Carbon Tax in an Economy with Informality
A Computable General Equilibrium Analysis for Côte d’Ivoire

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Abstract

In an economy with substantial informality, a carbon tax can produce fiscal co-benefits that improve economic performance in addition to reducing carbon dioxide emissions. If the carbon tax revenues are used to cut production or labor taxes on formal firms, particularly those not in the energy sector, the cost of imposing the carbon tax is reduced, and there may even be net economic benefits. These tax cuts can also provide an incentive for informal firms to move to formal parts of the economy. This study confirms these hypotheses using a computable general equilibrium model for Côte d'Ivoire. However, the scale and even the sign of overall economic impacts and formal-informal sectoral interactions are sensitive to the scheme and scale of revenue recycling. The largest fiscal co-benefits, in terms of gross domestic product and economic welfare gains, would occur when the entire carbon tax revenue, after keeping the government revenue neutral, is used to cut existing labor or production taxes for non-energy formal firms. Reducing the existing value-added tax also increases gross domestic product and economic welfare, but without reducing the informality. The study also shows that energy producers should be exempted from using the carbon tax revenues to cut their production or labor taxes; otherwise, carbon dioxide reduction decreases due to a rebound effect. Although a carbon tax with lump-sum transfers of revenues is progressive, it would be economically inefficient because of gross domestic product and welfare reduction and lack of incentives to encourage informal activities to move to the formal parts of the economy.

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1. Introduction

The carbon tax has been extensively investigated in the research literature as a policy for greenhouse gas (GHG) mitigation (see Timilsina, 2018a for a comprehensive review). However, relatively little consideration has been given to this policy for lower-income countries (Timilsina, 2021; Timilsina, 2018b; Telaye et al. 2019). Although lower-income countries’ contributions to global GHG emissions are quite low (IEA, 2020), a carbon tax applied to fossil energy can cause significant increases in the real costs of energy for economies in which many are struggling to meet basic needs. However, a carbon tax produces fiscal and economic co-benefits that might incentivize low-income countries to introduce this policy. The source of incentives is the new tax revenue generated from the carbon tax.

One standard argument in favor of these incentives is that carbon tax revenues can be used to reduce rates of existing taxes that exert a drag on output and employment – in particular, taxes on workers’ income. A second rationale, which has not received the same attention but is very relevant for analysis of carbon pricing in many lower-income countries, is the role played by “informality” in the economy. For various reasons, informal workers and firms tend to have lower productivity compared to their counterparts in the formal parts of the economy. Recycling carbon tax revenues through lower tax rates in the formal parts of the economy reduces the economic competitiveness and the size of the informal parts of the economy. More workers will

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2 As shown below, cutting the rate of a broad-based Value Added Tax (VAT) can have a similar effect, because such a broad-based tax on consumption that raises the real cost of living closely resembles a direct income tax.

3 Informality here refers to any economic activity that is not officially registered or licensed. Because they are thus invisible to authorities, they neither pay taxes (income taxes, general VAT, or social security contributions) nor are subject to state regulations (Fortin et al.1997; Gibson, 2005). For more details on issues related to informality, see Pena (2013) and Maloney (2004).

4 Possible explanations include less access to credit for modernization and expansion, and a lower capacity for taking advantage of comparative advantages among different workers.
migrate to the formal parts of the economy to take advantage of income possibilities with higher-productivity firms, even though they will face a tax on income. Recycling carbon tax revenues in ways that cause expansion of the more productive formal parts of the economy has the potential to increase overall economic output and individual well-being. Moreover, when a carbon tax is imposed on fossil fuels, the informal parts of the economy cannot avoid it if the carbon tax is imposed “upstream” of retail distribution of the products. Although there exists some incidence of stealing petroleum by breaking the oil pipeline in some countries (e.g., Nigeria), the practice is not common. Although these co-benefits of carbon tax sound intuitive, empirical analyses are needed to confirm.

The study considers the case of Côte d’Ivoire to numerically illustrate the fiscal co-benefits of a carbon tax. There are two reasons for the choice of Côte d’Ivoire. First, the scale of informality in the economy is relatively large. Second, data needed for CGE modeling (the country’s input-output tables) are available, and they provide essential information on economic informality across sectors of the economy. Of course, policy maker interest in investigating the issues considered in this volume is a major additional plus. The study employs a computable general equilibrium (CGE) model to investigate a carbon tax with different types of revenue recycling. CGE modeling is one of the main analytical tools for climate change policy analysis, particularly carbon pricing. There exists a rich literature on the deployment of CGE modeling for climate change policy analysis (Timilsina 2021; Timilsina, 2018b; De la Chesnaye, et al. 2006; Edenhofer et al. 2006; Weyant, 1999). However, to our knowledge, this is the first CGE application to assess carbon or other environmental pricing with a model designed to account for distinctions between informal and formal parts of the economy.5

The study aims to contribute to the literature in three fronts. First, it explicitly models the informal economy in a developing or low-income country. Existing studies analyzing the general equilibrium effects of a carbon tax accounting for informal activities in each production sector are rare. Second, most existing studies consider recycling the entire carbon tax revenues for a particular purpose, such as cutting existing taxes after keeping the government revenue neutral. Instead of recycling the entire carbon tax revenues either for cutting existing production or labor

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5 There are several studies that have attempted to incorporate informality in CGE modeling to address other topics (see e.g., Fortin et al. 1997; Stifel and Thorbecke, 2003; Gibson, 2005; Lay et al. 2006; Robilliard et al. 2011; Atuesta and Hewings, 2013; Morales et al. 2017).
taxes or VAT, our study distributes the tax revenue for multiple purposes, such as reduction of production taxes in the formal part of the economy and recycling the remaining part to the households after keeping the government revenue neutral. Third, our study illustrates how certain schemes of recycling carbon tax revenues could cause evaporation of a part of emission reduction caused by the carbon tax originally recycling; and offers a solution to reduce or eliminate this rebound effect.

The study shows that certain combinations of a carbon tax with revenue-neutral recycling complementary tax reforms can increase GDP and overall economic well-being while also reducing GHG emissions. If the carbon tax revenue is recycled to cut labor taxes in the formal part of the economy or if the revenue is used to partially swap the existing value-added tax suffering with evasion, the carbon tax would have positive impacts on the economy (i.e., increase in GDP and welfare from the baseline). If the carbon tax revenue is recycled to cut production taxes of all formal sectors, including energy producers, it will cause loss of half of CO\textsubscript{2} reduction achieved due to the rebound effect and it will also cause losses of GDP and welfare. If the carbon tax revenue is not provided to energy produces to cut their production or labor taxes, the rebound effects are minimized, and the policy would increase GDP and welfare. On the other hand, if the revenue is recycled to households as a lump-sum rebate, the carbon tax would have a negative impact (decrease in GDP and welfare from the baseline). The use of carbon tax revenues to reduce production or labor taxes of firms in the formal sector would cause informal firms to move toward more productive formal parts of the economy.

The next section reviews the literature on the interaction between formal and informal economic activities in response to environmental or any other policy shocks. Section 3 provides a summary description of the CGE model and corresponding data used in this analysis. Section 4 contains information on the design of policy scenarios. Section 5 presents and interprets the model results. Section 6 conclude the study with some policy implications.

2. Literature Review

Several studies have attempted to address the issue of informality using CGE modeling (see e.g., Fortin et al. 1997; Stifel and Thorbecke, 2003; Gibson, 2005; Lay et al. 2006; Robilliard et al. 2011; Atuesta and Hewings, 2013; Morales et al. 2017).
Fortin et al. (1997) is one of the early studies to address the informal sector in a CGE framework of economic policy analysis. The study examines the effects of taxation and wage controls in a developing economy with an informal sector. It employs a CGE model incorporating firm heterogeneity that allows a formal and an informal sector endogenously emerge in some productive sectors. Since the model incorporates unemployment, the wage rate in the formal sector is assumed to be fixed. Firms that are not willing to pay the fixed-wage rate are allowed to move to the informal sector, where the wage rate is expected to be lower as compared to that in the formal sectors. However, the informal sector faces a risk of getting caught and penalized. The model assumes that the informal sector bears a cost, which is relatively high, to implement measures to avoid government inspections. The model also assumes that anyone can work in an informal sector with a perfectly flexible wage; however, if s/he chooses an informal sector will not have access to formal jobs. Moreover, workers who choose the formal sector face a probability of not getting a job at all.

To simulate the impacts on the poverty of trade liberalization in Africa, Stifel and Thorbecke (2003) develops a CGE model specifically incorporation the informal sector. The model follows a dual-dual framework to represent a characteristic of the structure of a developing country and provides a basis for analyzing the distribution of modern and informal sector activities in both rural and urban areas.

Gibson (2005) incorporated an informal sector in a dynamic structuralist CGE model to evaluate the longer-term consequences for growth distribution, human capital formation and poverty of a hypothetical small, open lower-middle-income developing country with segmented labor markets. In his model, informal sectors are associated with non-traded goods sectors. Since the non-traded goods sectors are divided into formal and informal categories, they absorb surplus labor during recessionary periods and supply labor in periods of expansion. The informal sector acts as a last resort for job seekers. There is no price discrimination for outputs produced from the informal component of a sector. The output of the formal component of a sector is residual to the production of the informal component of the sector, which is itself determined by the supply of labor and (declining) level of productivity. Income is determined by the product of the formal price and the total output of that sector minus the intermediate costs. This surplus is appropriated by the operator of the informal process who pays no taxes, direct or indirect.
While investigating whether the Bolivian gas boom of the 1990s has increased the income of poor households and thereby reduces income inequality, Lay et al. (2016) also account for the informal sector in their CGE model-based analysis. The study classifies both capital and labor between the formal and informal categories. Capital mobility is allowed only within the category, meaning that formal capital can move within the formal sector and so does the informal capital. There is no direct substitution between formal and informal capital. On the labor front, labor market is differentiated between the skilled and unskilled; the latter is further differentiated between the rural and urban categories. Skilled labor is fully mobile across production sectors, that is not the case for unskilled labor. There is a huge difference in wage rate within the unskilled labor between the formal and the informal sectors. For example, unskilled workers receive about half the average wage in the informal construction sector, whereas they receive about the average wage in the formal sector.

