Estimating Global Environmental Implications of Agricultural Trade Liberalization: A Computable General Equilibrium Analysis

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Abstract

Preliminary results indicate a reduction in agricultural trade barriers offers some benefits to poorer nations at the expense of some richer nations. A positive externality if trade liberalization is a decrease in coal combustion and a slight decrease in global CO_2 emissions.

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Introduction

In the last decade, agricultural reform in the European Union (EU) has taken great strides first with the Common Agriculture Policy (CAP), followed by the Uruguay and Doha Rounds. Progress has met with dissent and disagreements abound on the issues of export subsidies, export credits, domestic support, and market access. A dominant concern among nations is the effect on national welfare. In an analysis of the Uruguay Round, Harrison et al. (1997) ascertained an overall gain in long term welfare at the expense of short term losses in several developing countries. In the Doha Round, developed nations argued against reform citing the potential for large welfare transfers to developing nations. Francois et al. (2005) found that developing countries could reap substantial gains from the Doha Round outcomes but were contingent on details in the final negotiation. Poor choices or badly negotiated arrangements could render negligible gains to developing nations. Bouët et al. (2004) determined that multilateral trade liberalization involving the EU and the USA would not result in welfare losses to the EU or the USA. Elbehri (2004) demonstrated that many factors influence the magnitude and direction of welfare transfers notably: volume of trade, terms of trade, resource allocation, accumulation, and scale.

Study overview

A multi-sector, multi-region, computable general equilibrium global trade with a flexible market structure is modeled with imperfect competition in some sectors (agriculture and energy) and perfect competition in the remaining sectors. Scale elements (size of firms and number of firms per sector) are endogenous. The model is parameterized and applied to analyze the effect of agricultural trade liberalization on domestic welfare, global welfare, energy use, and CO_2 emissions.

General equilibrium trade model

GTAP is a static general equilibrium model of the world economy with multiple regions and multiple sectors parameterized with a global database. Substitution elasticities are from the literature. The model was developed in 1992 and continues to evolve through the work of the GTAP team at Purdue.

Burniaux and Truong (2002) developed a version called GTAP-E that makes energy use more explicit by taking energy inputs are taken out of the intermediate input set, combining it with capital to form a capital-energy composite input in production. CO_2 emissions could then be captured as a function energy use by fuel type.

Berrittella, et. al, (2004) describe an extension of GTAP-E named GTAP-EF that further disaggregates industry by adding several energy specific industry sectors. In GTAP-EF allows modifications to model imperfect competition.

Regions

In GTAP, the world economy is divided into a number of geographical regions (1,..., r) each comprised of one or more nations. This model specifies 16 regions: USA, Canada, Western Europe, Japan & Korea, Australia & New Zealand, Eastern Europe, Former Soviet Union, Middle East, Central America, South America, South East Asia, China, North Africa, South Saharan, and the Rest of the world

Sectors

All final goods and intermediate goods are aggregated into 17 production sectors (1,..., j): Rice, Wheat, Cereal Crops, Vegetables and Fruits, Animals, Forestry, Fishing, Coal, Oil, Gas, Oil Products, Electricity, Water, Energy Intensive Industries, Other Industries, Manufacturing Services, and Non-manufacturing Services

Production

Each industry is modeled through a representative firm which minimizes costs given unit input costs. Output price is determined by average production cost. Production is specified through a multi-level series of nested CES functions Factor inputs are substitutable and may be purchased from domestic and foreign sources. Like products from different regions are modeled as heterogeneous using an "Armington assumption".

The capital-energy input is a composite of capital inputs and energy inputs. The energy input is a composite of non-electric and electric energy inputs. The non-electric energy

input is a composite of coal and non-coal fuels. And the non-coal fuels are a composite of gas, oil, and petroleum fuels. All inputs may be purchased from domestic or foreign sources. A representation of the production model structure is shown in Figure 1.

Primary factors

Primary factors include Natural Resources, Land, Labor, and Capital-Energy. Natural Resources and Land are assumed to be industry specific and therefore immobile across industries and regions. Households provide labor in return for income. Labor resources are free to move among industries but are immobile across regions. Capital resources can move across industries but are immobile across regions.

