector SAM in table 5.b.*

Table 5.a Two-sector SAM for Turkey (trillion of 2001 Turkish lira)

	Activity		Commodity		Factor		Agents	Accumulation	Total
	A	*N*	*A*	*N*	Capital	Labor	Household		
Activity									
A			99629.1						99629.1
N				57207.1					57207.1
Commodity									
A							99629.1		99629.1
N							52511.6	4695.5	57207.1
Factor									
Capital	46895.7	29672.0							76567.7
Labor	52733.4	27535.1							80268.4
Agents									
Household					76567.7	80268.4			156836.2
Accumulation							4695.5		4695.5
Total	99629.1	57207.1	99629.1	57207.1	76567.7	80268.4	156836.2	4695.5	

Table 5.b Single-sector SAM for Turkey (trillion of 2001 Turkish lira)

	Activity	Commodity	Factor		Agents	Accumulation	Total
			Capital	Labor	Household		
Activity							
Commodity							
Factor							
Capital							
Labor							
Agents							
Household							
Accumulation							
Total							

Problem 3 *What is the value-added for agriculture in table 2? What is the value-added for non-agriculture in table 2? In tables 5.a and 2, what is the difference between GDP and value-added?*

Problem 4 *Economic historians often talk about the Black Death, a disease reported to have killed over one third of the population in Europe in the 14th century. Given the aggregate technology calibrated for Turkey (using the 2001 data), estimate the impact on capital rental rates and wages, of a 15% drop in Turkey's population.*

Problem 5 *An economy's aggregate technology is given by*

$$Y = 200K^{0.4}L^{0.6}$$

If the economy is endowed with 10,000,000 units of capital and 100 units of labor, what is the equilibrium wage rate and the equilibrium rate of return to capital?

Problem 6 *Consider the values in Table 6 below.*

Table 6. Country SAM

		Activities	*Commod*	*rK*	*wL*	*HH*	*Accum*	*Col Sum*
Activities	*Activities*		*250.0*					*250.0*
Commodities	*Manuf*					*225.0*	*25.0*	*250.0*
Factors	*rK*	*133.0*						*133.0*
	wL	*117.0*						*117.0*
Agents	*HH*			*133.0*	*117.0*			*250.0*
Accumulation	*S*					*25.0*		*25.0*
	Row Sum	*250.0*	*250.0*	*133.0*	*117.0*	*250.0*	*25.0*	

1. *If the economy is endowed with* $\bar{K} = 1000000$ *units of capital and* $\bar{L} = 200$ *units of labor, what is its aggregate production technology?*
2. *What is the equilibrium rate of return to capital?*
3. *What happens to GDP and factor prices if half of the stock of capital is destroyed by a natural disaster?*

Problem 7 *Now, let's see how creative you are in solving problems. Table 5.a aggregates the Turkish economy into an agricultural and non-agricultural sector. Represent the two sectors by*

$$Y_A = \Psi_A K_A^{\alpha} L_A^{1-\alpha}$$

and

$$Y_N = \Psi_N K_N^{\beta} L_N^{1-\beta}$$

respectively. Here, Y_j, K_j, L_j *and* Ψ_j *represent value-added, capital stock, labor force, and technology levels in sector* $j = A, N$*, respectively. The* α *and* β *represent the capital cost shares for the agricultural and non-agricultural sectors. Using the data in table 5.a, and recalling the estimate of Turkey's stock of capital in 2001 is* $K_{2001} = 621938$ *(in billions), and the corresponding stock of labor is* $L_{2001} = 0.02311$.

1. *Calibrate (calculate) the parameters of the agricultural and non-agricultural sector technologies.*
2. *What is the equilibrium rate of return to capital?*
3. *Can you figure out what happens to sector value-added and factor prices if 10% of the capital stock is destroyed by a natural disaster? What assumptions did you make?*