Robilliard et al. (2011) also incorporate the informal sector in their CGE model developed for assessing the impacts of the financial crisis in Indonesia. They first divide the labor into eight categories: urban male unskilled, urban male skilled, urban female unskilled, urban female skilled, rural male unskilled, rural male skilled, rural female unskilled, and rural female skilled. The labor markets are then segmented between formal and informal sectors. The formal sector, with an increasing wage-employment curve, allows imperfect competition resulting in informal sector labor equivalent to self-employment. The informal sector absorbs any labor not employed in the formal sectors. Wages adjust to clear all labor markets in the informal sectors, whereas employment adjusts in the formal sectors. The informal sectors are also assumed not to require any imported intermediate inputs.

Atuesta and Hewings (2013) developed a CGE model for Colombia to analyze the effects of the legalization of drugs (narcotics) on the Colombian economy. Drug or narcotics production and trade is the informal sector. The model also introduced unemployment. Households are divided into 20 categories based on income and location. Changes in wages and migration are estimated using two separate microeconomic models: a labor participation model and a Nearly Ideal Demand System (NIDS), which are then linked to the CGE model. Microeconomic models use data from a household survey that collects information about the demographics, income, expenses, and labor characteristics of 64,119 different households in rural and urban areas. The labor participation micro model first estimates the labor supplies fed into the CGE model to determine the wage.
changes. The change is wage is a driver for labor supplies and migration flows across three different labor markets: rural, informal urban and formal urban. The other micro model, NIDS, estimates the consumer expenditure shares of the CGE model. The advantage of using a separate micro model NIDS over the standard CGE specifications for households (e.g., Cobb–Douglas or the linear expenditure specification) is that price and income elasticities are allowed to be different across household categories.

Morales et al. (2017) incorporate the informal sector in their CGE model when they analyze the impact on Bolivian wage and labor policy of decreasing international prices of its main exports. The definition of the informal sector in this study covers a wider spectrum of labor supply. It includes all non-remunerated workers, self-account workers without tax registration, and workers without long-term social security or contracts. The informal sector accounts for 80% of Bolivia’s labor force. The CGE model used in the study represents the labor mobility between the formal and the informal sectors through a labor supply function supplemented with a reservation wage curve. It allows the both-way (formal to informal and vice versa) migration of the labor force. The study assumes the unemployment elasticity of real wage is negative for the informal sector and zero for the formal sector. This means the wage curve is downward sloping in the informal labor market and horizontal in the formal labor market. The study defines four types of labor: formal, informal, private and government workers. But, the public sector does not hire informal workers. Labor supply between the formal and the informal sector is distributed through a CET functional form.

One of the biggest challenges to incorporate the informal sector into the CGE modeling is the lack of data. The social accounting matrix (SAM), the main database for CGE modeling, accounts data for the formal sector or aggregate sector, which includes both formal and informal activities without distinction. Some existing studies have illustrated how to incorporate the informal sector into the SAM. Rada (2009) is an example. In the absence of official statistics that differentiate the formal and informal economic activities, the study uses the shares of regular and irregular wage income in a given sector to derive an approximate size of informal and formal activities. Because there is no universal definition of the informal sector, for China, the study considers formal workers are those employed by both formal and informal enterprises as defined in the official statistics. Irregular employment, which are not included in the official statistics, is classified as informal labor. In India, the formal sector consists of those enterprises which are
registered and fall under the regulations. The informal sector includes enterprises that are neither registered with the state nor their activities regulated by official rules.

3. The Model and Data

The framework is a multisector CGE model designed to apply to a small open-economy developing country. Figure 1 provides a schematic summary of the framework. It is a static model, meaning it is designed to compare economy-wide equilibria with different policies but does not describe processes of adjustment over time. The model considers 32 production (sectoral/industrial) activities, including both formal and informal activities. An enumeration of the activities/sectors and commodities is provided in Table 1. As indicated in Table 1, formal and informal firms coexist in some sectors and produce goods that are treated as imperfect substitutes for meeting aggregate demand. Those outputs can be exported as well as sold domestically. In other sectors, only formal firms are found. The goods produced by the two types of firms in the same industry form a composite commodity that is sold to users. In that perspective, the number of commodities in the model is smaller than the number of activities. There are 18 commodities in the model. The model includes both primary energy forms (natural gas and refined petroleum products) and electricity generated using different technologies (fossil-fired and renewable).

Four types of economic agents are considered in the model: firms, households, the government and the rest of the world. They all evolve in a competitive setting where they consider in their decision-making all prices as given.

6 Other static general equilibrium models developed to analyze trade and environmental issues include Bernstein, Montgomery, and Rutherford (1999), and De Melo and Tarr (1992).

7 The way demand is modeled, these imperfect substitutes are aggregated into a composite commodity in order to keep the dimension of demand manageable. For example, “formal firm made furniture” and “informal firm made furniture” are combined into a composite good, “furniture,” in a way that allows the model to track both the demand for furniture versus other final goods and the tradeoff between the two constituent goods. This is why there are more activities/sectors than commodities in the model.

8 The imperfect substitute commodities produced by formal and informal firms in each industry are aggregated into a composite commodity exported to meet foreign demand. A cost-minimization technique is used to determine the optimal structure of the composite and its index price.
A peculiar feature of the model is the dualism in the production activities characterized by the presence of formal and informal firms in the same industry. While there are several definitions of an informal sector, we define informal sectors as the unregulated ones in which economic agents do not pay any taxes concerning their production activities (inputs, output and corporate income taxes). In some industries, formal and informal firms coexist and produce goods that are imperfect substitutes from the demand perspective. As discussed above, the analysis of the informal sector also covers the dualism in the labor market, in which skilled and unskilled workers coexist and the nominal wage is usually rigid in the former and flexible in the latter. In this study, we are not interested in the dualism of the labor market; we are instead interested in tax evasion by the informal firms and the role that carbon mitigation policies can play in reducing the size of the informal sector.

A distinctive feature of formal firms from informal firms is that the latter do not pay any taxes related to their production activities. Formal firms pay production taxes, which are levied on output, and a payroll tax which increases the unit cost of labor. Both taxes have an incidence on
the firm's optimal decisions in the formal sector and give them a cost disadvantage concerning their peers of the informal sector.\(^9\)

### Table 1: Definitions of Sectors/Commodities and Data

| Activity/sector No | Activity/sector contents | Presence of the informal sector | Commodity No |
|--------------------|--------------------------|---------------------------------|--------------|
| S1                 | Food agriculture; Breeding and hunting; Activities related to culture and breeding; Fishing and fish farming | Yes | C1 |
| S2                 | Cocoa production; Other industrial or export agriculture | Yes | C2 |
| S3                 | Forestry and Logging | Yes | C3 |
| S4                 | Extractive industries | Yes | C4 |
| S5                 | Meat and fish production; Grain work and product; manufacturing; Cocoa and coffee processing; Oilseed industry; Bakery, pastry and pasta; Dairy industry, fruit and vegetable industry; Beverage industry; Tobacco industry | Yes | C5 |
| S6                 | Textile and clothing industry; Leather and footwear industry | Yes | C6 |
| S7                 | Woodworking and manufacture of articles; Paper and paperboard industry, printing; Furniture manufacturing | Yes | C7 |
| S8                 | Oil refining and coking | No | C8 |
| S9                 | Chemical industry; Rubber and plastics industry | Yes | C9 |
| S10                | Manufacture of non-mineral mineral products | Yes | C10 |
| S11                | Basic metal products | Yes | C11 |
| S12                | Manufacture of machinery, equipment and machinery; Manufacture of audio equipment and appliances; Transportation equipment manufacturing | No | C12 |
| S13                | Electricity | No | C13 |
| S14                | Natural gas | No | C14 |
| S15                | Construction | Yes | C15 |
| S16                | Transport and communication services | Yes | C16 |
| S17                | Wholesale and retail trade; Repairs; Hotels and restaurants; Posts and Telecommunications; Financial activities; Real estate activities; Services provided to businesses | Yes | C17 |
| S18                | Public administration and social security; Education; Health and social action; Collective, social and personal services | Yes | C18 |

\(^9\) GAMS codes of the model are available upon request to the authors.
3.1 Modeling production activities

The model follows the tradition of static general equilibrium models developed by Bernstein et al. (1999), De Melo and Tarr (1992). All firms have access to a linear homogeneous technology to produce output. In each production activity, the representative firm in each sector uses physical capital, labor, energy inputs, and non-energy intermediate inputs to produce a good. To capture varying substitution possibilities between different types of inputs of a firm, we consider a nested production structure as portrayed by Figure 2.

Gross output either of the formal or informal firms is a Constant Elasticity of Substitution (CES) function of, on the one hand, the composite of value-added and energy and, on the other hand, of the aggregate of non-energy intermediate inputs. At the second level, the value-added and energy is a Cobb-Douglas aggregation of labor and the composite of capital and energy aggregate. The aggregate of non-energy intermediate inputs is obtained using a Leontief technology. At the third level, the composite of capital and energy is a CES aggregate of capital and the aggregate energy inputs. At the fourth level, the energy aggregate is a CES combination of various fossil energy inputs and electricity. At the bottom, fossil energy is a CES combination of natural gas and petroleum products.

The objective of the managers of all firms is to determine the optimal levels of input uses and output supply so as to maximize profits. Given the linear homogeneity property of the technology, the firm sets its price to the marginal cost and lets the demand side determine the optimal level of output. Following the nested structure of the production function, the optimal level of input uses will be determined sequentially such that, at each level, the marginal product of the input is set equal to its price.
Figure 2. Schematic to represent production activities
We assume that labor and physical capital are mobile across industries. There are two types of workers: skilled and unskilled workers which are not perfect substitutes. Thus, they do not receive the same wage rate. Only one type of worker is used per firm: skilled workers are employed by formal firms, while the other category of worker is used by firms operating in the informal sector. With that assumption, skilled workers are mobile across formal firms only; the same rule applies for unskilled workers who can be reallocated across informal firms only. Physical capital can be reallocated to any sector where it receives the same rental rate. As for the modeling of labor input, one may consider two types of physical capital. Still, we do not believe that this approach will bring additional insights given the interest of this paper.

The goods produced by formal and informal firms are imperfect substitutes. In each of the industries where the two types of firms coexist, their outputs are combined using a CES functional form to form a composite commodity that can be sold in the domestic and/or foreign markets. A cost-minimization technique is used to determine the optimal structure of the composite and its price. We use a CET (constant elasticity of transformation) function to allocate aggregate commodities into the domestic market and the export market. A revenue-maximization technique makes it possible to determine the optimal allocation of the aggregate supply of commodity into supplies in the two markets and to find the expression of its dual price. We assume that the total demand for each commodity is a CES composite of the domestically produced good and the imported good.

Total returns to capital in the economy are shared in fixed proportion between households and firms. The latter use their portion to pay corporate income taxes (for those operating in the formal sector) and for savings. Firms’ saving is part of national savings to fund investment expenditures.