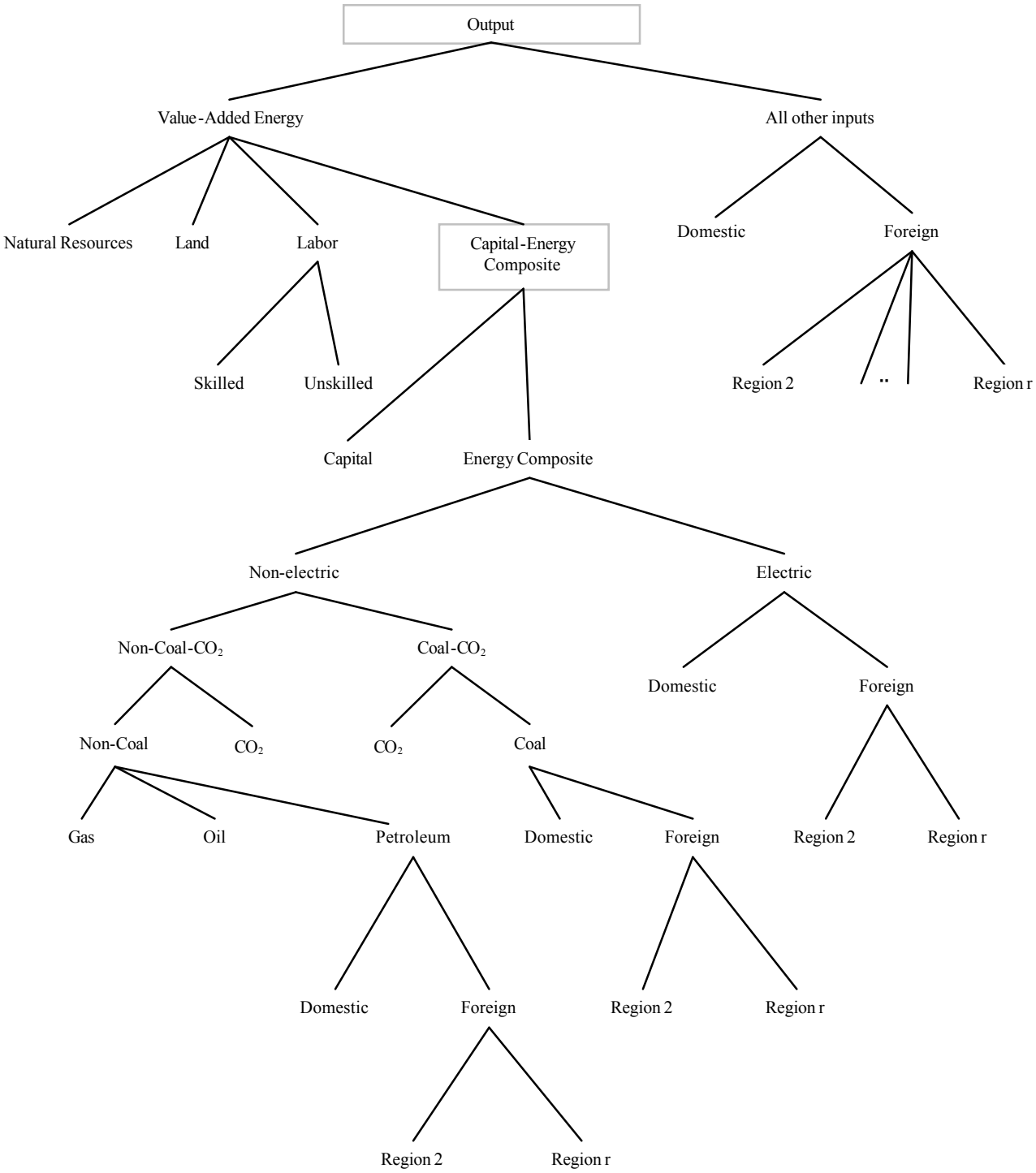


Figure 1. Structure of GTAP-E Nested Production Function Adapted from Burniaux and Truong (2002)

Consumption

Consumption in each region is represented by an aggregate household. The household consumer provides labor and earns income. Income is allocated to household consumption, public (government) consumption, and savings to maximize regional welfare. Welfare is Cobb-Douglas thus share of income to each of the three expenditures classes is constant.

Private consumption of j commodities is specified through a multi-level series of nested Cobb-Douglas function Private consumption is composed of "Armington aggregates" using a non-homothetic, a constant difference in elasticities form. A representation of the nested private consumption structure is shown in Figure 2.

Public consumption is Cobb-Douglas in j commodities with the bulk of public consumption is in the form of "Non-manufacturing Service" goods.

Savings from all regions are accumulated in a world "bank" which allocates fiscal resources to investments to balance current and future the rate of return. Saving and investment is balanced globally, but not regionally. Regional imbalances between saving and investment are interpreted as a trade deficits and trade surpluses.

