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by
U-Primo E. Rodriguez

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College of Economics and Management
University of the Philippines Los Baños
College, Laguna
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BIOFUELS AND THE ENVIRONMENT: AN ANALYSIS USING A COMPUTABLE GENERAL EQUILIBRIUM MODEL THE PHILIPPINES

U-Primo E. Rodriguez[1]

Abstract

This paper investigates the potential environmental impacts of using agricultural commodities as feedstock for biofuels in the Philippines. In particular, it explores the use of sugar and coconut as feedstock and its effects on industry performance and eleven pollution emissions. The analytical tool is a 15 commodity CGE model which has been augmented with information of pollution emissions. The key results of the study are as follows. First, industries which are used as feedstock are likely to expand. Second, industries which rely heavily on the agricultural commodities used as feedstock are likely to be adversely affected. Third, the variable impacts across pollution emissions suggest that the effects on the environment are not clear. Finally, the impacts on pollution emissions depend in part of the share of the industries in total emissions as well as the magnitudes of the output changes in the industries.

Keywords: Biofuels, Agriculture, CGE models, Philippines, Environment

I. INTRODUCTION

Republic Act 9367, otherwise known as the Biofuels Act of 2006, calls the mandatory mixing of ethanol and biodiesel in gasoline and diesel, respectively. Apart from reducing the dependence of the country on imported fossil fuels, the law is also envisioned as a means to promote the use of cleaner sources of energy.

Questions remain regarding the potential overall contribution of biofuels to a cleaner environment. The environmental gains from replacing fossil fuels need to be weighed against the potential environmental cost of, among others, growing feedstock. According to the World Bank (2007), such costs could include emissions from fertilizer production as well as changes in land use. It also cited the potential environmental costs of manufacturing biofuels and its transportation to consumption centers. Rajagopal and Zilberman (2007) stated that promoting biofuels as a means to address climate change maybe "too optimistic." The authors argued that "it is hard to generalize about the indirect carbon emissions (from agriculture and food processing) and emissions from other harmful pollutants, which can be significant." The points above suggest the need to conduct a broad analysis of the environmental impacts of promoting biofuels. This includes evaluating the effects of the initiative on industries outside agricultural feedstock and fossil fuel production, and the pollution emissions arising changes in production.

[1] Associate Professor, Department of Economics, University of the Philippines Los Baños. Email: uprime@gmail.com.

The general objective of this study is to investigate the potential environmental impacts of using agricultural commodities as biofuel feedstock in the Philippines. Using a Computable General Equilibrium (CGE) model, it seeks to examine how employing sugar and coconut as biofuel feedstock affects pollution emissions. The analytical procedure is a three-step process. The first step involves evaluating the impacts of promoting biofuels on the outputs of various industries. The second stage calculates the quantity of the emissions arising from the changes in the output of each industry. Finally, the emissions are added across industries to generate a national estimate of the impacts.

The contribution of this study is a broad analysis of the environmental impacts of promoting biofuels in the Philippines. It does so by incorporating the adjustment of non-feedstock industries and their impacts on pollution emissions. Second, it provides insights in the formulation of the links between the agricultural feedstock as biofuel and the environment within the confines of a CGE model.

The choice of sugarcane and coconut for the analysis is based on the following. First, these commodities are well-known sources of biofuels. Sugar as a source for bio-ethanol has been used extensively in countries like Brazil. On the other hand, coconut is currently being used as source for bio-diesel in the country. Second, sugarcane and coconut are well-established crops in the Philippines. Combined, both crops accounted for close to a fifth of the total value of production of crops in 2007 (Table 1). Both commodities also ranked among the top five crops, in terms of value of production, for the same period. Coconut and sugarcane also account for almost a third of all the land devoted to crops. In terms of area planted, coconut ranks second only to palay.

The decision to employ a CGE model is based on the following reasons. First, the tool provides a sound economic framework for analysis. These models allow the use of available data in a manner that is strongly grounded on economic theory and the accounting relationships between variables and sectors. Second, the explicit treatment of the links between various economic agents and markets facilitate the evaluation of the impacts on the markets of non-feedstock industries. The model also provides an automatic feedback mechanism in which changes in the non-feedstock industries affect the feedstock industries. Third, the model is transparent. An examination of the model equations and parameters illustrates the assumptions that are embodied in the analysis. Finally, a CGE allows an analysis in large dimensions. It facilitates the simultaneous analysis of a multitude of experiments and their effects on many economic variables.

This paper is organized as follows. Section II describes the tool that is used for the analysis. It also provides a brief background on CGE models and its applications. Section III discusses the simulation results. Section IV presents a few concluding remarks as well as the limitations of the study.

II. METHODOLOGY

This section describes the methodology that is used in the study. It begins with an overview of CGE models. This is followed by a brief discussion of the structure of the model used in the analysis. A description of the data sources and experimental design concludes this section.

II.A CGE models and their applications

CGE models are numerical tools which capture the interaction of various agents in the different markets of an economy. These models typically contain equations which describe the (a) different sources of demand and supply for outputs and inputs, (b) determination of prices, (c) household income and expenditure, (d) international trade, and (e) macroeconomic variables. More sophisticated variants may also include indicators relevant to the environment (e.g. emissions) and economic development (e.g. poverty and income inequality). The underlying assumptions may also differ from one model to the next, depending on the objectives of the exercise and the modeler's perception of the economy being modeled. CGE models have been applied to wide range of topics and issues. These include fiscal policy, trade policy, environmental issues and policy, regional issues and policy, and agriculture. [2]

The use of CGE models for assessing the impacts of biofuels is relatively new. However, the literature is growing. For example, Hertel et al. (2008) and Teheripour et al. (2008) examined the global implications of the biofuels mandates of the United States and European Union. On the other hand, Banse et al. (2008) evaluated the global impacts of the biofuel targets of the United States, Canada, Japan, South Africa and Brazil. CGE models have also been applied to examine country-specific impacts. Arndt et al. (2008), Giesecke et al. (2008, 2007), Gohin (2007) and Dixon et al. (2007) are examples of applications to Mozambique, Brazil, European Union and the United States, respectively.

CGE models have been used in the Philippines for about a quarter of century. The earliest applications were on the assessment of fiscal policy (Habito, 1984) and trade distortions (Clarete, 1984). It has since been used for the analysis of various issues and policies, including agriculture and different aspects of economic development. Recent examples include Briones (2008), Cockburn et al. (2008), Cabalu and Rodriguez (2007), Rodriguez et al. (2007), Cororaton (2006), Cororaton and Corong (2006), Rodriguez and Cabanilla (2006) and Cororaton et al. (2005).[3]

The impacts of various policy measures on the environment have also been evaluated in the Philippines. The typical modeling approach has been to examine the

[2] A detailed discussion on CGE models is beyond the scope of this paper. The interested reader is referred to Sadoulet (1995), Shoven and Whalley (1992 and 1984), Dixon et al. (1992), Robinson (1989) and Dervis et al. (1982) for a more in depth description of such models. Devarajan and Robinson (2002), Wajman (1995), Shoven and Whalley (1992 and 1984) are examples of papers which provide a review of its applications.