### 3.2 Modeling households and labor supply

The behavior of households is modeled through a representative household, which has preferences over commodities and leisure (Figure 3). It consumes various commodities and supplies the two types of labor in the market. We model its preferences by a weakly separable utility function, which is represented by a series of nested utility functions. At the top level, the utility function is a CES composite of the consumption of goods and leisure. At the second level,
the consumption good is an aggregation of various commodities. Finally, the labor force, both skilled and unskilled, spend their time on productive work (labor) or leisure.

Household income consists of labor income plus a fixed fraction of the return to capital inputs (i.e., households can be part-owners of firms as well as workers). Changes in tax policies can affect both the level of after-tax income available for financing consumption and the cost of living through broad-based commodity taxes (VAT) and taxes on specific commodities (carbon taxes on goods reflecting the carbon content of the energy used to supply produce and use them).

**Figure 3. Modeling the household consumption and labor supply**

There are two types of the labor force, skilled and unskilled, which are imperfect substitutes. We capture the ease of transformation of one type of labor into the other through the magnitude of the elasticity of transformation of the CET function. The larger the elasticity, the easier is the transformation of one type of labor in the other. The existing labor market also reflects informality. There are two types of workers: formal workers (those who are employed by formal firms), who are mostly skilled workers, and informal workers (those who are employed by
informal firms), who are mostly unskilled workers. Because the two types of labor are not perfect substitutes, they do not receive the same wage rate.

Maximizing utility subject to the budget constraint makes it possible to determine the demand for commodities and the supply of each type of labor in the market. At the margin, the demand for commodities and labor supply will be such that the marginal rate of substitution between aggregate consumption and leisure will be equal to the real wage rate. The latter is the ratio of aggregate wage rate and the consumption index price. The tax levied on payrolls by the government has an incidence on the aggregate wage and will introduce some distortions in labor supply decisions. Any policy that reduces these distortions may be welfare improving.

3.3 Government account, investment and model closing

The government consumes goods, makes transfers to economic agents (households and firms). We assume that its demands for commodities are discretionary and are consequently fixed in real terms. Similarly, we assume that its transfers to various agents are exogenous; their levels can be chosen to achieve some public finances’ objectives. The government funds its expenditures with revenue from income taxes (on households and firms) and indirect taxes on commodities and production activities. The difference between its total revenue and its total spending constitutes its savings, which are used to fund total investment in the economy.

The total demand of each commodity by domestic users in the economy is the sum of demands by households, the government, firms for intermediate uses and investment expenditures. We assume that investment expenditures are funded by total savings, which comprise households, firms, government and foreign savings. A fixed proportion of total savings is devoted to investment expenditures on each commodity. The current account is the difference between total financial transactions paid to the rest of the world and payments obtained from the rest of the world. To simplify the calculations in the model, “capital” (physical capital) is a single-dimensional input that can move across all sectors of the model until rates of return on capital are equalized across the economy (given the assumption of competitive markets).
3.4 Incorporation of carbon tax

A carbon tax is levied on the price of fossil fuels to cause a reduction of carbon dioxide emissions emanating from the use of fossil fuels. The carbon tax is modeled as an excise tax that adds to the unit price of the fossil fuels in proportion to their carbon contents. We consider an upstream implementation of the carbon tax whereby no user can escape its payment. The tax is already included in the prices paid by all users of the fossil energy good. This suggests that all firms pay the carbon tax. The government collects revenue from the carbon tax that may be recycled somehow in the economy. We will discuss in the next section different options to recycle carbon tax revenues considered in this study.

3.5 Data

One of the main challenges to analyze policy impacts on the informal economy is data. Despite the large informal economy, developing countries do not systematically collect data regarding the informal economy. Even if they conduct surveys occasionally, the results are not made available to the general public. A CGE analysis addressing the informality requires a social accounting matrix that explicitly accounts for the informal sector. Fortunately, the National Statistical Office (NSO) developed an input-output (I-O) table for the year 2013 that captures the informal sector based on surveys conducted by the same office. However, the data have not been published. We worked with the NSO to prepare a SAM explicitly identifying the informal sectors where possible. The original I-O table available from NSO has 107 production sectors and the same number of commodities. A production sector is divided into two categories – formal and informal. Based on the objective of our study, we developed a SAM with 18 sectors and 18 commodities by aggregating and disaggregating the original I-O table as required. Each sector in the SAM has two types of producers – formal and informal. It is not possible to distinguish the formal and informal categories as the data is not available to track the distinction. Moreover, it is not necessary to have the formal and informal categories in the consumption side. However, a household provides two types of labor – formal (those working in the formal sectors) and informal (those working in the informal sector). The data for the various components of the SAM are provided in Appendix A.
4 Designing the Policy Scenarios and Cases

We consider a carbon tax rate that causes a 10% reduction in national CO₂ emissions relative to the baseline. The required level of the carbon tax in the model is 13,169 FCFA or US$22 per ton of CO₂. The revenue from the carbon tax is recycled to the economy through the following schemes or scenarios:

- Scenario 1: Carbon tax with revenue recycled to all households through a lump-sum rebate
- Scenario 2: Carbon tax with revenue-neutral cut in production tax paid by formal firms
- Scenario 3: Carbon tax with revenue-neutral cut in income tax paid by formal labor
- Scenario 4: Carbon tax with revenue-neutral cut in VAT rate

The design of scenarios, particularly, Scenario 2 and 3, is guided by the principle of incentivizing the informal firms to move into the formal domain. One may envisage, for example, a recycling of the carbon tax revenues for cutting production tax rates or labor tax rates of formal firms could incentivize the informal producers to transform to formal firms to receive the benefits offered by the recycling of carbon tax revenues. If they do not transform, they have to pay carbon tax but do not benefit from the recycled revenues.

Under scenarios 2 and 3, there are several possibilities on how much revenues to recycle to the economy. Table 2 presents the multiple cases under each of these three scenarios. For example, Scenario 2 – Case a (referred to as ‘Scenario 2a’) recycles carbon tax revenues collected from the formal firms to cut their production tax rates; on the other hand, Scenario 2 – Case e (or ‘Scenario 2e’) recycles entire carbon tax revenues (carbon tax revenues collected from formal and informal firms and final consumers) to cut production tax rates of non-energy formal firms. Under Scenario 2a, 2b and 2c, all formal firms, including fossil fuels firms, get the benefit of carbon tax revenue to cut their production tax rates. However, this does not sound reasonable if the objective of the policy is reducing carbon emissions because the cuts in production tax of energy-producing firms dampen the effects of the carbon tax. In other words, it causes a ‘rebound effect’. Therefore, Scenarios 2d and 2e exclude energy-producing firms from receiving carbon tax revenues to cut
their production tax rates. In these two scenarios, the rebound effects are reduced.\textsuperscript{10} Under Scenario 4, we also considered two cases. In the first case (Scenario 4c) carbon tax revenues are used to cut VAT of all goods. This case also causes the rebound effect as VAT of energy commodities is also cut. We considered another case to avoid the rebound effect (Scenario 4e) where energy commodities are exempted from VAT cut.

Table 2. Definition of various cases under Scenarios 2, 3 and 4

| Scenario | Case a: Production tax cut | Case b: Labor tax cut | Case c: VAT cut |
|----------|-----------------------------|----------------------|-----------------|
| Scenario 2: Production tax cut | Carbon tax revenue from \textit{formal firms} to cut production tax rate of \textit{all} formal firms | Carbon tax revenue from \textit{formal and informal firms} to cut production tax rate of \textit{all} formal firms | Not simulated |
| Scenario 3: Labor tax cut | Carbon tax revenue from \textit{formal firms} to cut labor tax rate of \textit{all} formal firms | Not simulated | Carbon tax revenue from \textit{formal and informal firms} and \textit{final consumers} to cut labor tax rate of \textit{non-energy} formal firms |
| Scenario 4: VAT cut | Not simulated | Not simulated | Carbon tax revenue from \textit{formal and informal firms} and \textit{final consumers} to cut VAT of \textit{all} commodities |

Note: the remaining carbon tax revenue under Cases a, b and d are recycled to households after keeping the government revenue neutral.

Although the carbon tax rate is the same, the level of CO\textsubscript{2} reduction varies across the scenarios due to the effect of recycled revenue or the rebound effect mentioned above. Different approaches to revenue recycling imply different allocations of resources across the economy,

\textsuperscript{10} Note, however, that emission intensive industries, such as transportation, still enjoy cutting their production tax rates using the carbon tax revenues. It means that some rebound effects still exist. One possible way to minimize the rebound effect would be not to allow all emission-intensive sectors to cut their production tax rates. However, we have not done so; otherwise there will be too many scenarios, and comparison of results will be too cumbersome.
including different demands for fossil fuels. In all scenarios, we maintained government revenue neutral to the carbon tax, which means that only the government revenues (including carbon tax revenue) in excess of that in the baseline is recycled to the economy.

Under Scenario 1 all households that supply labor to formal as well as informal sectors get benefits of lump-sum transfer from carbon tax revenue recycling. This is because households can not be differentiated as formal and informal households. Similarly, under Scenario 4, all commodities, irrespective of their origins (formal firms, informal firms, imports) get VAT reduction through the carbon tax revenues. This is because it is not possible to distinguish a commodity in the market based on its supply source (formal firms, informal firms, imports). The swapping of VAT with carbon tax reduces tax evasion because the carbon tax is applied upstream and is already embedded in the price of the commodity when it is transacted in the market.

5 Findings from the Model Simulations

In this section, we first present and discuss the impacts of the policies on some of the main economy-wide indicators, followed by a discussion of formal and informal sector trade-offs. At the end of the section, we discuss CO2 mitigation impacts under alternative scenarios.

5.1 Impacts on the overall economy

Figure 4 presents changes in GDP and welfare under alternative scenarios. GDP is composed of final consumption plus exports minus imports, given that investment is fixed in this static model.

Under Scenario 1, the carbon tax causes a loss in both GDP and welfare in the model (Figure 4). This result is an expected result reported in most CGE analyses of a carbon tax.\footnote{Please see Timilsina (2018) for economic impacts of carbon tax reported by existing studies.} The carbon tax still causes GDP and welfare loss even if the tax revenue is used to cut production tax rates of the formal firms. However, if the carbon tax revenues are recycled to cut production tax rates of non-fossil fuels industries, the revenue recycling effects offset the GDP loss. If all carbon tax revenues are used to cut production tax rates of non-energy goods (Scenario 2e), GDP and welfare will increase. Some existing studies (e.g., Jorgenson et al. 2015; McKibbin et al. 2015)
also report positive economic impacts of a carbon tax when the tax revenue is recycled to cut production tax rates.