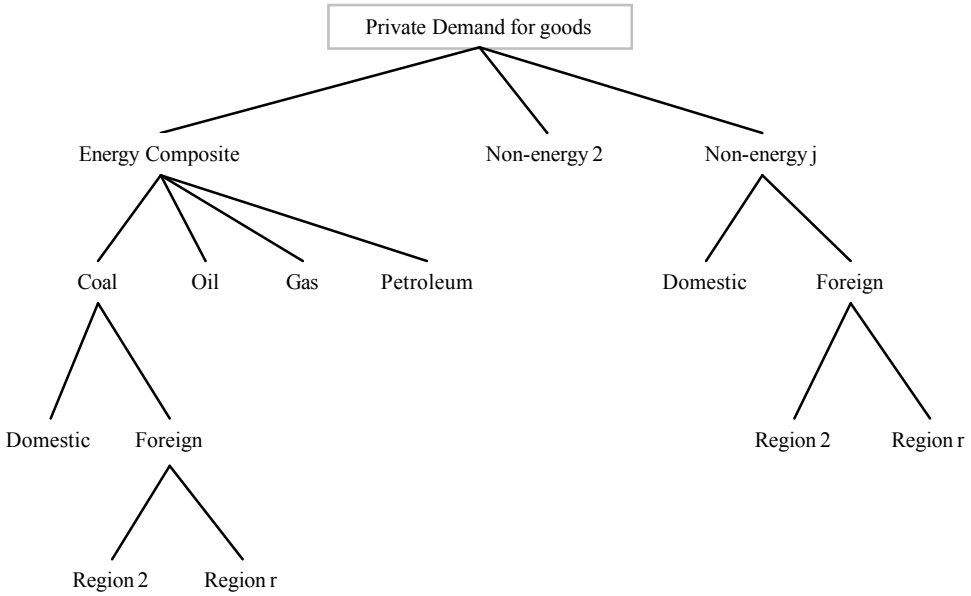


Figure 2. Structure of GTAP-E Nested Private Demand Function Adapted from Burniaux and Truong (2002)

Policy Scenarios

Three scenarios were constructed to examine the impact of trade liberalization on regional welfare and CO_2 emissions. Simulated reductions in import taxes, output taxes and combined taxes are imposed on each region based on the development status of the region. Developed regions are USA, Canada, Western Europe, Japan and Korea, Australia and New Zealand, Eastern Europe, Former Soviet Union. Developing regions are: Middle East, Central America, South America, South Asia, South East Asia, China, and the Rest of the World. Least developed regions are: South Asia, North Africa, and South Saharan Africa.

Scenario "C" simulates a reduction in import taxes, output taxes, and combined taxes that are staggered, with developing countries enduring the largest cuts (-60%), developing countries the next largest reductions (-40%) and the least developed countries facing the smallest cuts (-20%). Scenario "A" simulates an across the board elimination of import taxes, output taxes, and combined taxes (-100%). Scenario "B" simulates a reduction in import taxes, output taxes, and combined taxes that are staggered, with developing countries enduring the largest cuts (-60%), developing countries the next largest reductions (-40%) and the least developed countries facing no cuts (-0%).

Table 1. Policy scenarios – tariff reduction (%)

Scenario	Developed	Developing	Least developed
C	-60%	-40%	-20%
A	-100%	-100%	-100%
B	-60%	-40%	-0%

Selected Results (Preliminary)

Welfare effects based on estimated changes in equivalent variation indicate that Japan and Korea, Middle Eastern nations, and to a lesser extent African nations gain the most from unilateral and staggered agricultural trade liberalization. Gains ranges from $1 billion to more than $3 billion. Losers are USA, South America, and China. Losses ranged from $0.5 billion to $1.5 billion.

Energy prices for fossil fuels are mixed. The price of coal is expected to decrease in most countries up to -1.2%. The price of oil will rise 1% to 2% and the price of gas will increase up to 1%.

Energy production of fossil fuels is mixed. The output of coal will fall in most countries by up to -0.7%. Output of oil will rise in most countries up to 0.9%. The production of gas in the USA will drop by up to 2% and rise in Western Europe by up to more than 2% and rise in the rest of the world by up to 1.5%.

Production of consumer goods, agriculture, and forestry Change in the production of consumer goods is most notable in the Middle East with a project increase of 3-4% as a result of agricultural trade liberalization. A reduction in wheat production in the USA and Canada of 20% is expected under scenario C (staggered tariff reductions). Wheat production in Western Europe is expected to rise by more than 50% under scenario B (elimination of all tariffs). Forestry production is expected to increase in the USA, Australia and New Zealand, and South Africa by 1% to 2%. Reductions in forestry

production are projected in Japan and Korea, Central America, and South America of up to 1.5%.