[3] For a review of older CGE models of the Philippines, see Rodriguez (2007), Yap (2002) and Rodriguez and Briones (1997).

impact of a policy measure on a set of pollution emissions. For example, Dufournaud et al. (2003) and Rodriguez (2003) analyzed the impacts of a commercial log ban on, among others, 11 types of pollution emissions. On the other hand, Inocencio et al. (2001) evaluated the effects of tax changes (tariffs, income taxes and indirect taxes) on the same set of pollution emissions. Aldaba and Cororaton (2002) and Corong (2008) explored the impacts of tariff changes on six pollution emissions and carbon emissions, respectively. Despite differences in the policies and emissions covered, a common thread in most of the studies is the manner in which emissions are introduced in the model. The approach has been to specify a pollution intensity, which is measured as the quantity of emissions per peso of output, and to multiply this by industry output in order to derive the emissions per industry. Corong (2008) differed in this regard as the study estimated emissions as a function of input use rather than industry output. The approach was to multiply actual fossil fuel use in each economic sector by a pre-determined carbon-specific fuel coefficient.

There are very few applications of CGE models to the analysis of biofuel issues in the Philippines. Examples are Rodriguez and Cabanilla (2008a and 2008b) and Cabanilla and Rodriguez (2008). These studies focused on the impacts of using sugar and/or coconut as feedstocks for biofuels on agriculture and food security. To date, the author has not found any CGE model of the Philippines which has been used to evaluate the environmental impacts of promoting biofuels.

II.B. Model Structure[4]

The core of the analytical tool is taken from Rodriguez and Cabanilla (2008a and 2008b). This is a CGE model of the Philippines which divides the economy into four major blocks; namely, production, households, government and foreign trade.

The household block assumes a representative household that owns the factors of production. Payments for the use of these factors, along with net transfer payments, serve as the sources of income for the household. Its consumption of goods and services is determined by means of an optimization process in which the household seeks to maximize utility. The utility function is assumed to be a Cobb-Douglas.

Each industry in the production side is represented by optimizing firms that operate in perfectly competitive markets. Each firm is assumed to combine value added and intermediate inputs in fixed proportions (Leontief technology) to produce its output. Value added, on the other hand, is formulated as a Cobb-Douglas composite of labor and capital. The optimization process generates the input demand and output supply equations of the model.

Government enters the model though its spending and revenue functions. Its revenues are generated mainly from taxes on income, transactions and imports. Any excess of its spending over revenues is reflected in the budget deficit.

[4] A complete list of equations is presented in Annex 1.

The foreign block is represented by imports and exports. It assumes that the Philippines is a small open economy; implying that the import supply and export demand equations are perfectly elastic. On the other hand, the export supply and import demand equations are formulated on the notion that domestic and foreign goods are not perfectly substitutable – the Armington assumption (Armington, 1969).

The four blocks of the model are integrated by means of equilibrium conditions. The supply side is made-up of domestic output and imports. On the other hand, the demand side is composed of household consumption, intermediate demand, government spending and exports. These equilibrium conditions determine domestic prices. The exchange rate is the numeraire.

The environmental impacts are modeled using the approach employed by Aldaba and Cororaton (2002) and Inocencio et al. (2001). These studies specify that the emission of pollutant *k* coming from industry *i* $\left(EMIT_{ki}\right)$ is the product of its pollution intensity $\left(\pi_{ki}\right)$ and the output of the industry $\left(Q_i\right)$. The total emissions of pollutant *k* $\left(EMIT_k\right)$ are calculated by taking the sum of its emissions from the different industries.

$$EMIT_{ki} = \pi_{ik} \cdot Q_i \qquad (1)$$

$$EMIT_k = \sum_{i=1}^{N} EMIT_{ki} \qquad (2)$$

where: i = 1, …, N industries; k = 1, … K pollutants

II.C Disaggregation of the model and sources of data

Disaggregation of the model

The model disaggregates the Philippine economy into 15 commodities/industries. The *Agriculture, Fishery and Forestry* (AFF) sector is composed of seven commodities/industries; namely, (a) *Palay*, (b) *Corn*, (c) *Sugar*, (d) *Coconut,* (e) *Other crops*, (f) *Livestock and poultry*, and (g) *Other agriculture, fishery and forestry* (*Other AFF*). The *Industry* sector is also made-up of seven commodities/industries. These are (a) *Mining*, (b) *Rice and corn milling*¸(c) *Sugar milling*, (d) *Other food processing*, (e) *Coconut oil and related products*, (f) *Non-food manufacturing*, and (g) *Petroleum refining*. The *Services* sector is modeled as one industry/commodity.

Each industry is potentially capable of emitting eleven types of pollutants. These are biochemical oxygen demand (BOD5), carbon monoxide (CO), nitrogen (N), nitrogen oxide (NOX), oil, phosphorus (P), particulate matter (PM), sulfur oxide (SOX), suspended solids (SS), total suspended solids (TDS) and volatile organic compounds (VOC).

Sources of data for the core model and the baseline solution

A CGE model requires a Social Accounting Matrix (SAM) and values for the parameters of the behavioral equations. The SAM, which captures disaggregated income and expenditure flows of and between economic agents, was constructed for this model using information from the 2000 input-output table of the Philippines, the national accounts and tariff rates from the Philippine Tariff Commission. The parameters of the behavioral equations were determined in two ways. The elasticities of substitution between domestic and imported goods and the elasticities of transformation between goods destined for the domestic and foreign markets were borrowed Cororaton (2000) and Inocencio et al (2001), respectively. The remainder of the parameters were calibrated to ensure that the baseline solution of the model replicates the values in the SAM. Annex 2 shows the selected baseline values of the model.

Sources of data and adjustments to emissions data

Since updated emissions data are very difficult to find, the strategy adopted in this study was to borrow the pollution intensities used in Inocencio et al (2001). However, two adjustments were made to make the values relevant to the current study.

The first adjustment is related to the level of disaggregation. Inocencio et al. (2001) used a more disaggregated model with 35 industries/commodities. For the most part, this was not really a problem because some of industries in the two models are the same while others are simply required aggregation (see Annex 3). For industries in the current model that are aggregates of the industries in Inocencio et al. (2001), the pollution intensity was calculated as a weighted average of the "sub-industries". For example, the current model represents *Services* as one industry whereas Inocencio et al (2001) models this as 10 sub-industries. To construct the pollution intensity for *Services*, a three-step procedure was used.[5] The first step was to take the sum of the baseline emissions of the 10 sub-industries in Inocencio et al. (2001). The second step was to calculate the sum of the baseline outputs of the 10 sub-industries in Inocencio et al. (2001). The final step generates the pollution intensity by taking the ratio of the values which were calculated in the first and second steps.