The carbon tax would raise GDP and welfare from the baseline when the carbon tax revenue is recycled to cut labor tax rates in the formal firms (Scenario 3). The results also indicate that the higher is the recycled revenue, the higher would be the GDP and welfare under Scenario 3 (see Scenario 3c and 3e in Figure 4). The higher GDP and welfare under Scenario 3e compared to that under Scenario 3c indicates that rebound effects of a carbon tax should be avoided as much as possible to realize favorable economic impacts of a carbon tax. The model results show economic gain (GDP and welfare increase) when the carbon tax revenue is used to cut VAT (Scenario 4).

Table 3 presents the impacts of the carbon tax on the households under the different scenarios. These results also help explain the GDP and welfare impacts discussed above. The rise in household income under Scenario 1 is caused by lump-sum transfers of carbon tax revenues to households. Increased household income under Scenario 3 is caused by a reduction in labor tax. The higher the labor tax cuts (Scenario 3c and 3e), the higher would be the disposable income. Household consumption expenditure is affected by two factors: changes in household income and changes in prices of goods consumed by households. Under Scenario 1, household expenditure decreases despite increased disposable income because prices of commodities are higher (see next section). The movements of household income and expenditure determine household savings. Household consumption of energy decreases by more than 14% unless it is affected by the rebound effects. The lower reductions of household energy consumption under Scenarios 2a, 2b, 2c, 3a, 3c and 4a are caused by rebound effects. The results show the substitution of energy goods for non-energy goods due to the carbon tax.

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12 The reason for positive economic impacts under Scenario 3 is the increased real income of formal sector labor as their income tax is cut using the carbon tax revenue. The increased income also causes increased consumption. The higher the household income would lead to a higher welfare and the higher household consumption would cause a higher GDP.

13 Under Scenario 4, commodity prices of non-energy commodities drop as carbon tax revenue is used to cut VAT rates. It would cause production and consumption of non-energy intensive commodities cheaper. Which ultimately cause welfare and GDP to increase.
Figure 4. Impacts on GDP and welfare due to the carbon tax

(a) Percentage change in GDP from the baseline

(b) Percentage change in welfare from the baseline

Table 3. Impacts on households
(Percentage change from the baseline)

| Scenario | Disposable income | Household expenditure | Household energy consumption | Household non-energy consumption | Household savings |
|----------|-------------------|-----------------------|-------------------------------|---------------------------------|------------------|
| 1        | 0.18              | -0.05                 | -14.35                        | 0.51                            | 5.86             |
| 2a       | 0.00              | -0.11                 | -9.17                         | 0.24                            | 2.29             |
| 2b       | -0.04             | -0.14                 | -8.04                         | 0.17                            | 1.53             |
| 2c       | -0.11             | -0.17                 | -6.45                         | 0.07                            | 0.47             |
| 2d       | 0.13              | -0.01                 | -14.47                        | 0.56                            | 4.71             |
| 2e       | -0.02             | 0.12                  | -14.85                        | 0.71                            | 0.90             |
| 3a       | 0.32              | 0.16                  | -10.23                        | 0.57                            | 4.29             |
| 3c       | 0.37              | 0.22                  | -8.71                         | 0.57                            | 3.71             |
| 3d       | 0.26              | 0.09                  | -14.35                        | 0.66                            | 5.05             |
| 3e       | 0.51              | 0.53                  | -14.34                        | 1.12                            | 2.52             |
5.2 CO₂ emissions impacts of the carbon tax

Figure 5 presents total CO₂ emission reductions under the different scenarios. One important observation to make from Figure 5 is the differences in percentage reduction of emissions across the scenarios despite the same carbon tax rate (US$22/tCO₂). The same carbon tax rate causes a 10% reduction of total CO₂ emissions from the base case under Scenario 1. The percentage reductions of emissions range between 9.5% and 10% in four scenarios (Scenarios 2d, 2e, 3e, 3e). However, the percentage reductions are much smaller in several scenarios (Scenarios 2a, 2b, 2c, 3a, 3c, 4c). The ‘rebound effect’ mentioned earlier is responsible for the smaller reductions. When the carbon tax revenue is used to recycle to cut production taxes of the formal firms, including energy producers, the rebound effect would be so prominent that it could offset 40%-60% of emission reductions (Scenarios 2a, 2b, 2c). When the carbon tax revenues are not given back to energy producers to cut their production taxes (Scenario 2d, 2e), the rebound effects are corrected. Rebound effects also occur in Scenarios 3a, 3c although not as stronger as in Scenarios 2a, 2b, and 2c. This can also be corrected by avoiding recycling carbon tax revenues to cut labor tax rates in energy firms. It cannot be justified to cut VAT or excise tax of energy goods by using carbon tax revenues if the primary objective of the carbon tax is to reduce CO₂ emissions. When energy goods are denied carbon tax revenues to cut their VAT rates, rebound effects are eliminated (Scenario 4e). These results indicate that the design of revenue recycling schemes is critical to accomplish the climate change mitigation objective of a carbon tax. Most of the existing studies that consider using carbon tax revenues to cut production or labor taxes ignore this critical design architecture of the carbon tax.

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14 The electricity and natural gas sectors, which are the primary source of CO₂ emissions in Côte d’Ivoire, also receive carbon tax revenues to cut their production taxes. In fact, production of electricity is already subsidized in Côte d’Ivoire, recycling carbon tax revenues to further subsidize electricity production causes carbon tax to be ineffective to reduce CO₂ emissions from this sector.
The other interesting finding on the impact of a carbon tax on CO₂ emissions is the variations of CO₂ reductions between the formal and informal firms (see Table 4). Under Scenario 1, while the formal parts of the economy reduce their CO₂ emissions in response to the carbon tax by 10.1%, the informal sectors reduce 3.5%. The reason is that carbon-intensive sectors are mostly formal ones. Under Scenario 2a, 2b, and 2c, the CO₂ reductions in the formal firms are about the same or smaller than those in informal firms because of the rebound effect (formal firms receive carbon tax revenues to cut their production taxes, whereas informal firms do not). The higher the amounts of carbon tax revenues to cut production taxes in the formal firms, the smaller would be their CO₂ mitigation; the reduction of formal sector CO₂ emissions under scenario 3c drops to below 2% under Scenario 2c where entire carbon tax revenue (after keeping the government revenue neutral) is recycled to cut production taxes of formal firms including energy firms. These rebound effects are almost eliminated when energy firms are denied the carbon tax revenues to cut their production taxes (Scenario 2d, 2e).

Table 4 also presents overall CO₂ reductions associated with the vectors of commodities consumed in each scenario. Percentage emission reductions from the final demand sectors are higher than from the production (intermediate) sectors. This is because households are more sensitive to energy prices than firms. One notable result here is the difference between Scenario 4c and 4e. Under 4e, emission reductions from final demand are 14.5% when VAT of energy commodities are not provided carbon tax revenues to cut their VAT rates. The emission reduction
drops to 11% if energy commodities are allowed to cut their VAT rates using carbon tax revenues (rebound effect).

**Table 4. CO2 mitigation from different sources due to the carbon tax**

(Percentage change from the baseline)

| Scenario | Formal firms | Informal firms | Final demand |
|----------|--------------|----------------|--------------|
| 1        | -10.1        | -3.5           | -13.9        |
| 2a       | -4.7         | -4.6           | -12.4        |
| 2b       | -3.5         | -4.9           | -12.1        |
| 2c       | -1.8         | -5.2           | -11.7        |
| 2d       | -9.9         | -3.8           | -13.9        |
| 2e       | -9.2         | -4.8           | -14.2        |
| 3a       | -8.0         | -3.7           | -12.6        |
| 3c       | -7.2         | -3.8           | -12.1        |
| 3d       | -10.0        | -3.7           | -13.8        |
| 3e       | -9.5         | -4.2           | -13.8        |
| 4c       | -9.7         | -1.8           | -11.0        |
| 4e       | -10.3        | -3.2           | -14.5        |

5.3 Interactions between the formal and informal sectors

In this section, we examine interactions between formal and informal parts of the economy as a consequence of imposing the carbon tax with different recycling scenarios. The main indicators considered are formal and informal sectoral outputs and their labor demand.

The change in total outputs from the formal and informal sectors is presented in Figure 6. The impacts on outputs between the formal and informal sectors depend on how the carbon tax revenues are used to reward the formal firms. If the formal firms do not receive carbon tax revenues (Scenarios 1, 4c, 4e) or receive a small amount of revenues (Scenario 2a, 2b, 2d) to cut either their production taxes, they will bear the higher burden of carbon tax compared to informal sectors. Their outputs decrease, whereas informal firms’ output increase under these scenarios (except the informal outputs in Scenario 2b). The impacts will reverse if the entire carbon tax revenue is used to cut formal firms' production taxes (Scenario 2c, 2e). For example, if the entire carbon tax revenue (after keeping government revenue neutral) is recycled to cut production taxes of non-energy formal firms (Scenario 2e), the total outputs of formal firms increase by 0.46% compared to the baseline, whereas the total outputs of informal firms drop by 0.21%. All of the cases under
Scenario 3 provide stronger incentives for informal firms to move to the formal domain, compared to the other scenarios.

**Figure 6. Impacts of the carbon tax on sectoral outputs (% change from the baseline)**

![Figure 6](image)

Figure 7 shows changes in employment under the various scenarios. Since households and commodities are not distinguished between formal and informal categories, we cannot observe the interactions between formal and informal components of the economy under Scenario 1 and 4 (i.e., 4c, 4e). We could have excluded these scenarios, yet we included them because some readers might be interested in comparing labor demand impacts under these scenarios with those under Scenarios 2 and 3.

The direction as well as the magnitudes of labor demand effects under Scenario 2 and 3, clearly indicate that recycling the carbon tax revenue to benefit the formal firms would incentivize the informal firms to move to the formal domain. Under Scenarios 2a, 2b and 2c, total labor demand for formal firms increase, whereas total labor demand for informal firms decreases. Since total labor demand is in equilibrium with the total labor supply in a general equilibrium setting, the result suggests movements of labor from informal to formal parts of the economy. Even under the Scenario 2e, where energy firms do not receive carbon tax revenues to cut their production tax rates, labor demand in the formal sector increases at a higher rate than that in the informal sector. Under Scenario 2d, recycled carbon tax revenue is not enough to incentivize the movement of informal labor to the formal domain because only part of carbon tax revenue is used to cut production tax, and only non-energy firms receive that benefit. Under Scenario 3, where formal
labor benefits from reduced income tax, there is a strong movement of labor from informal to formal sectors. In all cases under this scenario (except Case d), the informal labor supply declines and formal labor supply increases.