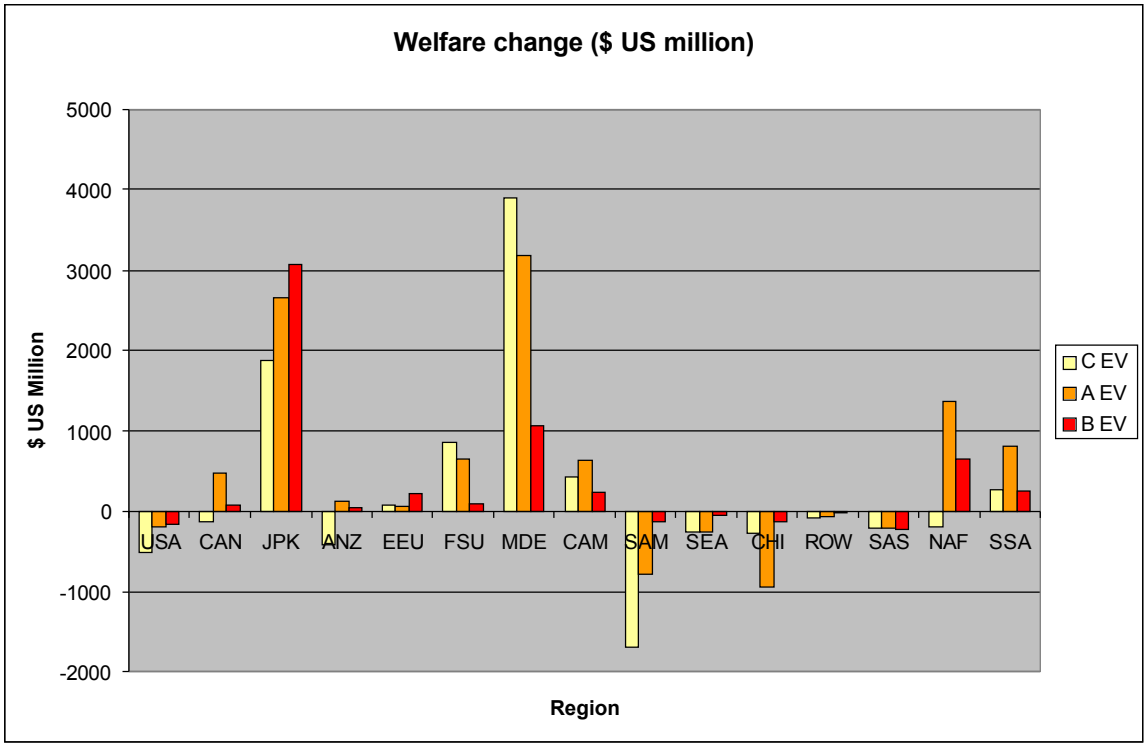
CO_2 emissions from coal will drop in the USA, Canada, and the former Soviet Union up to 1%. CO_2 emissions from Japan and Korea and the Middle East are project to rise, less that 1%. CO_2 emissions from oil combustion is projected to fall in nearly all regions, -0.5% to 2% CO_2 emissions from gas combustion will fall in the USA, Canada, Former Soviet Union, and the Middle East by -0.75% to more than -2%.