There are three industries in the current model for which the above procedure was not used. These industries are *Coconut*, *Sugar* and *Coconut oil and related products.* In the case of the first two industries, the issue is that Inocencio et al. (2001) treats this as a composite industry called *Coconut and sugarcane.* The problem was confronted by simply assuming that the pollution intensities for *Coconut* and *Sugar*, as separate industries, are the same as the composite industry. The issue is a bit more difficult for *Coconut oil and related products* because this is included in a composite industry called *Other food* in Inocencio et al. (2001). As such, the approach was simply to borrow the pollution intensities of *Other food*.

[5] A similar procedure was also used for computing the pollution intensities of *Other AFF, Other food manufacturing* and *Non-food manufacturing.*

The second adjustment involves re-scaling the pollution intensities. Pollution intensities here and in Inocencio et al. (2001) are measured in tons per million pesos. A problem arises because Inocencio et al. (2001) uses the 1994 input-output table whereas the current model uses the 2000 input-output table. This means that changes in the value of output embody changes in quantity and prices. The impact of the price changes should be eliminated because it is the change in output that really affects emissions.[6] Fortunately, this problem can be overcome by deflating the value of the outputs in 2000 to 1994 prices. However, this process is tedious and risky because it involves adjusting all the values in the SAM. If the objective is to construct emissions which are at least comparable to the 1994 dataset, an equivalent and efficient approach would be to simply deflate the pollution intensities. Annex 4 shows the unadjusted and adjusted pollution intensities.

II.D Design of the experiment

The experiment implemented in the study is identical to Rodriguez and Cabanilla (2008b). This is based on Republic Act 9367 which eventually calls for a 10 percent mix of bioethanol in gasoline and a 2 percent mix of biodiesel. In the experiment, this was implemented by replacing cost of *Petroleum refining* that is attributable to crude petroleum by inputs coming from the *Sugar* and *Coconut* industry.

It is important to note that gasoline and diesel are only two of the outputs produced by the petroleum refining industry. Moreover, these sub-industries do not explicitly appear in the input-output table. As such, displacing 10 and 2 percent of the inputs of crude petroleum by *Sugar* and *Coconut*, respectively, is likely to overstate the magnitude of the impacts. To overcome this difficulty, the magnitude of the shock was scaled down by the estimated shares of gasoline and diesel in the output of *Petroleum refining*.

III. SIMULATION RESULTS

This section presents the simulation results from the experiments. It begins by discussing the impacts on industry output. This lays the foundation for explaining the impacts on emissions.

III.A Industry impacts

Table 2 shows the industry impacts for selected variables in the model. It indicates that there is contraction in the value added and output of all but three of the industries in the model.[7] The industries that benefit the most are *Sugar* and *Coconut*. The

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[6] Consider an extreme situation in which output and other real variables are constant but prices are higher. While this implies that the value of output is higher, it is very difficult to imagine why pollution emissions should higher.

[7] The assumption of a Leontief technology implies that, in the absence of technological change, the changes in output and value added are the same.

outputs of these industries are projected to be 13.41 and 2.71 percent higher than the baseline, respectively. In contrast, the industries that are most adversely affected are *Sugar milling*, *Mining*, and *Coconut oil and related products.* The impacts on the outputs of the other industries, while mostly negative, are significantly smaller than the industries mentioned above.

The expansion in the outputs of *Sugar* and *Coconut* can be explained by an increase in demand. Their "new" use as a feedstock for biofuels represents an increase in intermediate demand. This tends to raise the outputs and prices of these industries (see Table 2). The increase in the market price in this case is due solely to the increase in the price of the domestic good as import and export prices were kept constant in the experiment. Despite the increase in the domestic price, exports of these commodities are projected to expand. This is due solely to the projected expansion in output. The results also indicate that the expansion in intermediate demand and exports comes at the expense of lower household consumption. Consumption spending is projected to fall by 15.36 and 3.16 percent for *Sugar* and *Coconut*, respectively. This is due to their higher domestic prices as the disposable income of the representative household is projected to expand by 0.15 percent under the experiment.

The decline in the outputs of *Sugar milling* and *Coconut oil and related products* is due to the fact that these are industries which use inputs of the feedstock commodities in their production. The higher price of *Sugar* and *Coconut* therefore translate to higher production costs and contributed to the 6.53 and 1.15 percent increase in the market price of *Sugar milling* and *Coconut oil and related products*, respectively. Higher market prices explain the decline in the household consumption of these commodities. Since import and export prices were kept constant in the experiment, the higher market price also reflects higher prices of the domestically produced good. This in part explains the expansion in imports and decline in exports of these commodities.

The decline in the output of the *Mining* can be explained by noting that crude petroleum in subsumed in this industry. The replacement of crude petroleum by sugar and coconut inputs in *Petroleum Refining* therefore represents a decline in intermediate demand. This translates into lower domestic demand which, in turn, causes a decline in the market (and domestic) price and imports. The lower market price and higher disposable income explains the increase in consumption. On the other hand, the lower domestic price explains the expansion in exports. The finding that domestic output declines despite higher consumption, higher exports and lower imports highlights the strength of the impact of the decline in intermediate demand.

III.B Impacts on emissions

Figure 1 shows the impacts on total emissions. It shows that using sugar and coconut as feedstock for biofuels raises emissions of BOD5, nitrogen, phosphorus and suspended solids. The rest of the emissions are projected to decline. The largest increase is projected for suspended solids (0.77 percent) while the largest decline is for total dissolved solids (-0.29 percent).

The increase in emissions of suspended solids is due primarily to the larger output of *Sugar and Coconut*, respectively. These two industries explain 0.89 percentage points (=0.58 + 0.31) of the 0.77 percent increase in emissions (see Table 3). The remainder of the industries, particularly *Mining*, simply weaken the impacts. An important point to note here is that the combined share of *Sugar and Coconut* in the total emissions of suspended solids is quite small. Combined, these industries account for only 15.84 percent (=4.29 + 11.55) of the total emissions of suspended solids (see Table 3). This means that the relatively large increase in the outputs of these industries, rather than the size of their share in total emissions, is driving the results. However, it also important to note that the share of these two industries in total emissions is larger for suspended solids than for any other emission. This suggests the higher emissions are more likely for pollutants in which the initial contribution, relative to the total, of the expanding industries are highest.