**Figure 7. Impacts on labor supply (% change from the baseline)**

5.4 Impacts of a carbon tax at the sectoral and commodity levels

Tables 5-9 provide more detailed or sectoral and commodity level results under selected scenarios. These results include sectoral outputs of formal and informal sectors, final demand for goods and services, household demand for goods and services, imports and exports of goods and services and reductions of CO2 emissions from formal and informal activities in each sector.

5.4.1 Impacts on sectoral outputs

Table 5 presents the impacts of the carbon tax on outputs of formal and informal sectors. Under Scenario 1, the formal firms that face relatively higher loss of their outputs are in agriculture, forestry, mining, oil refinery and electricity & gas; informal firms that face a reduction of their outputs are in mining, forestry and transport; informal firms in the rest of the sectors exhibit an output gain due to the carbon tax. Under Scenario 2, the impacts on sectoral outputs depend on two factors: how much revenues are recycled to cut production taxes and whether or not energy producers are allowed to use carbon tax revenues to cut their production taxes. If only carbon tax revenues from the formal firms, instead of all carbon tax revenues after keeping the government revenue neutral) are recycled to reduce production taxes in all formal sectors including energy
producers (Scenario 2a), outputs increases in all formal sectors except extractive industry (S4) and petroleum refinery industry (S8). Informal firms in cocoa (S2), forestry and lumber (S3), extractive (S4) transportation (S16) would lose their outputs. On the other hand, if all carbon tax revenues (i.e., carbon tax revenues from formal and informal sectors and final demand sectors) are recycled to cut production taxes of formal sectors (Scenario 2c), outputs of several formal sectors would increase further. Note that a huge increase of electricity output (S13) under this scenario because of increased production subsidy caused by recycled carbon tax revenues. More informal sectors are losing outputs in this scenario than that in Scenario 2a. Not allowing the energy producers to cut their production tax benefits non-energy sectors (Scenario 2e). Outputs of the electricity sector drop under this scenario. Scenario 2c and 2e cause significant switching of informal firms to the formal part in many sectors. The comparison of sectoral outputs within the sub-groups of Scenario 3 is similar to those of sub-groups of Scenario 2. Note that the outputs of formal energy sectors under Scenario 3c are higher as compared to those under Scenario 3e due to the rebound effect. The reduction of VAT with the carbon tax under Scenario 4 helps to diminish output reductions for many formal firms or increase outputs for many informal firms, thereby reducing the adverse impact of the carbon tax on aggregate output.

5.4.2 Impacts on commodity demand and trade

Table 6 presents the impacts of the carbon tax on total final demand and household demand for goods and services. As expected, demand for energy goods and services and also demand for fossil fuel-intensive products decrease at higher proportions than other goods and services. This is because the prices of fossil fuels and increase more compared to other commodities with the carbon tax. However, the reductions in demand for goods and services would be higher under Scenarios 2 and 3 due to the rebound effects. Household electricity demand exhibits significant changes due to the rebound effect. For example, household electricity demand increases due to rebound effects in Scenarios 2a, 2c, 3c, whereas it drops by about 14% under Scenarios 2e and 3e, where the electricity sector does not get carbon tax revenues for production subsidy or labor tax cut.

Table 7 present the impacts of the carbon tax on imports and exports of goods and services due to the carbon tax. Imports and exports of mining goods/services and petroleum products decrease under all scenarios. In all scenarios, the change in exports follows the path of sector outputs, whereas the change in imports follows the path of total domestic demand.
5.4.3 Impacts on sectoral CO₂ emissions

Table 8 presents the reduction of CO₂ emissions by firms in each sector under each scenario. These results follow the output impacts presented in Table 5, and the explanations provided there are applicable here too. CO₂ emissions from industry are sensitive to their emission intensity. Most emission-intensive sectors, such as petroleum, mining/extractive, electricity generation and transport, would experience a relatively higher level of CO₂ reduction in each scenario. This tables presents some results which could be very critical in the design of a carbon tax. First, recycling carbon tax revenue to cut production or labor taxes in the electricity sector could wipe out entire emission reductions. For example, the carbon tax reduces more than 12% of emissions from the electricity sector (Scenario 1, 4) when tax revenues are not recycled to cut production or labor taxes in the formal sectors. If all tax revenues (keeping the government revenue neutral) are recycled to cut production taxes of formal sectors, including energy sectors, the CO₂ reduction from the electricity sector is completely wiped out (Scenario 2c) due to the rebound effect. In fact, CO₂ emissions from the electricity sector under this case would be higher than that in the baseline. Note that the electricity sector is already subsidized in the baseline. Recycling carbon tax revenue to further subsidize this sector would not be desirable from a carbon reduction perspective. If energy sectors, including the electricity sector, are denied from cutting the production taxes (Scenario 2e), emission reductions bounce back to the original level (12% below the baseline level). The results, however, do not imply that production taxes of clean or renewables electricity should not but cut using the carbon tax revenues.
Table 5. Impacts on sectoral outputs due to the carbon tax (% change from the baseline)

| Sector | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|--------|------------|------------|------------|------------|
|        | Case a     | Case c     | Case e     | Case a     | Case c     | Case e     | Case c     | Case e     |
|        | Formal     | Informal   | Formal     | Informal   | Formal     | Informal   | Formal     | Informal   |
| S1     | -1.23      | 1.44       | 0.30       | 0.54       | 1.00       | 0.06       | 4.14       | 0.51       |
| S2     | 3.29       | 2.91       | 0.62       | -0.26      | -0.83      | -1.94      | 3.03       | 0.93       |
| S3     | -2.78      | -0.13      | 0.64       | -0.08      | 2.31       | -0.08      | 10.1       | 1.15       |
| S4     | -12.9      | -11.2      | -5.5       | -5.03      | -1.33      | -1.65      | -12.8      | -12.0      |
| S5     | 1.23       | 1.40       | 0.62       | 0.62       | 0.24       | 0.18       | 1.69       | 1.25       |
| S6     | 1.71       | 2.65       | 2.08       | 2.30       | 2.03       | 1.90       | 6.37       | 5.96       |
| S7     | -1.06      | 0.85       | 0.43       | 0.52       | 1.12       | 0.32       | 4.25       | 0.73       |
| S8     | -9.55      | 0.00       | -6.67      | 0.00       | -5.25      | 0.00       | -9.49      | 0.00       |
| S9     | 2.64       | 2.68       | 1.70       | 1.47       | 1.08       | 0.73       | 5.25       | 3.95       |
| S10    | 0.19       | 1.65       | 0.50       | 0.76       | 0.62       | 0.29       | 0.67       | 0.97       |
| S11    | 0.96       | 1.39       | 0.58       | 0.64       | 0.33       | 0.22       | 1.78       | 1.32       |
| S12    | -0.01      | 0.00       | 0.32       | 0.00       | 0.46       | 0.00       | 0.95       | 0.00       |
| S13    | -8.25      | 0.00       | 1.78       | 0.00       | 7.38       | -0.67      | -7.96      | 6.05       |
| S14    | 0.40       | 0.16       | 0.25       | 0.12       | 0.15       | 0.09       | 0.60       | -0.06      |
| S15    | -0.21      | -2.15      | 0.57       | 2.36       | 0.91       | -2.49      | 4.16       | -3.11      |
| S16    | 0.09       | 0.45       | 0.20       | 0.13       | 0.23       | -0.04      | 0.82       | 0.28       |
| S17    | -0.04      | 1.45       | 0.04       | 0.41       | 0.06       | -0.11      | 0.00       | 0.35       |
| S18    |           |            |            |            |           |            |            |            |
Table 6. Impacts on total final demand and household demand for goods and services due to the carbon tax (% change from the baseline)