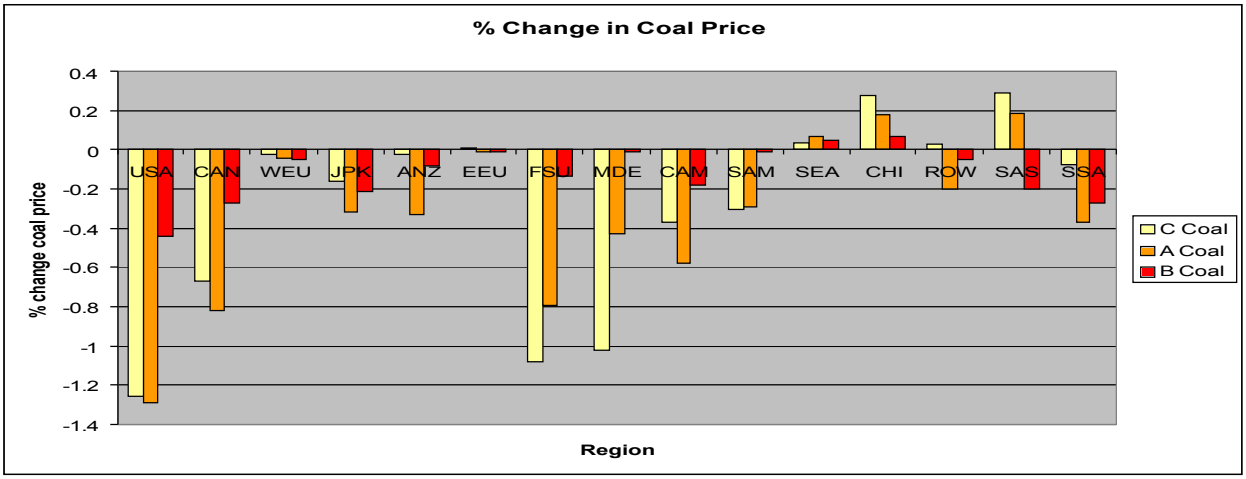
Brief summary

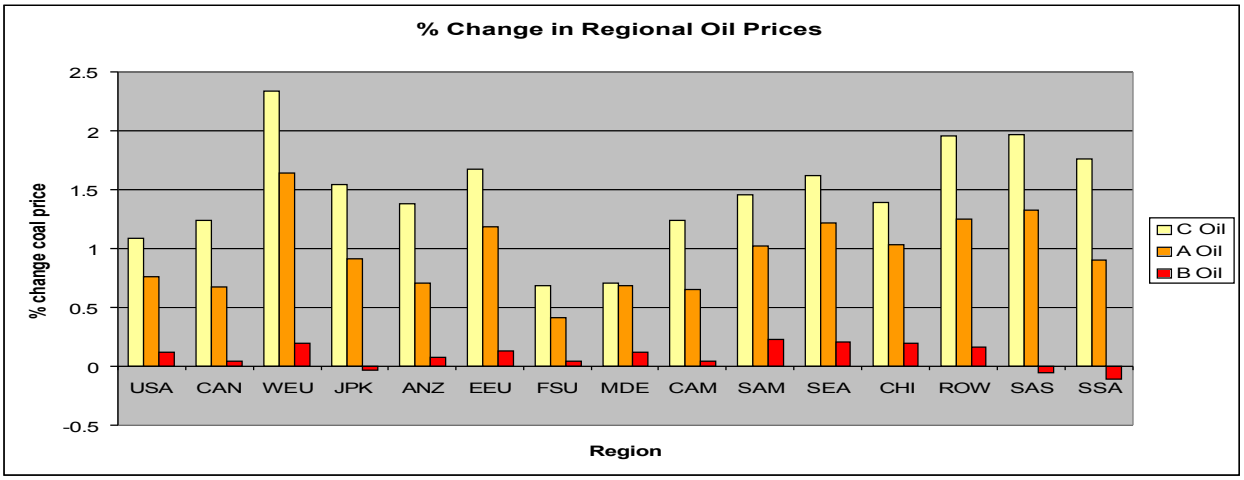
Preliminary results indicate that the reduction in tariffs designed to be most protective of least developed nations (Scenario B), was most beneficial (or least harmful) to developed nations as well as being beneficial, but to a lesser extent, to the least developed nations. According to the welfare results, least developed nations gained the most from unilateral elimination of agricultural tariffs.

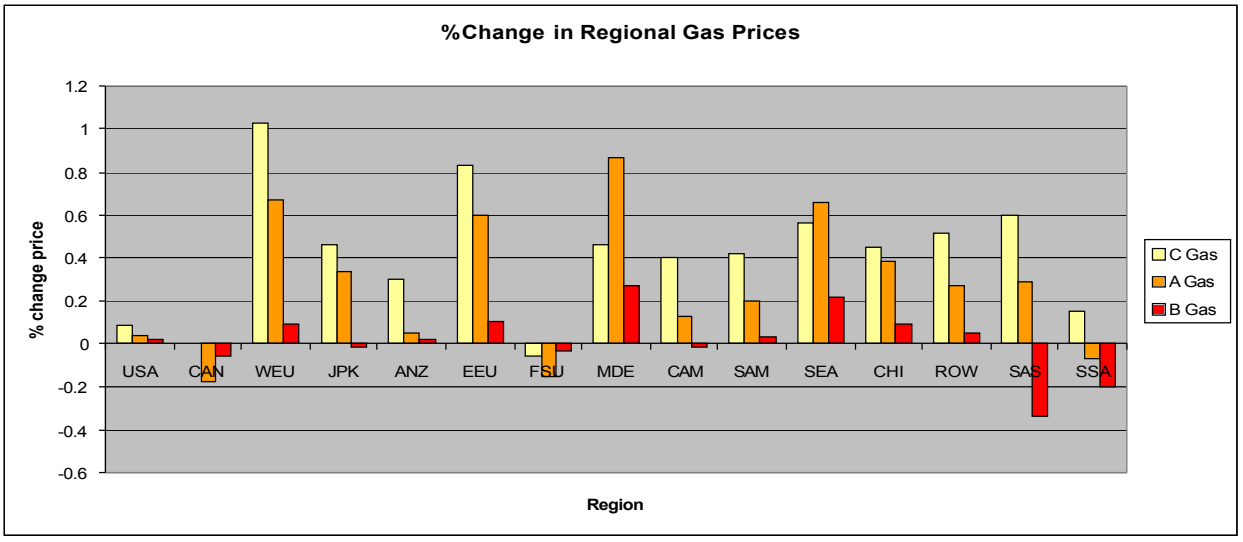
Increased use of oil and gas and reduced reliance on coal, led to a reduction in CO2 emissions in most countries, developed, developing, and least developed.