The previous arguments are supported by a closer examination of the impacts on BOD5, nitrogen and phosphorus. The primary sources of the increase in these emissions are also *Sugar* and *Coconut.* Relative to the remainder of the emissions, the shares of these industries in total emissions are also larger. In the case of nitrogen, the combined share of *Sugar* and *Coconut* in total emissions is 11.80 percent (= 3.20 + 8.60). On the other hand, their combined shares in phosphorous and BOD5 are 7.95 and 4.01 percent, respectively. For the emissions that experienced a decline in the experiment, the shares of these industries are less than one percent.

The decline in the remainder of the emissions is explained not only by relatively small contribution of expanding industries - *Coconut* and *Sugar* – but also by the contraction of the other industries in the model. In the case of total dissolved solids, the lower emissions are due mostly to the contraction of *Sugar milling*, *Coconut oil and related products* and *Other food manufacturing*. For oil, particulate matter, nitrogen oxide, volatile organic compounds and carbon monoxide, the contraction in *Sugar milling* and/or *Coconut and related products* is augmented by the decline in other industries. For example, the decline in carbon monoxide emissions is due to lower outputs of *Mining, Sugar milling* and *Non-food manufacturing.* It is also worth noting that the contraction in the output of *Non-food manufacturing* plays an important role in explaining the decline in many of the emissions. This industry is the largest single source of the decline in the total emissions of particulate matter, sulfur oxide, nitrogen oxide and volatile organic compounds.

IV. CONCLUDING REMARKS

This study employed a CGE model to generate insights on the potential impacts of promoting agricultural commodities as feedstock for biofuels. In particular, it examined how using sugar and coconut as biofuel feedstock affects industry outputs and pollution emissions.

The findings are as follows. First, the simulation results show that industries which are used as feedstock are likely to expand. This is driven mostly to the increase in the intermediate demand for their outputs. Second, industries which rely heavily on the agricultural commodities used as feedstock are likely to be adversely affected. This can be seen from the projected contraction in the outputs of *Sugar milling* and *Coconut and related products.* Third, the effects on pollution emissions vary from one emission to the next. This can be seen from the simulation results which show that four out of the eleven emissions are projected to expand. Fourth, the impacts on pollution emissions depend in part of the share of the industries in total emissions as well as the magnitudes of the output changes in the industries.

The results from this study do not offer a concrete statement on the whether the environment truly benefits or loses from the use of agricultural feedstock as biofuels. Rather, it only contributes to the debate by showing that the impacts on emissions are mixed. It therefore adds fuel to the burning question of whether the use of agricultural feedstock as biofuels delivers net benefits to the environment.

At this stage, it is important to note a few limitations of the analysis. Since many of these have been discussed in Rodriguez and Cabanilla (2008a and 2008b), the focus here will be confined to the way in which the environment is modeled. First, the model does not incorporate waste and emissions coming from the household sector. These are likely to be significant and will arise from the consumption of goods and services. Second, the present model, like many other CGE models, treats emissions recursively. It does not allow such emissions to feedback on the real economy. Finally, the model uses relatively old emissions coefficients. More recent data on emissions coefficients and the income and expenditure flows would certainly make the analysis more relevant especially in capturing changes in technology and the structure of the Philippine economy.

REFERENCES

Aldaba, R. and C. Cororaton, 2002. Trade Liberalization and Pollution: Evidence from the Philippines. Research report submitted to the Environment and Economy Program fro Southeast Asia (EEPSEA), November.

Armington, P., 1969. A theory of demand for products distinguished by place of production. IMF Staff Papers, 16(1): 159-176.

Arndt, C., R. Benfica, F. Tarf, J. Thurlow, and R. Uaiene, 2008. Biofuels, poverty and growth: A computable general equilibrium analysis for Mozambique. Presented at the Eleventh Annual Conference: Future of Global Economy, June 12-14, 2008. Helsinki, Finland.

Banse, M., H. van Meijl and G. Woltjer, 2008. The impact of first and second generation biofuels on global agricultural production, trade and land use. Presented at the Eleventh Annual Conference: Future of Global Economy, June 12-14, 2008. Helsinki, Finland.

Briones, R., 2008. Impact Assessment of National and Regional Policies using the Philippine Regional General Equilibrium Model (PRGEM). Research report submitted to the PEP Network, 10 September.

Cabalu, H. and U. Rodriguez, 2007. Trade-offs in trade liberalization: Evidence from the 2005 Philippine tariff changes. Journal of Economic Integration, 22(3), 637-663.

Cabanilla, L.S. and U. Rodriguez, 2008. The food versus fuel issue: Case of the Philippines. ATDF Journal, 5(1/2): 68-74.

Clarete, R., 1984. The Costs and Consequences of Trade Distortions in a Small Open Economy. PhD Dissertation. University of Hawaii, Hawaii, United States of America.

Cockburn, J., E. Corong and C. Cororaton, 2008. Poverty effects of the Philippines' tariff reduction program: insights from a computable general equilibrium analysis. Asian Economic Journal, 22(3): 289-319.

Corong, E., 2008. Tariff reductions, carbon emissions and poverty: An economy-wide assessment of the Philippines. ASEAN Economic Bulletin, 25(1): 20-31.

Cororaton, C. and E. Corong, 2006. Agriculture-sector policies and poverty in the Philippines: A computable general equilibrium analysis. MPIA Working Paper 2006-19. Poverty and Economic Policy Research Network.

Cororaton, C., 2006. The impact of trade reform in the 1990s on welfare and poverty in the Philippines. MPIA Working Paper 2006-11. Poverty and Economic Policy Research Network.

Cororaton, C., J. Cockburn and E. Corong, 2005. Doha scenarios, trade reforms, and poverty in the Philippines: A CGE analysis. MTID Discussion Paper No. 86. International Food Policy Research Institute, Washington D.C., United States of America.

Devarajan, S. and S. Robinson, 2002. The Influence of Computable General Equilibrium Models on Policy, TMD Discussion Paper No. 98, International Food Policy Research Institute, Washington D.C.

Dervis, K., J. De Melo and S. Robinson, 1982. General Equilibrium Models for Development Policy, World Bank, Washington D.C.

Dixon, P., S. Osborne, and M. Rimmer, 2007. The economy-wide effects in the United States of replacing crude oil petroleum products with biomass. Presented at the Tenth Annual Conference: Assessing the Foundations of Global Economic Analysis, June 7-9, 2007. Purdue University, Indiana, United States of America.

Dixon, P., B. Parmenter, A. Powell and P. Wilcoxen, 1992. Notes and problems in applied general equilibrium economics. In Bliss, C. and M. Intriligator (eds), Advanced Textbooks in Economics, Vol. 32, Elsevier Science.