| Sector | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|--------|------------|------------|------------|------------|
|        | Case a     | Case c     | Case e     | Case c     | Case e     | Case c     | Case c     | Case e     |
| C1     | 1.16       | 0.46       | 0.61       | 0.46       | 1.08       | 1.07       | 1.05       | 1.04       | 1.33       | 1.25       | 0.52       | 0.25       | 0.59       | 0.31       |
|        | 1.45       | 0.63       | -0.26      | 0.20       | 0.14       | -0.91      | 2.04       | -0.16      | 1.29       | 0.52       | 1.21       | 0.33       | 2.20       | 0.53       | 2.20       | 0.32       | 2.31       | 0.13       |
| C3     | -0.52      | -0.85      | 0.06       | -0.23      | 0.31       | 0.05       | 2.41       | 2.22       | 0.13       | -0.07      | 0.40       | 0.26       | 1.92       | 2.00       | -0.13      | -0.59      | -0.31      | -0.88      |
| C4     | -6.79      | 0.00       | -4.65      | 0.00       | -3.59      | 0.0        | -6.73      | 0.0        | -5.16      | 0.00       | -4.49      | 0.0        | -6.75      | 0.0        | -5.74      | 0.00       | -7.10      | 0.0        |
| C5     | 0.70       | 0.59       | 0.34       | 0.27       | 0.12       | 0.08       | 0.92       | 0.76       | 0.77       | 0.72       | 0.79       | 0.76       | 1.32       | 1.29       | 1.28       | 1.25       | 1.41       | 1.40       |
| C6     | 0.63       | 0.32       | 0.69       | 0.42       | 0.74       | 0.41       | 2.07       | 1.32       | 0.97       | 0.65       | 1.07       | 0.76       | 2.14       | 1.55       | 2.78       | 2.26       | 3.11       | 2.55       |
| C7     | 0.00       | -0.16      | 0.32       | 0.28       | 0.25       | 0.45       | 1.53       | 1.68       | 0.35       | 0.50       | 0.48       | 0.77       | 1.29       | 1.90       | 0.55       | 0.45       | 0.58       | 0.48       |
| C8     | -7.8       | -14.8      | -6.9       | -13.2      | -6.5       | -12.5      | -7.3       | -15.2      | -7.0       | -13.4      | -6.7       | -12.8      | -7.4       | -14.6      | -5.7       | -11.7      | -7.7       | -15.3      |
| C9     | 1.16       | 0.36       | 0.65       | 0.26       | 0.32       | 0.18       | 2.25       | 0.81       | 1.09       | 0.52       | 1.06       | 0.57       | 2.18       | 1.99       | 2.58       | 1.72       | 2.77       | 1.96       |
| C10    | 0.45       | 0.16       | 0.38       | 0.18       | 0.32       | 0.18       | 0.63       | 0.03       | 0.45       | 0.41       | 0.44       | 0.48       | 0.56       | 0.54       | 0.76       | 0.99       | 0.81       | 1.20       |
| C11    | 0.58       | 0.15       | 0.28       | 0.13       | 0.09       | 0.10       | 0.95       | 0.43       | 0.53       | 0.32       | 0.51       | 0.38       | 0.96       | 0.85       | 1.17       | 1.31       | 1.24       | 1.53       |
| C12    | -0.28      | -0.05      | -0.08      | -0.04      | 0.02       | -0.03      | -0.27      | -0.02      | -0.15      | 0.16       | -0.10      | 0.22       | -0.15      | 0.46       | 1.05       | 2.68       | 1.24       | 3.14       |
| C13    | -6.9       | -13.3      | 1.6        | 1.3        | 6.3        | 9.44       | -6.6       | -14.3      | -1.2       | -2.1       | 0.8        | 2.0        | -6.7       | -13.7      | -7.0       | -14.2      | -7.1       | -14.5      |
| C14    | -12.9      | 0.0        | -5.5       | 0.0        | -1.3       | 0.0        | -12.8      | 0.0        | -10.1      | 0.0        | -9.1       | 0.0        | -12.7      | 0.0        | -13.1      | 0.0        | -13.5      | 0.0        |
| C15    | 0.30       | 0.58       | 0.19       | 0.35       | 0.14       | 0.21       | 0.33       | 0.83       | 0.25       | 0.68       | 0.23       | 0.72       | 0.34       | 1.31       | -0.14      | 0.57       | -0.16      | 0.66       |
| C16    | -0.65      | -1.34      | -0.34      | -0.69      | -0.21      | -0.40      | 1.23       | 1.46       | -0.25      | -0.72      | -0.08      | -0.45      | 1.23       | 1.42       | 0.01       | -0.59      | -0.17      | -0.92      |
| C17    | 0.10       | 0.78       | 0.13       | 0.39       | 0.13       | 0.17       | 0.58       | 0.74       | 0.22       | 0.71       | 0.24       | 0.65       | 0.67       | 1.15       | 0.36       | 0.25       | 0.38       | 0.36       |
| C18    | -0.01      | -0.05      | 0.03       | 0.14       | 0.04       | 0.21       | -0.01      | -0.03      | -0.17      | -0.95      | -0.27      | -1.47      | -0.24      | -1.31      | -0.11      | 0.32       | -0.12      | -0.66      |
Table 7. Impacts on imports and exports of goods and services due to the carbon tax (% change from the baseline)

| Goods and services | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|--------------------|------------|------------|------------|------------|
|                    | Case a     | Case c     | Case e     | Case c     | Case e     | Case c | Case e |
| Imports            | -0.38      | 1.59       | -0.14      | 1.19       | -0.07      | 0.29   | -0.08  | 1.44   | -0.01     | 2.40     | 0.09   | 2.21   | 0.33   | 2.53     | -0.38   | 1.59   | -0.42  | 1.82   |
| Exports            | 1.21       | 3.50       | 1.40       | -0.36      | 2.08       | -2.33   | 2.87    | 0.97   | 0.96       | 1.71     | 1.32   | 1.07   | 2.57   | 1.73     | 1.21    | 3.50   | 1.70   | 3.11   |
| Imports            | -0.10      | -0.16      | 0.18       | -0.07      | 0.17       | 0.45   | -0.22   | 5.15   | 0.29       | -0.03     | 0.29   | 0.52   | 0.11   | 3.79     | -0.10   | -0.16  | -0.02  | -0.60  |
| Exports            | -5.31      | -13.8      | -4.60      | -5.53      | -3.72      | -1.12   | -6.38   | -13.3  | -4.9       | -10.6     | -4.2   | -9.5   | -6.41  | -13.2    | -5.31   | -13.8  | -6.74  | -14.0  |
| Imports            | 0.38       | 1.59       | -0.08      | 1.03       | -0.05      | 0.40   | -0.10   | 2.61   | 0.07       | 1.94     | 0.13   | 1.88   | 0.29   | 3.04     | 0.38    | 2.77   | 0.47   | 2.97   |
| Exports            | 1.64       | 3.50       | 0.10       | 2.54       | 0.07       | 2.43   | 0.36    | 7.59   | 0.33       | 2.97     | 0.40   | 3.21   | 0.76   | 6.55     | 1.64    | 6.44   | 1.90   | 6.98   |
| Imports            | 0.38       | -0.16      | -0.10      | 0.91       | -0.16      | 1.31   | -0.56   | 4.50   | -0.10      | 0.98     | -0.19  | 1.42   | -0.45  | 3.76     | 0.38    | 0.78   | 0.47   | 0.72   |
| Exports            | -3.51      | -13.8      | -7.17      | -6.56      | -7.8       | -4.7   | -5.0    | -10.4  | -6.79      | -7.28     | -7.13  | -6.01  | -5.2   | -10.4    | -3.51   | -8.80  | -5.7   | -10.7  |
| Imports            | 1.66       | 1.59       | 0.26       | 2.15       | 0.04       | 1.39   | 1.15    | 6.50   | 0.61       | 2.93     | 0.61   | 2.78   | 1.22   | 5.80     | 1.66    | 6.12   | 1.78   | 6.61   |
| Exports            | 0.19       | 3.50       | 0.05       | 1.09       | 0.05       | 0.94   | 0.41    | 1.12   | 0.08       | 1.27     | 0.08   | 1.22   | 0.35   | 1.03     | 0.19    | 2.01   | 0.13   | 2.32   |
| Imports            | 0.51       | -0.16      | 0.00       | 1.04       | -0.11      | 0.65   | 0.27    | 2.86   | 0.24       | 1.35     | 0.25   | 1.21   | 0.40   | 2.54     | 0.51    | 3.03   | 0.50   | 3.33   |
| Exports            | 1.04       | -13.8      | -0.09      | -0.07      | 0.02       | 0.04   | -0.29   | -0.23  | -0.15      | -0.15     | -0.10  | -0.11  | -0.16  | -0.13    | 1.04    | 1.08   | 1.23   | 1.27   |
| Imports            | 8.07       | 1.59       | 0.13       | 3.14       | -3.0       | 16.4   | 8.7     | -19.7  | 0.91       | -3.34     | -1.04  | 2.73   | 8.4    | -19.7    | 8.07    | 19.9   | 7.9   | -20.1  |
| Exports            | -1.18      | 0.90       | -0.31      | 0.70       | -0.17      | 0.44   | -0.76   | 1.43   | -0.42      | 0.92     | -0.38  | 0.84   | -0.70  | 1.39     | -1.18   | 0.90   | -1.32  | 1.02   |
| Imports            | 0.64       | -0.80      | 0.19       | -1.01      | 0.09       | -0.58  | -0.49   | 3.48   | -0.42      | 0.92     | -0.38  | 0.84   | -0.70  | 1.39     | 0.64    | -0.80  | 0.85   | -1.47  |
| Exports            | -0.24      | 1.03       | -0.42      | 0.74       | -0.15      | 0.43   | -0.41   | 1.68   | -0.48      | 0.98     | -0.30  | 0.84   | -0.20  | 1.64     | -0.24   | 1.03   | -0.28  | 1.11   |
| Imports            | -0.14      | -0.08      | -0.27      | 0.35       | -0.27      | 0.37   | -0.24   | 0.24   | 0.80       | -1.20     | 1.33   | -1.96  | 1.36   | -1.92    | -0.14   | -0.08  | -0.17  | -0.06  |
| Exports            | -1.79      | -1.63      | -1.32      | -1.99      | -1.09      | -1.65  | -1.29   | -1.18  | -1.09      | -1.01     | -1.50  | -1.38  | -0.83  | -0.76    | -1.17   | -1.06  |
| Sector | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|--------|------------|------------|------------|------------|
|        | Case a     | Case c     | Case e     | Case a     | Case c     | Case e     | Case a     | Case c     | Case e     |
|        | Formal     | Informal   | Formal     | Informal   | Formal     | Informal   | Formal     | Informal   | Formal     |
| S1     | -5.42      | -3.73      | -3.52      | -3.80      | -2.62      | -3.86      | -0.23      | -4.39      | -4.14      | -3.38      | -3.60      | -3.25      | -2.29      | -3.72      | -3.99      | -3.12      | -5.36      | -4.26      |
| S2     | -1.68      | -1.93      | -3.57      | -4.27      | -4.64      | -5.54      | -1.79      | -3.66      | -2.40      | -2.74      | -2.68      | -3.04      | -2.03      | -3.05      | -0.28      | -0.45      | -1.66      | -1.93      |
| S3     | -6.40      | -4.69      | -2.74      | -4.10      | -0.94      | -3.84      | 6.12       | -3.81      | -3.89      | -4.11      | -2.80      | -3.88      | -0.11      | -3.80      | -5.20      | -3.23      | -6.87      | -4.46      |
| S4     | -15.9      | -14.2      | -8.38      | -7.72      | -4.22      | -4.19      | -15.6      | -14.8      | -13.0      | -11.6      | -11.9      | -10.6      | -15.7      | -14.5      | -15.2      | -14.0      | -16.3      | -15.1      |
| S5     | -2.07      | -1.97      | -2.54      | -2.55      | -2.83      | -2.89      | -1.52      | -2.07      | -2.05      | -1.97      | -2.02      | -1.95      | -1.40      | -1.58      | -0.59      | -0.39      | -1.37      | -1.08      |
| S6     | -2.94      | -2.40      | -1.71      | -1.76      | -1.31      | -1.65      | 1.54       | 0.75       | -1.67      | -1.41      | -1.22      | -1.07      | 0.29       | 0.27       | 1.59       | 2.26       | 0.88       | 1.67       |
| S7     | -5.18      | -3.99      | -3.21      | -3.27      | -2.27      | -2.94      | 0.25       | -4.12      | -3.92      | -3.29      | -3.40      | -3.05      | -2.58      | -4.07      | -3.20      | -2.73      | -4.42      | -3.69      |
| S8     | -14.7      | 0.00       | -12.8      | 0.00       | -11.9      | 0.00       | -14.8      | 0.00       | -13.1      | 0.00       | -12.4      | 0.00       | -14.7      | 0.00       | -13.4      | 0.00       | -15.2      | 0.00       |
| S9     | -2.22      | -2.22      | -2.20      | -2.56      | -2.36      | -2.87      | 0.32       | -0.92      | -1.84      | -2.03      | -1.71      | -1.97      | -0.50      | -1.17      | 1.10       | 0.73       | 0.30       | -0.11      |
| S10    | -2.94      | -1.89      | -2.97      | -2.91      | -3.02      | -3.41      | -2.42      | -2.38      | -2.99      | -2.42      | -3.00      | -2.59      | -2.74      | -2.17      | -1.25      | -1.08      | -2.12      | -1.99      |
| S11    | -3.82      | -3.35      | 0.00       | 0.00       | -3.17      | 0.00       | -3.04      | 0.00       | -3.35      | 0.00       | -3.17      | 0.00       | -3.42      | 0.00       | -1.96      | 0.00       | -2.99      | 0.00       |
| S12    | -4.58      | -2.85      | 0.00       | 0.00       | -2.02      | 0.00       | -3.61      | 0.00       | -3.58      | 0.00       | -3.26      | 0.00       | -4.42      | 0.00       | -2.13      | 0.00       | -2.86      | 0.00       |
| S13    | -12.5      | -4.16      | 0.00       | 0.00       | 0.50       | -12.3      | 0.00       | 0.00       | -9.51      | 0.00       | -8.37      | 0.00       | -12.3      | 0.00       | -12.9      | 0.00       | -13.0      | 0.00       |
| S15    | -4.48      | -4.51      | -3.76      | -2.41      | -3.41      | -1.37      | -4.16      | -4.85      | -3.98      | -2.91      | -3.78      | -2.35      | -4.51      | -4.80      | -4.04      | -4.06      | -5.25      | -4.83      |
| S16    | -4.65      | -5.89      | -3.21      | -5.59      | -2.54      | -5.47      | 0.31       | -6.75      | -3.74      | -5.40      | -3.35      | -5.23      | -2.20      | -6.26      | -3.26      | -3.55      | -4.48      | -5.01      |
| S17    | -4.76      | -4.54      | -3.72      | -3.87      | -3.22      | -3.56      | -3.91      | -4.59      | -4.00      | -3.77      | -3.72      | -3.48      | -4.22      | -4.21      | -3.35      | -3.16      | -4.47      | -4.27      |
| S18    | -3.21      | -2.02      | -3.23      | -2.52      | -3.25      | -2.76      | -3.02      | -2.93      | -3.31      | -1.20      | -3.33      | -0.75      | -3.25      | -1.23      | -2.36      | -1.73      | -3.30      | -2.46      |
4.5 Sensitivity analysis