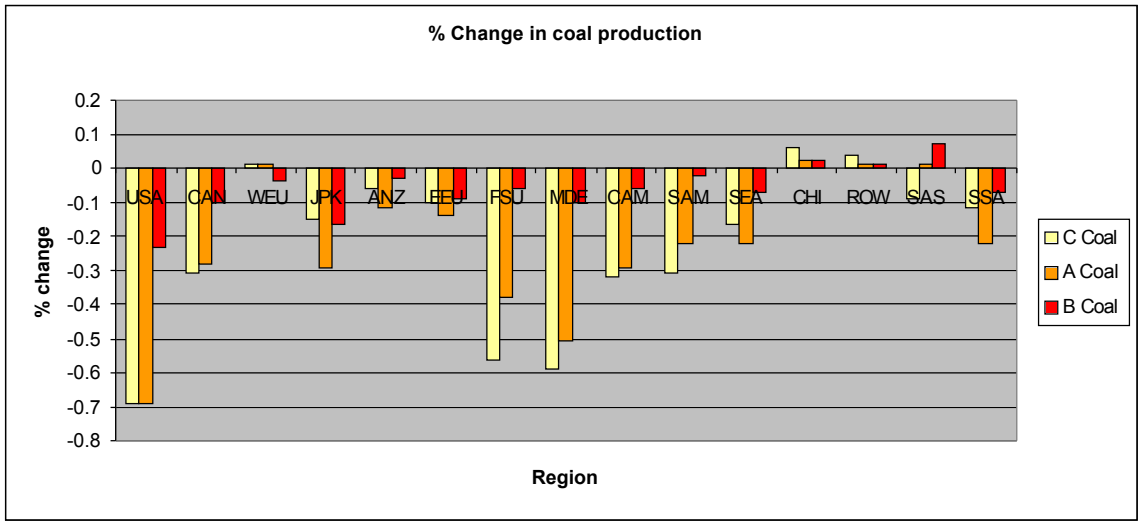
A graphical display of the results discussed here is shown on the following pages.

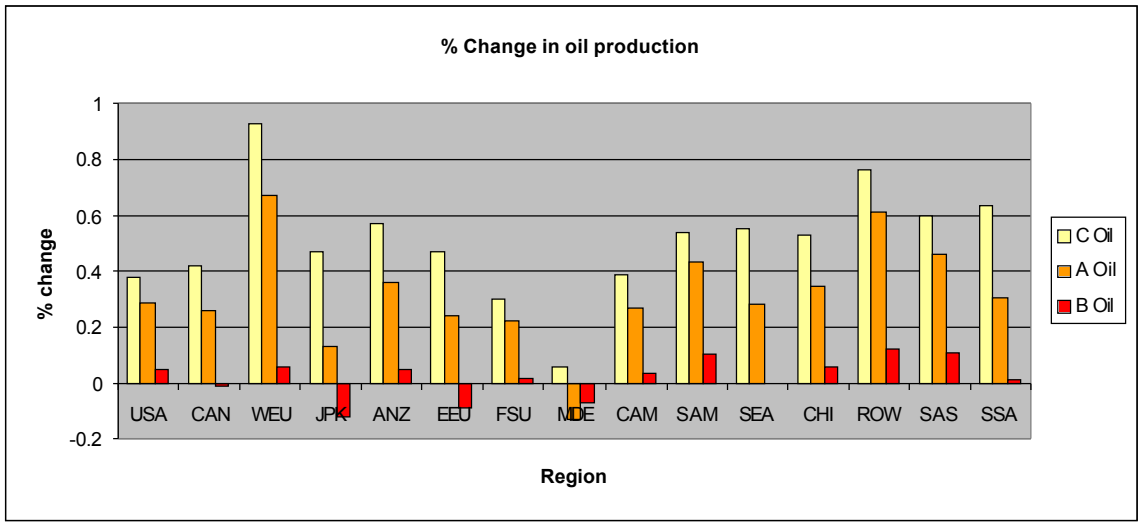

Welfare change ($ US million)
5000
4000
3000
2000
1000
0
-1000
-2000
$ US Million
USA
CAN
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
NAF
SSA
Region
C EV
A EV
B EV