Dufournaud, C., M. Jerrett, U. Rodriguez, J. Quinn and A. Inocencio, 2003. The Net Cost of Banning Commercial Foresting: An AGE Analysis for the Philippines. Environment and Planning A, Vol. 35(April): 745-758.

Giesecke, J., M. Horridge and J. Scaramucci, 2007. The downside of domestic substitution of oil and biofuels: Will Brazil catch the Dutch disease?. General Paper No. G-169. Center of Policy Studies and the Impact Project, Monash University, Melbourne, Australia.

Giesecke, J., M. Horridge and J. Scaramucci, 2008. Brazilian structural adjustment to rapid growth in fuel ethanol demand. Presented at the Eleventh Annual Conference: Future of Global Economy, June 12-14, 2008. Helsinki, Finland.

Gohin, A., 2007. The impacts of biofuels on European agriculture. Research in Economics and Rural Sociology No. 2-3 (September). French National Institute for Agricultural Research, Paris, France.

Habito, C., 1984. Equity and Efficiency Trade-offs in Philippine Tax Policy: A General Equilibrium Approach. PhD Dissertation. Harvard University, Boston, United States of America.

Hertel, T., W. Tyner and D. Birur, 2008. Biofuels for all? Understanding the global impacts of multinational mandates. Presented at the Eleventh Annual Conference: Future of Global Economy, June 12-14, 2008. Helsinki, Finland.

Inocencio, A., C. Dufournaud and U. Rodriguez, 2001. Impact of tax changes on environmental emissions: An applied general equilibrium approach for the Philippines. IMAPE Research Paper No. 7. IMAPE Project, Policy and Development Foundation, Makati Philippines.

NSCB, 2008. Philippine Statistical Yearbook. National Statistics Coordination Board, Makati.

Rajagopal, D. and D. Zilberman, 2007. Review of environmental, economic and policy aspects of biofuels. Policy Research Working Paper 4341. Washington D.C.: World Bank. 107 p.

Robinson, S., 1989. Multisectoral models. Chapter 18 in H. Chenery and T. N. Srinivasan (eds), Handbook of Development Economics, Vol. 2, Elsevier Science Publishers, pp. 836-935.

Rodriguez, U. and L.S. Cabanilla, 2008a. Sugar as a biofuel: Implications for Philippine agriculture and food security. The Philippine Agricultural Scientist, 91(4): 459-468.

Rodriguez, U. and L.S. Cabanilla, 2008b. Promoting Biofuels in the Philippines: Implications on Agriculture and Food Security. Paper presented at the 46th Annual Meeting of the Philippine Economic Society, 14 November 2008.

Rodriguez, U., 2007. State of the art in regional computable general equilibrium modelling with a case study of the Philippines. Agricultural Economics Research Review, 20(January-June): 1-28.

Rodriguez, U. and L. Cabanilla, 2006. The impact of a Philippine-US FTA: The case of Philippine agriculture. Discussion Paper Series No. 2006-06. Philippine Institute for Development Studies, Makati, Philippines.

Rodriguez, U., 2003. The Effects of a Commercial Logging Ban on Equity, Efficiency and the Environment. Working Paper 03-01, Department of Economics, UP Los Baños.

Rodriguez, U., Y. Garcia, R. Tan and A. Garcia, 2007. Can trade policies soften the economic impacts of an avian influenza outbreak? Simulations from a CGE model of the Philippines. Asian Journal of Agriculture and Development, 4(2), 41-50.

Rodriguez, U. and R. Briones, 1997. Economywide models and the rural economy. Research report submitted to the Center for Integrative Studies, University of the Philippines.

Shoven, J. and J. Whalley, 1992. Applying General Equilibrium. Cambridge University Press.

Shoven, J. and J. Whalley, 1984. Applied general equilibrium models of taxation and international trade: An introduction and survey. Journal of Economic Literature, 22: 1007-1051.

Sadoulet, E., 1995. Quantitative Development Policy Analysis. Johns Hopkins University Press.

Teheripour, F., T. Hertel, W. Tyner, J. Beckman and D. Birur, 2008. Biofuels and the by-products: global economic and environmental implications. Presented at the Eleventh Annual Conference: Future of Global Economy, June 12-14, 2008. Helsinki, Finland.

Wajsman, N., 1995. The use of computable general equilibrium models in evaluating environmental policy. Journal of Environmental Management, 44: 127-43.

World Bank, 2007. World Development Report 2008: Agriculture for Development. World Bank, Washington D.C.

Yap, J., 2002. A Perspective on Macroeconomic and Economy-wide Quantitative Models of the Philippines: 1990-2002. Paper presented at the PIDS Symposium Series on Perspective Papers, 15 August.

FIGURES AND TABLES

Figure 1. Impacts of emissions, percent deviation from base

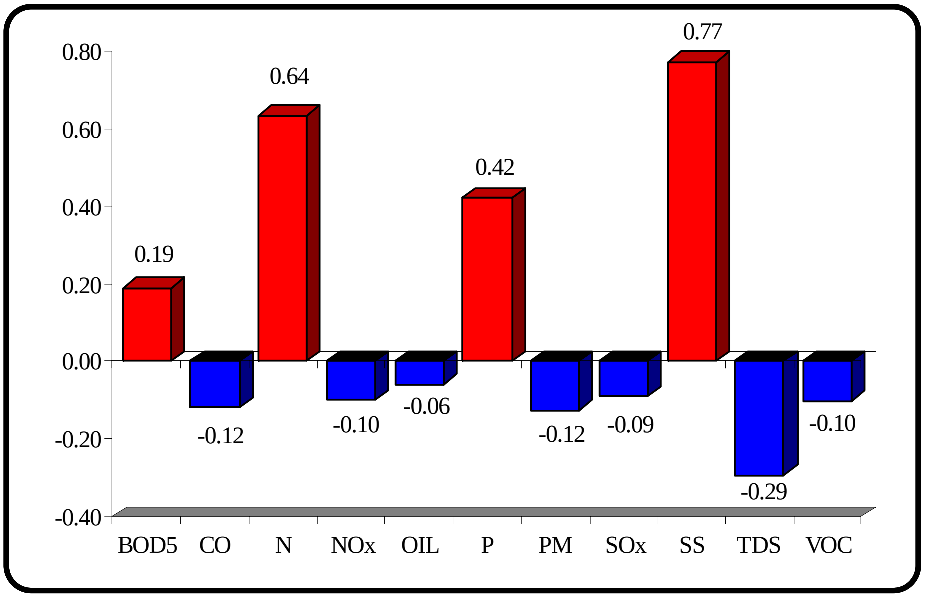

Table 1. Selected information on coconut and sugarcane, 2007, in percent

Item	Coconut	Sugarcane
Share in total land area devoted to crops	27.12	3.09
Share in the value of production of crops	11.70	5.66
Share in export value of agro-based products	37.54	4.85
Share in agriculture value added	4.31	2.85

Sources: NSCB (2008).