Results from a CGE model are sensitive to many parameters. The most critical parameters are the "elasticities of substitution," which are measures of how flexibly producers can respond to changes in relative prices, including a carbon tax and cuts in other taxes. We carried out two sets of sensitivity analyses for all scenarios. In the first set of sensitivity analyses, we decreased the value of all elasticity parameters by 25%. In the second set of sensitivity analyses, we increased the values of elasticity parameters by 25%.

The results of the sensitivity analyses are presented in Table 9. The results confirm that the findings of the study are robust. There is no change in the direction of results, and the magnitudes of the changes are as expected. When the values of elasticity parameters are increased, both economic impacts and emission impacts improve: GDP and welfare become less negative if they are negative in the main analysis and more positive if they are positive in the main analysis. Similarly, the increase in elasticity values increases emission reductions. The economic and emissions reduction impacts of decreased elasticities of substitution are the opposite of those under increased elasticity values.

Table 9. Results of sensitivity analysis on key variables along with that in the main analysis (% change from the base case)

| Scenario | Main Case | Sensitivity case | Main Case | Sensitivity case |
|----------|-----------|-----------------|-----------|-----------------|
|          | GDP       | Elasticity increased | GDP       | Elasticity increased |
|          |           | Elasticity decreased |           | Elasticity decreased |
| Scenario 1 | -0.028  | -0.025 | -0.032 | -0.038 | -0.034 | -0.041 |
| Scenario 2a | -0.072  | -0.069 | -0.075 | -0.062 | -0.060 | -0.065 |
| Scenario 3a | 0.103   | 0.108  | 0.097  | 0.089  | 0.093  | 0.084  |
| Scenario 4c | 0.121   | 0.123  | 0.118  | 0.082  | 0.084  | 0.080  |
| Scenario 1 | -1.477  | -1.609 | -1.343 | 1.184  | 1.234  | 1.132  |
| Scenario 2a | -0.512  | -0.609 | -0.413 | 0.112  | 0.160  | 0.062  |
| Scenario 3a | -0.853  | -0.987 | -0.716 | 0.877  | 0.964  | 0.784  |
| Scenario 4a | -0.913  | -1.031 | -0.792 | 1.254  | 1.304  | 1.202  |
| Scenario 1 | -10.119 | -11.257 | -8.949 | -3.541 | -4.486 | -2.598 |
| Scenario 2a | -4.741 | -5.611 | -3.853 | -4.627 | -5.380 | -3.878 |
| Scenario 3a | -7.977 | -9.368 | -6.527 | -3.735 | -4.492 | -2.997 |
| Scenario 4c | -9.699 | -10.739 | -8.633 | -1.809 | -2.524 | -1.106 |
6. Conclusions

A large presence of informal activities is a common characteristic of many developing economies, particularly low-income countries in Sub-Saharan Africa. Economic progress is more rapid under conditions in which more firms and workers move into the formal parts of the economy, where productivity is higher. To the extent that a carbon tax, coupled with cuts in other taxes, can help reduce informality by providing incentives for workers and firms to move to the formal parts of the economy, the policy can gain support as a consequence of its economic co-benefits as well as its GHG emission reductions.

This study explores that question for Côte d’Ivoire, using a computable general equilibrium model developed to explicitly represent informality in various production sectors. The analysis shows that the economic and CO₂ reduction impacts of a carbon tax depend on the schemes to recycle the carbon tax revenue to the economy. The results indicate that a carbon tax with revenue recycling can benefit the overall economy if the carbon tax revenues are used to cut labor tax in the formal parts of the economy or to reduce the existing value-added tax. A carbon tax also increases GDP and welfare when the tax revenue is recycled to cut production taxes of non-energy formal sectors. If the tax revenue is recycled to cut production taxes of energy sectors, more than half of emission reduction achieved will be lost or emissions rebound. The rebound effects also exist when energy-producing formal sectors use the carbon tax revenues to cut their labor tax and when the VAT of energy commodities is allowed to be cut. The study shows that the rebound effects are minimized or almost eliminated by denying the energy commodities or energy-producing sectors from enjoying the carbon tax revenues. Doing so also increases GDP and welfare.

The study also confirms that using the carbon tax revenues to benefit formal parts of the economy by allowing the formal firms to cut their production or labor taxes causes the informal production activities to move toward the formal part of the economy. The model results show a flow of workers from the informal part of the economy to the formal part. Although lump-sum transfers of carbon tax revenues to households would be progressive from a distributional perspective, this approach leads to a greater net loss in GDP and welfare, and no benefit in moving workers and firms toward the more formal parts of the economy.
Several caveats apply to the analysis and suggest directions for further research. The CGE model in this paper is static, and it does not incorporate equilibrium unemployment (i.e., outcomes other than the standard setup with full employment). Moreover, available data were not sufficient to explore systematic differences in labor productivity between related formal and informal activities (i.e., productivity differences beyond differences in capital-labor ratios).

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Appendix A: Data Used for the Côte d’Ivoire CGE Social Accounting Matrix

Table A1. Côte d’Ivoire 2013 Social Accounting Matrix – Use Table (Million Local Currency, FCFA)

| Commodity | S1    | S2       | S3       | S4   | S5     | S6   | S7     |
|-----------|-------|----------|----------|------|--------|------|--------|
|            | Formal| Inform   | Formal   | Inform| Formal | Inform| Formal |
| C1         | 8,119 | 223,759  | 0        | 4,598 | 0      | 0    | 0      |
| C2         | 180   | 0        | 4,334    | 14,768| 0      | 0    | 0      |
| C3         | 0     | 0        | 0        | 0     | 4,031  | 0    | 0      |
| C4         | 1,606 | 0        | 0        | 0     | 0      | 3    | 4,619  |
| C5         | 13,387| 11,788   | 0        | 0     | 0      | 0    | 593,266|
| C6         | 238   | 7,996    | 389      | 0     | 0      | 0    | 17     |
| C7         | 6,067 | 781      | 20,272   | 518  | 225    | 0    | 11,923 |
| C8         | 9,747 | 6,326    | 6,702    | 110,554| 10,203| 3,917| 14,241 | 761   | 42,400|
| C9         | 17,581| 51,295   | 13,838   | 152,414| 0     | 0    | 593,266|
| C10        | 246   | 35       | 32,060   | 0     | 0      | 86   | 0      |
| C11        | 420   | 70,792   | 2,199    | 71,569| 13     | 10,118| 10,586 | 864   | 43,045|
| C12        | 772   | 11,560   | 1,356    | 11    | 60     | 8,701| 17,928 | 0     | 13,732|
| C13        | 3,241 | 158      | 3,222    | 49    | 2,034  | 6    | 6,096  | 0     | 36,702|
| C14        | 0     | 0        | 0        | 0     | 0      | 0    | 0      | 0     | 0     |
| C15        | 1     | 507      | 18       | 121   | 0      | 0    | 0      | 4     | 0      |
| C16        | 0     | 1,246    | 0        | 20,082| 0      | 119,350| 378    | 0     | 7,902  |
| C17        | 7,005 | 21,648   | 28,944   | 54,801| 5,737  | 47,090| 168,158| 942   | 165,269|
| C18        | 0     | 0        | 0        | 0     | 0      | 0    | 0      | 0     | 0     |
| Labor      | 18,199| 30,000   | 37,174   | 113,198| 4,812  | 127  | 43,162 | 1,017 | 117,800|
| Capital    | 21,306| 1,696,435| 132,702  | 1,129,569| 21,575| 39,709| 838,365| 31,928| 781,280|
| Tax &      | 139   | 0        | 1,546    | -5,200|-983    | 0    | 12,330 | 0     | 15,439 |
| Subsidy    |       |          |         |       |        |      |        | -59   | 0      |