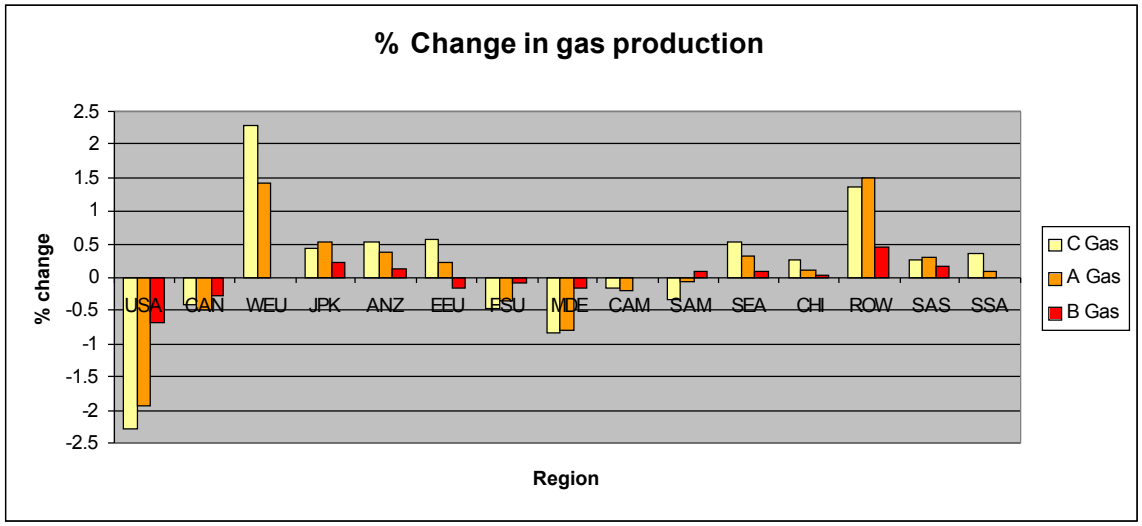

% Change in Coal Price
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
% change coal price
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Coal
A Coal
B Coal

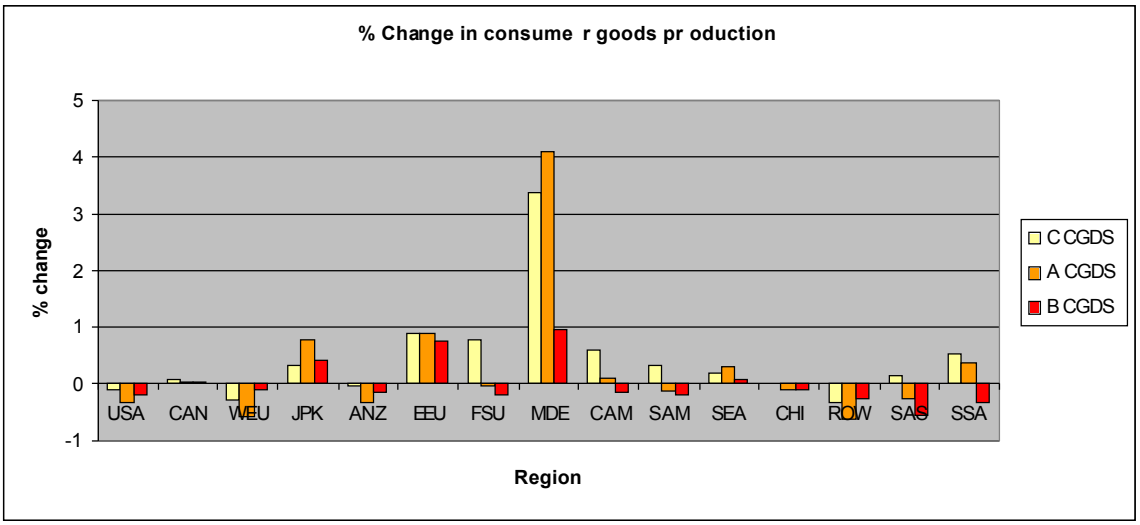

% Change in Regional Oil Prices
2.5
2
1.5
1
0.5
0
-0.5
% change coal price
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Oil
A Oil
B Oil

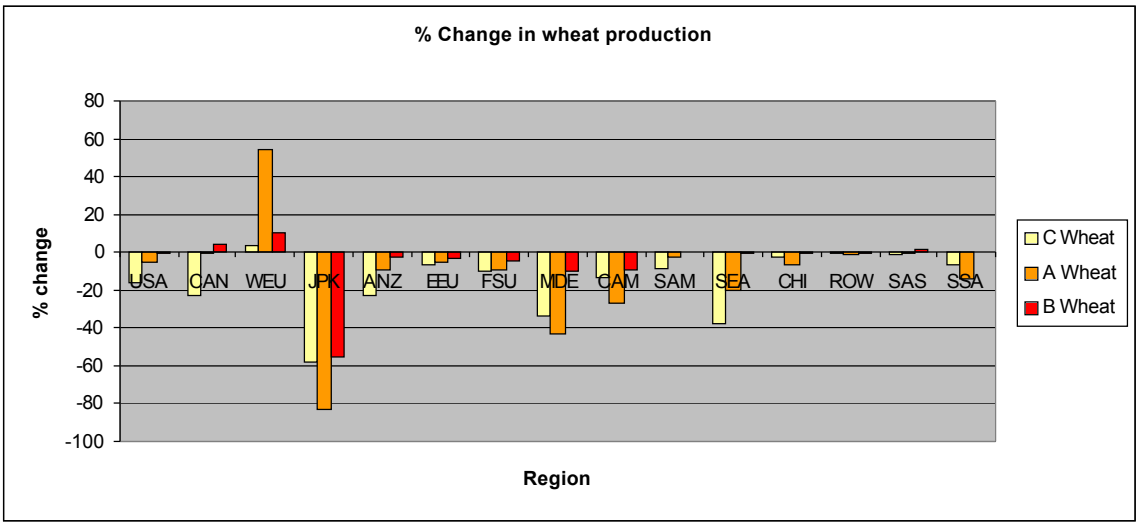

%Change in Regional Gas Prices
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
% change price
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Gas
A Gas
B Gas