Table 2. Industry impacts, percent deviation from the base

Industry	Value Added	Labor	Consumption	Imports	Exports	Market price[1]
Palay	-0.03	-0.05	na	0.00	0.00	0.16
Corn	-0.08	-0.13	0.02	0.45	-0.17	0.13
Sugar	13.41	42.74	-15.36	0.00	1.32	18.32
Coconut	2.71	6.41	-3.16	0.00	0.42	3.42
Other Crops	-0.04	-0.11	0.03	-0.01	-0.12	0.12
Livestock and poultry	-0.07	-0.20	0.05	0.07	-0.14	0.10
Other AFF	0.01	0.03	-0.07	0.06	-0.13	0.23
Mining	-0.83	-3.72	0.49	-2.50	0.30	-0.33
Rice and corn milling	-0.03	-0.07	0.00	0.54	-0.13	0.15
Sugar milling	-5.77	-20.01	-5.99	26.25	-9.77	6.53
Other food manufacturing	-0.11	-0.40	-0.08	0.10	-0.27	0.23
Coconut oil and related products	-0.57	-5.93	-0.99	0.00	-0.88	1.15
Non-food manufacturing	-0.08	-0.29	0.11	0.05	-0.10	0.04
Petroleum refining	-0.05	-0.13	0.00	0.07	-0.15	0.15
Services	-0.03	-0.07	0.00	-0.02	-0.13	0.15

[1] This is the composite price of imports and the domestic good.
na.. not applicable

Table 3. Industry contribution to total emissions

Industry	Emission										
	BOD5	**SS**	**TDS**	**OIL**	**N**	**P**	**PM**	**SOx**	**NOx**	**VOC**	**CO**
Contribution to change in total emissions (percentage points)											
Sugar	0.15	0.58	0.00	0.00	0.43	0.29	0.00	0.00	0.00	0.01	0.01
Coconut	0.08	0.31	0.00	0.00	0.23	0.16	0.00	0.00	0.00	0.00	0.01
Mining	0.00	-0.10	0.00	0.00	0.00	0.00	-0.04	-0.01	-0.02	-0.03	-0.04
Sugar Milling	0.00	0.00	-0.18	-0.02	0.00	0.00	-0.03	0.00	-0.01	-0.02	-0.03
Other food manufacturing	0.00	0.00	-0.06	-0.01	0.00	0.00	-0.01	0.00	-0.01	-0.01	-0.01
Coconut oil and related products	0.00	0.00	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-food manufacturing	0.00	0.00	-0.01	0.00	0.00	0.00	-0.04	-0.08	-0.06	-0.04	-0.04
Services	-0.01	0.00	0.00	-0.02	0.00	-0.02	-0.01	0.00	0.00	-0.01	-0.01
Other industries[1]	-0.01	-0.01	0.00	0.00	-0.02	-0.01	0.00	0.00	0.00	0.00	0.00
Total	0.19	0.77	-0.29	-0.06	0.64	0.42	-0.12	-0.09	-0.10	-0.10	-0.12
Share of industry emissions in total emissions (percent)											
Sugar	1.09	4.29	0.00	0.00	3.20	2.15	0.01	0.00	0.03	0.06	0.08
Coconut	2.92	11.55	0.00	0.00	8.60	5.80	0.04	0.01	0.08	0.17	0.21
Mining	0.00	11.85	0.00	0.00	0.00	0.00	4.56	0.75	2.28	4.17	5.33
Sugar Milling	0.04	0.00	3.20	0.34	0.00	0.00	0.45	0.06	0.20	0.35	0.47
Other food manufacturing	2.45	0.05	57.47	5.19	0.00	0.00	7.58	1.62	4.81	7.77	10.51
Coconut oil and related products	0.08	0.00	5.63	0.60	0.00	0.00	0.80	0.11	0.36	0.61	0.82
Non-food manufacturing	1.31	0.05	14.49	4.99	0.13	0.00	50.26	95.73	79.77	45.28	46.59
Services	48.07	1.24	0.33	86.31	5.53	61.74	33.42	1.24	10.32	38.51	27.31
Other industries[1]	44.03	70.96	18.87	2.57	82.55	30.30	2.88	0.49	2.14	3.07	8.68

[1] This combines the seven remaining industries in the model.

ANNEX 1
EQUATION LIST

A. MODEL EQUATIONS

Production block

Industry value added

$$VA_i = \alpha_i L_i^{\beta_i} K_i^{1-\beta_i} ; \qquad i \in I$$

Labor demand

$$L_i = \frac{\beta_i \cdot PVA_i \cdot VA_i}{W} ; \qquad i \in I$$

Price of value added

$$PVA_i = \frac{PCS_i - \sum_j A_{ij} \cdot PCD_i - \tau_{1i} \cdot P_i}{A_i} ; \qquad i, j \in I$$

Return to fixed capital

$$RFK_i = PVA_i \cdot VA_i - W \cdot L_i ; \qquad i \in I$$

Industry output

$$Q_i = \frac{VA_i}{A_i} ; \qquad i \in I$$

Intermediate demand

$$ID_{ji} = A_{ji} \cdot Q_i ; \qquad i, j \in I$$

Household Block

Gross income of households

$$Y = \sum_i W \cdot L_i + \left(1 - \tau_2\right) \cdot (1 - \eta_1) \cdot \sum_i RFK_i ; \qquad i, j \in I$$

Disposable income of households

$$YD = Y + TRHG + TRHF - TAXY$$

Household savings

$$SH = \eta_2 \cdot YD$$

Household consumption

$$C_i = \frac{\gamma_i \cdot \left(1-\eta_2\right) \cdot YD}{PCD_i}; \qquad ; \qquad i \in I$$

Government Block

Government revenues

$$GREV = TAXI + TAXY + TAXM + TAXC$$

Revenues from indirect taxes

$$TAXI = \sum_i \tau_{1i} \cdot P_i \cdot Q_i \; ; \qquad i \in I$$

Revenues from income taxes

$$TAXY = \tau_3 \cdot Y \; ; \qquad i \in I$$

Revenues from import taxes

$$TAXM = \sum_i \tau_{4i} \cdot PMF_i \cdot EXC \cdot M_i \; ; \quad i \in MG$$

Revenues from corporate taxes

$$TAXC = \tau_2 \cdot \sum_i RFK_i \; ; \qquad i \in I$$

Government spending on goods

$$GSPEND = \sum_i PCD_i \cdot G_i \; ; \quad i \in I$$

Government savings

$$SG = GREV - GSPEND - TRHG - TRRG$$

Foreign Trade

Foreign savings

$$ST = \sum_i PMF_i \cdot EXC \cdot M_i + TRRG - TRHR - \sum_i PXF_i \cdot EXC \cdot X_i \; ; \quad i \in MG, \; j \in XG$$