|            | Formal| Inform   | Formal   | Inform| Formal | Inform| Formal |
| C1         | 165,499| 176,922  | 0        | 0     | 0      | 0    | 0      |
| C2         | 622,296| 4,795    | 0        | 0     | 0      | 0    | 16     |
| C3         | 4,598  | 16      | 10,627   | 0     | 0      | 0    | 38,973 |
| C4         | 2,499  | 1,354    | 0        | 0     | 0      | 0    | 423    |
| C5         | 593,266| 204,292  | 0        | 0     | 0      | 0    | 54     |
| C6         | 85     | 0        | 0        | 0     | 0      | 0    | 173    |
| C7         | 73,686 | 5,718    | 10,778   | 241   | 78,921 | 56,459|
| C8         | 42,400 | 4,647    | 7,014    | 112   | 28,939 | 3,493 |
| C9         | 70,436 | 6,320    | 52,594   | 4,516 | 56,748 | 24,561|
| C10        | 11,210 | 0        | 0        | 0     | 0      | 0    | 1,008  |
| C11        | 10,606 | 760      | 10,606   | 760   | 5,187  | 894   |
| C12        | 13,732 | 1,409    | 418      | 10    | 5,187  | 894   |
| C13        | 36,702 | 3,233    | 8,269    | 90    | 11,194 | 6,809 |
| C14        | 0      | 0        | 0        | 0     | 0      | 0    | 0      |
| C15        | 4      | 0        | 0        | 0     | 0      | 0    | 0      |
| C16        | 541    | 109      | 5,875    | 2,525 | 39,114 | 18,484|
| C17        | 21,352 | 32,270   | 41,404   | 32,270| 41,404 | 32,270|
| C18        | 24,515 | 2,680    | 39,114   | 18,484| 64,770 | 258,054|
| Tax &      | 15,439 | 0        | 5,683    | 0     | 0      | 0    |
| Subsidy    | -59    | 0        | 5,683    | 0     | 0      | 0    |
| Commodity | S8   | S9   | S10  | S11  | S12  | S13  | S15  | S16  |
|-----------|------|------|------|------|------|------|------|------|
|           | Formal | Inform | Formal | Inform | Formal | Inform | Inform | Inform |
| C1        | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| C2        | 0     | 134   | 841   | 217   | 0     | 0     | 0     | 0     |
| C3        | 0     | 0     | 0     | 0     | 0     | 0     | 35    | 1,506 |
| C4        | 1,145 | 1,14   | 1,963 | 3,033 | 7,372 | 2,488 | 1,048 | 0     |
| C5        | 0     | 15,26 | 3      | 0     | 0     | 0     | 0     | 0     |
| C6        | 0     | 680   | 0     | 0     | 2,136 | 0     | 0     | 305   |
| C7        | 3,780 | 28,25 | 9      | 140   | 11,26 | 5     | 4,260 | 0     |
| C8        | 11,863| 20,18 | 6      | 593   | 907   | 1     | 5,100 | 0     |
| C9        | 3,151 | 388   | 0     | 85     | 3,158 | 613   | 226   | 10,915|
| C10       | 32    | 17,84 | 6      | 70,80 | 4     | 2,430 | 723   | 0     |
| C11       | 4,898 | 12,56 | 3      | 0     | 20,61 | 4     | 9,311 | 0     |
| C12       | 1,058 | 2,389 | 0     | 479   | 140   | 6,181 | 0     | 3,671 |
| C13       | 920   | 15,49 | 5      | 225   | 4,850 | 282   | 2,863 | 0     |
| C14       | 30,38 | 9      | 0     | 0     | 0     | 0     | 0     | 0     |
| C15       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| C16       | 0     | 1,350 | 0     | 0     | 183   | 0     | 5,398 | 0     |
| C17       | 26,54 | 63,57 | 0     | 10,83 | 7      | 0     | 77,22 | 17,098|
| C18       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| Labor     | 18,94 | 79,82 | 2     | 829   | 9,319 | 1,484 | 23,835| 3,004 |
| Capital   | 174,67| 7     | 346   | 0,999 | 14,32 | 6      | 20,557| 64,546|
| Tax & Subsidy | 3,85 | 9      | 6,65 | 9      | 0     | 1,188 | 0     | 2,036 |

Table A1 (Continued). Cote d’Ivoire 2013 Social Accounting Matrix – Use Table (Million Local Currency, FCFA)
Table A1 (Continued). Cote d’Ivoire 2013 Social Accounting Matrix – Use Table (Million Local Currency, FCFA)

| Commodity | S17 | S18 | Government | Households | Capital goods | Stock change | Trade margin | Exports |
|-----------|-----|-----|------------|------------|---------------|--------------|--------------|---------|
|           | Formal | Infrml | Formal | Infrml |               |              |              |         |
| C1        | 0   | 8,911 | 1,061   | 0   | 0             | 2,040,801 | 45,269       | 14,254  |
| C2        | 0   | 0     | 0       | 0   | 0             | 269,228    | 1,689,114    | 21,902  |
| C3        | 0   | 2,120 | 0       | 0   | 0             | 176,525    | 16,845       | 769,751 |
| C4        | 0   | 0     | 0       | 0   | 0             | 0          | 410,462      | 984,798 |
| C5        | 0   | 23,171| 9,500   | 0   | 0             | 2,510,159 | 465,812      | 984,798 |
| C6        | 0   | 451   | 399     | 0   | 0             | 260,253    | -3,787       | 220,825 |
| C7        | 184,104 | 2,743 | 27,422  | 2,241| 0             | 287,154    | 115,995      | 124,086 |
| C8        | 77,183 | 7,710 | 38,060  | 210 | 0             | 275,641    | 39,608       | 919,246 |
| C9        | 2,795 | 8,379 | 17,395  | 32  | 0             | 610,865    | 134,607      | 612,797 |
| C10       | 1,687 | 2,140 | 1,114   | 0   | 0             | 39,145     | 52,034       | 8,705   |
| C11       | 38,268 | 18,250 | 467    | 2   | 0             | 36,611     | 81,724       | 51,261  |
| C12       | 25,974 | 12,939 | 48,849  | 915 | 0             | 393,956    | 839,244      | 489,509 |
| C13       | 52,353 | 4,508 | 76,523  | 6   | 0             | 110,256    | 0            | 46,604  |
| C14       | 0   | 0     | 0       | 0   | 0             | 0          | 0            | 0       |
| C15       | 6   | 0     | 250     | 0   | 0             | 30,455     | 1,011,888    | 991     |
| C16       | 63,987 | 216,247 | 17,276  | 809 | 0             | 590,972    | 0            | 67,893  |
| C17       | 669,352 | 27,907 | 295,021 | 1,500| 0             | 2,152,982  | 2,048,137    | 231,830 |
| C18       | 0   | 0     | 0       | 0   | 0             | 1,897,574  | 419,398      | 71,822  |
| Labor     | 627,010 | 50,847 | 1,240,791 | 3,045| 0             | 2,040,801  | 45,269       | 14,254  |
| Capital   | 2,540,915 | 1,373,180 | 463,791 | 59,335| 0            | 2,040,801  | 45,269       | 14,254  |
| Tax & Subsidy | 98,506 | 0     |         |     |               |            |              |         |
Table A2. Cote d'Ivoire 2013 Social Accounting Matrix – Make Table (Million Local Currency, FCFA)

| Sector | C1     | C2     | C3     | C4     | C5     | C6     | C7     | C8     | C9     | C10    | C11    | C12    | C13    | C14    |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| S1 - Form | 108,253 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S1-Infml | 2,134,294 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S2 - Form | 252,730 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S2-Infml | 1,699,113 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S3 - Form | 47,709 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S3-Infml | 235,285 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S4 - Form | 888,293 |        |        |        |        |        |        |        |        |        |        |        |        | 235,596 |
| S4-Infml | 40,694 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S5 - Form | 2,762,411 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S5-Infml | 694,168 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S6 - Form | 289,542 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S6-Infml | 50,768 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S7 - Form | 380,656 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S7-Infml | 464,498 |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S8-Form |        |        |        |        |        |        |        |        |        |        |        |        | 1,425,229 |        |
| S8-Infml |        |        |        |        |        |        |        |        |        |        |        |        | 1,135,080 |        |
| S9 - Form |        |        |        |        |        |        |        |        |        |        |        | 27,110 |        |        |
| S9-Infml |        |        |        |        |        |        |        |        |        |        |        | 158,987 |        |        |
| S10 - Form |        |        |        |        |        |        |        |        |        |        |        |        | 83,049 |        |
| S10-Infml |        |        |        |        |        |        |        |        |        |        |        |        | 356,706 |        |
| S11 - Form |        |        |        |        |        |        |        |        |        |        |        |        |        | 54,600 |
| S11-Infml |        |        |        |        |        |        |        |        |        |        |        |        |        | 36,571 |
| S12-Form |        |        |        |        |        |        |        |        |        |        |        |        |        | 481,147 |
| S12-Infml |        |        |        |        |        |        |        |        |        |        |        |        |        | 5,910  |
| S13 - Form |        |        |        |        |        |        |        |        |        |        |        |        |        | 601,481 |
| S13-Infml |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| S15 - Form |        |        |        |        |        |        |        |        |        |        |        |        |        | 422,381 |
| S15-Infml |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Tax on products | 0 0 0 861 150,928 22,396 33,615 154,576 94,887 17,166 37,752 185,510 5,321 0        |
| Tax on exports | 0 210,408 934 32 83,683 87 2,584 505 600 7 94 37 0 0        |
| Import duty | 10,560 11,609 5 918 91,665 23,950 18,420 4,014 78,114 29,343 34,611 144,741 0 0        |
| Imports | 204,807 59,182 2,247 1,459,605 733,518 103,555 121,762 113,688 690,898 108,984 285,390 1,386,583 613 0        |
| Trade margin | 231,480 558,028 25,099 1,064 317,877 50,559 141,305 95,946 263,267 34,286 37,055 278,973 0 0        |
Table A2 (Continued). Cote d’Ivoire 2013 Social Accounting Matrix – Make Table (Million Local Currency, FCFA)

| Sector          | C15     | C16   | C17     | C18     |
|-----------------|---------|-------|---------|---------|
| S15 – Formal    | 601,481 |       |         |         |
| S15-Informal    | 422,381 |       |         |         |
| S16 – Formal    |         | 647,726|         |         |
| S16-Informal    |         | 344,119|         |         |
| S17 – Formal    |         |       | 4,382,138|         |
| S17-Informal    |         |       | 1,759,503|         |
| S18 – Formal    |         |       |         | 2,237,855|
| S18-Informal    |         |       |         | 68,095  |
| Tax on products | 7,200   | 29,646| 89,088  | 60      |
| Tax on exports  | 0       | 0     | 0       | 0       |
| Import duty     | 0       | 0     | 0       | 0       |
| Imports         | 37      | 132,131| 287,293| 82,784  |
| Trade margin    | 13,198  | 0     | 0       | 0       |