Appendix: Model

The computable general equilibrium model of this paper employs the conventional static model. The Ghanaian economy is assumed to consist of 59 different production sectors, two different types of households, the government, and the investment firm sector. All 59 industries are allowed to have intermediate production processes, and they are assumed to maximize their profit. Each production sector employs 6 factors in its production; self-employed labor , unskilled employed labor , skilled employed labor , capital specific for agriculture , general capital , and land . Households are divided into two groups based on their living place indexed by ; the household living in the rural area and the household living in the urban area . While households in different areas are different, households living in the same area are assumed to be identical. The household is assumed to maximize its utility over 59 different consumption goods.

The government is assumed to determine its tax revenue, its imports, its exports, income transfers to households, and its consumption in order to satisfy its budget constraint. The economy is assumed to be fully competitive, so that all prices are determined in the relevant markets in order to equate the amount of demand to the amount of supply at its fully competitive price level in equilibrium. Note that the model is static and thus the short-run effect is only investigated. Thus, it is assumed for simplicity that factor inputs are not mobile among different sectors in the short-run. All parameter values are presented in Table 6.

<Household>

Utility of the household indexed by  based on his/her living area is given by:

 (1)

 where  denotes consumption of good  consumed by type .  is assumed for both types of .

The household of type  is assumed to maximize (1) with respect to its consumption goods subject to its budget constraint such that:



 where  and denote the price of good  and disposal income of type , respectively.  denotes the total amount of savings, and the household is assumed to save the constant amount relative to its disposal income such that:



 where the constant ratio, , or the private saving rate, is given exogenously[[1]](#endnote-1). The value of  has been calculated by using the actual SAM. Then disposal income is given by



 where and denote the government income transfers, net income transfers from the other type of the household, and the remittance sent from the rest of the world, respectively[[2]](#endnote-2). and denote the rental cost of capital specific for agriculture , and general capital  in sector  , respectively. and denote the wage rate of self-employed labor , unskilled employed labor , and skilled employed labor  employed in sector  , respectively.  denotes the unit price of land Each type is assumed to have endowments of and  in sector  . Both types are also assumed to pay taxes, and and  denote the capital income tax rate for agriculture, the capital income tax rate for others, the wage income tax rate for self-employed worker, the wage income tax rate for unskilled employed worker, the wage income tax rate for skilled employed worker, and the land tax rate, respectively. Note that all taxes are assumed to be proportional, and the tax rates have been calculated by using the actual social accounting matrix. The tax rate can be negative in the simulations if the effect of the case when the government subsidizes a particular factor input is explored. Note also that all factors are assumed to be immobile between different production sectors by assumption. The value of factor payments can be obtained from the actual social accounting matrix[[3]](#endnote-3).

The first order conditions yield the demand functions such that:

  (2)

 where . Note that  can be calculated by using (2) and the actual social accounting matrix so that:



 where both the values of the denominator and the numerator can be obtained from the actual social accounting matrix.

<Production Sector>

Following the conventional assumption, the multiple decisions by each firm are described by the tree structure, where each firm is assumed to make a decision over several different items. In the tree structure, the optimal behavior of each firm which makes a decision over different items is described as if the firm always makes a decision over two different items at different steps. Each firm makes a decision over different items; exports of its own product, the amount of imported goods and intermediate goods used for its production, and labor and capital. This assumption simplifies a complicated decision over several items by each firm.

At step 1, a private firm, , is assumed to use labor and capital to produce its composite goods, . Then, the firm is assumed to produce its domestic goods, , by using its own  and  at the second step.  denotes the final consumption goods produced by firm  used by firm  for its production. Thus,  is the amount of the final consumption goods produced by firm  for the intermediate production process of firm . At the third step, the firm is assumed to decompose its domestic goods, , into exported goods, , and final domestic goods, . This step is concerned about its optimal decision over the amount of its product to be exported. At the final step (the fourth step), the firm is assumed to produce its final consumption goods, , by using its final domestic goods, , and imported goods, . This step corresponds to its optimal decision over how much it uses imported goods, , and its own goods, , to produce its final consumption goods, , which are consumed by domestic households. The assumption of this tree structure in terms of different decisions can incorporate firm's complicated decisions over exports of its own product, the amount of imported goods and intermediate goods which the firm uses in its production process, and the amount of factor inputs into the model in a tractable way.

Note that all market clearing conditions are used to determine all prices endogenously in their corresponding markets, and also that at each step the private firm is assumed to determine the amount of relevant variables in order to maximize its profit.

By the assumption of the above tree structure, all decision making processes can be simplified, and the optimal behavior about all different decisions can be incorporated as follows:

Step 1: The production of composite goods

Each firm is assumed to produce its composite goods by using capital and labor. Each firm is assumed to maximize its profit given by:

 (3)

 where  and  denote the composite goods produced by firm  and its price, respectively. The production technology is given by:

 (4)

 where  is assumed for all  . It is also assumed such that:



Each firm is assumed to maximize (3) with respect to labor and capital subject to (4), and the first order conditions yield the demand functions such that:

 (5)

Note that parameter values can be calculated by using from (5), and the actual social accounting matrix so that:



Step 2: The production of domestic goods

Each firm is assumed to produce domestic goods, , by using intermediate goods and its own composite goods, which production has been described at step 1. The optimal behavior of each firm in terms of the production of domestic goods can be described such that:



 where  and  denote an intermediate good  used by firm  and its price, respectively.  is the price of . denotes the amount of an intermediate good  used for producing one unit of a domestic good of firm  , and  denotes the amount of its own composite good for producing one unit of its domestic good. Note that the production function at this step is assumed to be the Leontief type. Using  and , and assuming that the market is fully competitive, the zero-profit condition can be written by:



Step 3: Decomposition of Domestic Goods into Exported Goods and Final Domestic Goods

The optimal decision made by firm  in terms of the amount of exports of its own goods is described as the decomposition of  (  ) into exported goods, , and final domestic goods, . Each firm is assumed to maximize its profit such that:

 (6)

 where  and  denote the price when the domestic goods are sold abroad, and the price when the domestic goods are sold domestically, respectively. Note that  is measured in the domestic currency.  and  are the tax rates of a production tax imposed on the production of , and the tax rate on exports, respectively. The values of  and  are calculated by using the actual social accounting matrix. The decomposition is assumed to follow the Cobb-Douglas technology such that[[4]](#endnote-4):

 (7)

 where   is assumed. Each firm is assumed to maximize (6) with respect to  and  subject to (7), and the first order conditions yield

(8)

Note that  and  can be calculated by using (8) and the actual social accounting matrix so that:



 where and  can be obtained from the actual social accounting matrix.

Step 4: The Production of the final goods

Denote the final consumption goods by  (  ). The final consumption goods are assumed to be produced by using the final domestic goods, , and the imported goods, . This step corresponds to the optimal decision making behavior of each firm in terms of the amount of imported goods which are used in its production process. The production technology at this final step is given by the following Cobb-Douglas function:

 (9)

 where   is assumed. Each firm is assumed to maximize its profit with respect to  and  subject to (9). Its profit is given by:



 where  and  denote the price of its final consumption goods, and the import tariff rate, respectively. The import tariff rate is calculated by using the actual social accounting matrix. Then, the first order conditions yield

 (10)

Note that and can be calculated by using (10) and the actual social accounting matrix so that:



 where   and  can be obtained from the actual social accounting matrix.

<The Government>

The government is assumed to impose several taxes to satisfy its budget constraint. Its budget constraint is given by:



where the left hand side is the total government expenditure, and the right hand side is the total government revenue.  and  denote government consumption of a final consumption good and government savings, respectively.  denotes the total amount of income transfers to both types of  such that:



  and  denote direct imports and exports by the government, respectively. The total tax revenue is given by:



where  and denote the total income tax revenue, the total land tax revenue, the total production tax revenue, the total import tariff revenue, and the total export tax revenue, respectively. The government is assumed to save the constant amount relative to the total amount of tax revenue, and the government savings are assumed to be given by



 where the constant ratio, , is given exogenously, and its value has been calculated by using the actual SAM.

<Equilibrium Conditions>

There are two factor inputs, labor and capital. Since the model is static and thus the short-run effect is explored, it is assumed that each factor cannot move among different sectors (industries) in the short-run. This implies the equilibrium conditions of factor markets such that

 (11)

 Note that and   are determined in order to satisfy (11).

In terms of the market clearing condition of a good   a private investment sector is introduced in order to close the economy in this paper[[5]](#endnote-5). Denoting the amount of a good  consumed by the private investment sector by , the market clearing condition of a good  is given by:



 where the left hand side is the total supply, and the right hand side is the total demand for a good .   is determined in order to satisfy (16). Note that the budget constraint of the private investment sector is given by:



where the left hand side is the total amount of its consumption, and the right hand side is the total amount of its income.  denotes the total amount of savings by the foreign sector, or the deficits in the current account, and it is given by subtracting exports from imports[[6]](#endnote-6). Since both the amount of exports and the amount of imports can be obtained from the actual social accounting matrix,  can be calculated from the actual social accounting matrix, and thus it is exogenously given in the model. Furthermore, the foreign trade balance is given by



where and denote the world price of an export good, and an import good of , respectively, and both of them are assumed to be given exogenously. Since  and  are both measured in the domestic currency, they are also expressed such that:



where  denotes the exchange rate. Note that the exogeneity assumption on the world prices implies that the exchange rate is endogenously determined within the model.

1. The assumption that the ratio is exogenously given is made only for the model to be consistent to the actual social accounting matrix, and this assumption is very common in the literature. [↑](#endnote-ref-1)
2. Preciously speaking, also includes self-consumption within the same group. [↑](#endnote-ref-2)
3. The total number of self-employed as well as employed workers in each production sector can be obtained from the IO table of year 2005. Since per capita wage income of employed workers and total wage income can also be obtained from the IO table of year 2005,  can be calculated for both  and . On , the ratio of the number of each type of workers has simply been used to divide the total capital income of each production sector. [↑](#endnote-ref-3)
4. While it is common in the literature to assume (7) and (9) to be expressed by the CES technology, it is assumed in this paper that both technologies are expressed by the Cobb-Douglas technology. While the Cobb-Douglas function is the special case of the CES function and thus the CES function provides more generality, our assumption gives us more advantages in terms of preciseness of our benchmark model. As our benchmark results show, the assumption of the Cobb-Douglas technology substantially contributes to our perfectly well-fitted benchmark result. We believe that the benchmark model should be well-fitted to re-produce the actual economy within the model in any simulation analysis, and the Cobb-Douglas technology is assumed at the sacrifice of a certain level of generality, in order to obtain our perfectly well-fitted benchmark model. [↑](#endnote-ref-4)
5. This is also the conventional assumption in the literature. [↑](#endnote-ref-5)
6. The FDI is assumed to be negligible in this paper. [↑](#endnote-ref-6)