Export supply, by commodity

$$X_i = DD_i \cdot \left[\frac{\delta_i^X}{1-\delta_i^X} \cdot \frac{PX_i}{P_i} \right]^{\sigma_i^X} \; ; \; i \in XG$$

$$X_i = 0; \qquad ; \; i \in XGN$$

Imports, by commodity

$$M_i = DD_i \cdot \left[\frac{\delta_i^M}{1-\delta_i^M} \cdot \frac{P_i}{PM_i} \right]^{\sigma_i^M} \quad ; \; i \in MG$$

$$M_i = 0 \quad ; \; i \in MGN$$

Domestic price of exports, by commodity

$$PX_i = PXF_i \cdot EXC \, ; \qquad i \in XG$$

Domestic price of imports, by commodity

$$PM_i = PMF_i \cdot EXC \cdot (1 + \tau_{4i}) \, ; \qquad i \in MG$$

Other equations

Product market equilibrium

$$Q_i = DA_i + X_i - M_i \qquad i \in I$$

Domestic spending by commodity

$$DA_i = C_i + INV_i + G_i + \sum_j ID_{ij} \; ; \qquad i, j \in I$$

Investment

$$INV_i = \frac{\psi_i \cdot S}{PCD_i} \, ; \qquad i \in I$$

Total savings

$$S = SH + SG + ST + \eta_1 \cdot (1 - \tau_2) \cdot \sum_i RFK_i \; ; \qquad i \in I$$

Domestic demand for the domestically produced commodity

$$DD_i = Q_i - X_i \; ; \qquad i \in I$$

Labor market equilibrium

$$LTOT = \overline{L}$$

Total employment

$$LTOT = \sum_i L_i \, ; \qquad i \in I$$

Composite price in demand

$$PCD_i = \frac{P_i \cdot DD_i + PM_i \cdot M_i}{DA_i}; \qquad i \in I$$

Composite price in supply

$$PCS_i = \frac{P_i \cdot DD_i + PX_i \cdot X_i}{Q_i}; \qquad i \in I$$

Emissions

Emissions per industry

$$EMIT_{ki} = \pi_{ik} \cdot Q_i \qquad i \in I; \; k \in K$$

Total emissions

$$EMIT_k = \sum_{i=1}^{N} EMIT_{ki} \qquad i \in I; \; k \in K$$

B. SET AND VARIABLE DEFINITIONS

Endogenous variables

Variables	Description
C_i	Household consumption of commodity *i*
DA_i	Domestic spending on commodity *i*
DD_i	Domestic demand for the domestically produced component of commodity *i*
$EMIT_{ki}$	Emissions of pollutant *k* originating from industry *i*
$EMIT_{ki}$	Total emissions of pollutant *k*
GREV	Government revenues
GSPEND	Government spending on goods
ID_{ij}	Intermediate demand for commodity *j* of industry *j*
INV_i	Investment demand for commodity *j*
L_i	Labor demand of industry *i*
LTOT	Total employment
M_{ri}	Imports of commodity *I*
PCD_i	Composite price in demand of commodity *i*
PCS_i	Composite price in supply of commodity *i*
P_i	Output price of industry *i*
PM_{ri}	Domestic currency price of importable good *i*
PVA_i	Price of value added of industry *i*
PX_{ri}	Domestic currency price of exportable good *i*
Q_i	Output of industry *i*
RFK_i	Return to fixed capital in industry *i*
S	Total savings
SG	Government savings

SH	Household savings
ST	Foreign savings
$TAXC$	Tax revenues from corporations
$TAXI$	Tax revenues from indirect taxes
$TAXM$	Tax revenues from import tariffs
$TAXY$	Tax revenues from income
VA_i	Value added of industry *i*
W	Wage rate
X_{ri}	Exports of commodity *i*
Y	Household income
YD	Household disposable income

Exogenous variables and parameters

Variables	Description
γ_i	Share of commodity *i* in total household spending
τ_{1i}	Tax rate on goods and services
τ_2	Tax rate on corporate income
τ_3	Tax rate on household income
τ_{4i}	Tariff rate on commodity *i,* imported from region *r*
η_1	Corporate savings rate
η_2	Household savings rate
α_i	Constant in the production function
δ_i^X	Share parameter in the transformation function (i.e., between exports and domestic output)
δ_i^M	Share parameter in the Armington function (i.e., between imports and domestic output)
π_{ki}	Pollution intensity
σ_i^X	Elasticity of transformation between domestic goods and exports
σ_i^M	Elasticity of substitution between domestic goods and imports
ψ_i	Investment share of industry *i*
A_i	Proportion of value added in production
A_{ij}	Input-output coefficient
EXC	Exchange rate
G_i	Government expenditure on good *i*
$\bar{L}$	Labor supply
PMF_i	Import price of commodity *i*, foreign currency
PXF_i	Export price of commodity *i*, foreign currency
$TRHF$	Net transfers from foreigners to households
$TRHG$	Net transfers from government to households
$TRRG$	Net transfers from government to foreigners

Sets

Set	Description	Relationships
I	All commodities	
MG	Commodities that are imported	$MG \subset I;\ MG \cup MGN = I$
MGN	Commodities that are not imported	$MG \subset I;\ MG \cup MGN = I$
XG	Commodities that are exported	$XG \subset I;\ XG \cup XGN = I$
XGN	Commodities that are not exported	$XGN \subset I;\ XG \cup XGN = I$
K	All pollutants	

ANNEX 2
SELECTED BASELINE VALUES OF THE MODEL, BILLION PESOS, 2000 PRICES

Commodity	Total output	Value Added	Employment	Consumption	Imports	Exports
Agriculture Fishery and Forestry						
Palay	105.11	78.88	39.13	-	-	-
Corn	29.97	22.67	13.05	4.84	2.65	0.02
Sugar	17.31	11.86	4.20	0.05	-	0.00
Coconut	27.19	23.94	10.29	5.10	-	0.05
Other Crops	141.84	109.10	37.58	66.18	28.54	17.21
Livestock and poultry	194.89	120.98	42.65	26.75	2.77	0.08
Other Agriculture Fishery and Forestry	170.43	132.13	34.70	92.39	0.39	12.08
Industry						
Rice and corn milling	179.33	52.97	18.17	144.34	5.45	0.01
Sugar milling	30.37	6.58	1.75	17.21	2.45	2.47
Other food manufacturing and beverages	646.74	174.77	46.26	410.74	65.18	34.50
Coconut oil and related products	27.27	7.05	0.65	0.36	-	16.15
Mining	37.79	22.86	5.04	2.60	160.41	5.69
Non-food manufacturing	2,693.05	1,208.23	344.31	379.49	1,210.61	1,504.77
Petroleum refining	208.44	23.31	8.52	37.06	32.15	21.81
Services	3,010.88	1,886.34	731.91	1,728.59	281.48	211.28
Total	7,520.61	3,881.68	1,338.21	2,915.69	1,792.07	1,826.13

ANNEX 3
INDUSTRIES IN THE CURRENT MODEL AND INOCENCIO ET AL. (2001)

Current Model	Innocencio et al. (2001)
Palay	Palay
Corn	Corn
Sugar	Coconut and Sugarcane
Coconut	
Other Crops	Fruits and vegetables
Livestock and poultry	Livestock and poultry
Other AFF	Fishing; Other agricultural production; Forestry
Mining	Mining
Rice and corn milling	Rice and corn milling
Sugar milling	Milled sugar
Other food manufacturing	Meat manufacturing; Fish manufacturing; Beverage and tobacco manufacturing; Other food manufacturing
Coconut oil and related products	Other food manufacturing
Non-food manufacturing	Textile manufacturing; Garments and leather manufacturing; Wood manufacturing; Paper and paper products manufacturing; Chemical manufacturing; Cement manufacturing; Non-metal manufacturing; Metal manufacturing; Electrical equipment manufacturing; Transport and other equipment manufacturing; Other manufacturing; Electricity and gas; Water
Petroleum refining	Petroleum refining
Services	Transport and communication; Trade, storage and warehousing; Finance; Life and non-life insurance; Private education services; Public education services; Private health services, Public health services; General government services; Other services

ANNEX 4
POLLUTION INTENSITIES

Pollution intensities before adjustment (tons/million pesos)

Industry	BOD5	SS	TDS	OIL	N	P	PM	SOx	NOx	VOC	CO
Palay	8.61	1,708.42	0.00	0.00	6.62	0.10	0.00	0.00	0.00	0.00	0.00
Corn	8.61	1,708.42	0.00	0.00	6.62	0.10	0.00	0.00	0.00	0.00	0.00
Sugar	7.04	1,397.99	0.00	0.00	5.42	0.09	0.02	0.01	0.02	0.02	0.11
Coconut	7.04	1,397.99	0.00	0.00	5.42	0.09	0.02	0.01	0.02	0.02	0.11
Other Crops	0.20	39.79	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.03
Livestock and poultry	8.39	60.38	0.00	0.00	2.68	0.00	0.00	0.00	0.00	0.00	0.03
Other AFF	8.78	769.61	0.00	0.00	4.46	0.04	0.01	0.00	0.01	0.01	0.08
Mining	0.00	1,681.25	0.00	0.00	0.00	0.00	2.83	0.83	0.67	0.56	3.27
Rice and corn milling	0.19	0.19	3.86	0.04	0.00	0.00	0.42	0.10	0.09	0.07	0.43
Sugar milling	0.19	0.19	3.86	0.04	0.00	0.00	0.42	0.10	0.09	0.07	0.43
Other food manufacturing	0.48	0.50	3.23	0.03	0.00	0.00	0.33	0.13	0.10	0.07	0.45
Coconut oil and related products	0.19	0.19	3.86	0.04	0.00	0.00	0.42	0.10	0.09	0.07	0.43
Non-food manufacturing	0.06	0.10	0.18	0.01	0.00	0.00	0.49	1.67	0.37	0.10	0.45
Petroleum refining	0.03	0.01	0.00	0.01	0.00	0.00	0.02	0.03	0.05	0.02	0.66
Services	2.22	2.88	0.00	0.11	0.07	0.02	0.34	0.02	0.05	0.08	0.27

Source of basic data: Inocencio et al. (2001)

Price deflators

Industry	Deflator[1]	Deflator 1994[2]	Deflator 2000[2]
Palay	1.45	1.8	2.6
Corn	1.32	1.7	2.3
Sugar	1.38	2.3	3.1
Coconut	0.80	3.4	2.8
Other Crops	1.44	2.5	3.6
Livestock and poultry	1.15	2.2	2.5
Other AFF	1.16	2.0	2.3
Mining	1.31	1.5	2.0
Rice and corn milling	1.58	2.4	3.8
Sugar milling	1.58	2.4	3.8
Other food and bev	1.57	2.4	3.7
Coconut oil and related products	0.80	3.4	2.8
Non-food manufacturing	1.47	2.2	3.2
Petroleum refining	1.61	1.0	1.7
Services	1.71	2.3	4.0

[1] Deflator = Deflator 2000/Deflator 1994

[2] These values calculated from the NEDA (2008a). The base year is 1985.

Pollution intensities after adjustment (tons/million pesos)[1]

Industry	BOD5	SS	TDS	OIL	N	P	PM	SOx	NOx	VOC	CO
Palay	5.94	1,178.78	0.00	0.00	4.57	0.07	0.00	0.00	0.00	0.00	0.00
Corn	6.51	1,292.32	0.00	0.00	5.01	0.08	0.00	0.00	0.00	0.00	0.00
Sugar	5.10	1,013.36	0.00	0.00	3.93	0.07	0.01	0.01	0.01	0.01	0.08
Coconut	8.75	1,736.82	0.00	0.00	6.73	0.11	0.02	0.01	0.02	0.02	0.14
Other Crops	0.14	27.62	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.02
Livestock and poultry	7.32	52.65	0.00	0.00	2.34	0.00	0.00	0.00	0.00	0.00	0.03
Other AFF	7.58	664.40	0.00	0.00	3.85	0.04	0.01	0.00	0.01	0.01	0.07
Mining	0.00	1,282.19	0.00	0.00	0.00	0.00	2.16	0.63	0.51	0.43	2.49
Rice and corn milling	0.12	0.12	2.44	0.03	0.00	0.00	0.27	0.06	0.06	0.04	0.27
Sugar milling	0.12	0.12	2.44	0.03	0.00	0.00	0.27	0.06	0.06	0.04	0.27
Other food manufacturing	0.31	0.32	2.06	0.02	0.00	0.00	0.21	0.08	0.06	0.05	0.29
Coconut oil and related products	0.24	0.24	4.80	0.05	0.00	0.00	0.52	0.12	0.11	0.09	0.53
Non-food manufacturing	0.04	0.07	0.12	0.00	0.00	0.00	0.33	1.14	0.25	0.07	0.31
Petroleum refining	0.02	0.01	0.00	0.01	0.00	0.00	0.01	0.02	0.03	0.01	0.41
Services	1.30	1.68	0.00	0.07	0.04	0.01	0.20	0.01	0.03	0.05	0.16

[1] Based on author's calculations