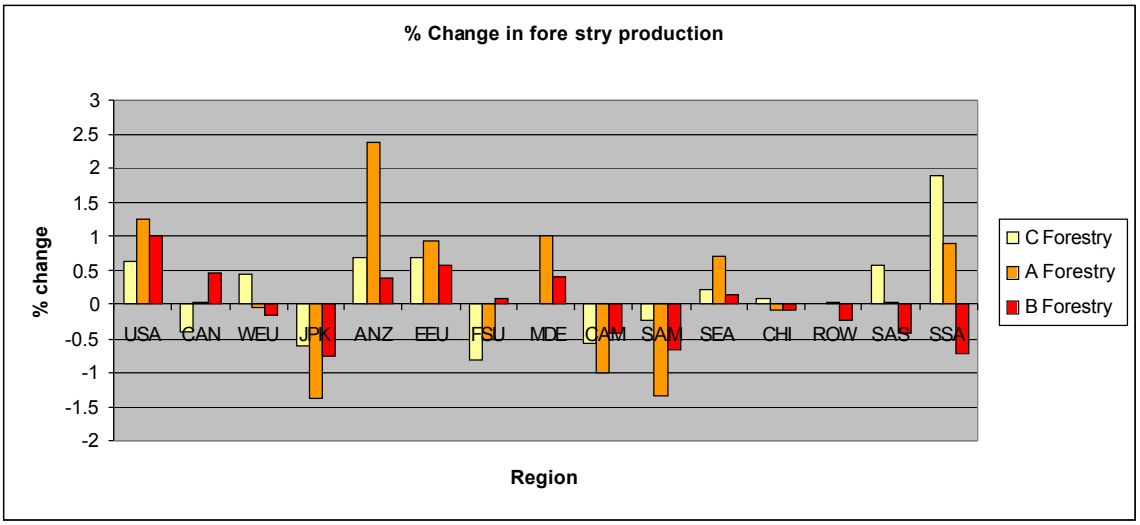

% Change in coal production
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
% change
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Coal
A Coal
B Coal

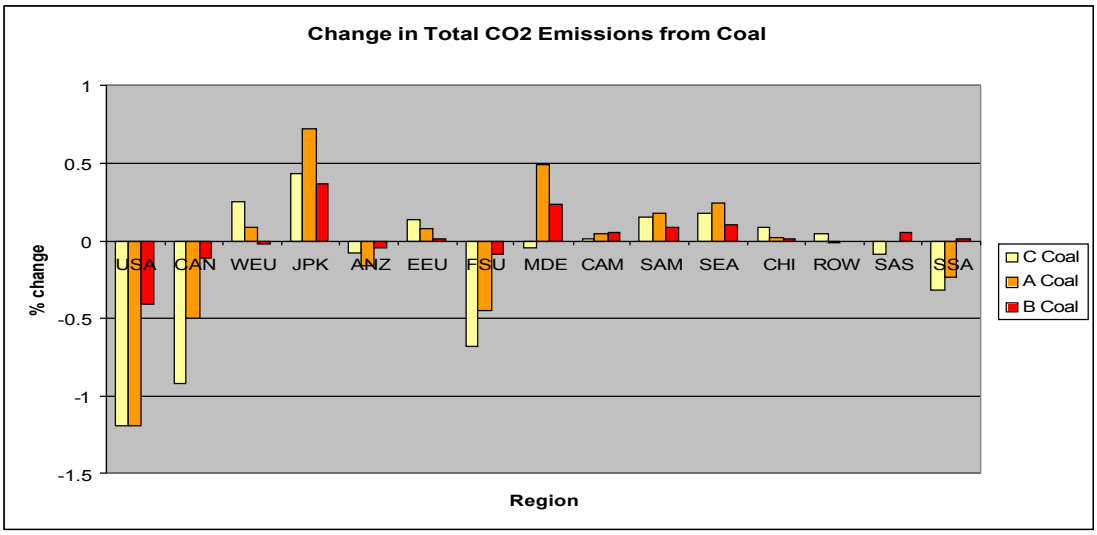

% Change in oil production
1
0.8
0.6
0.4
0.2
0
-0.2
% change
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Oil
A Oil
B Oil

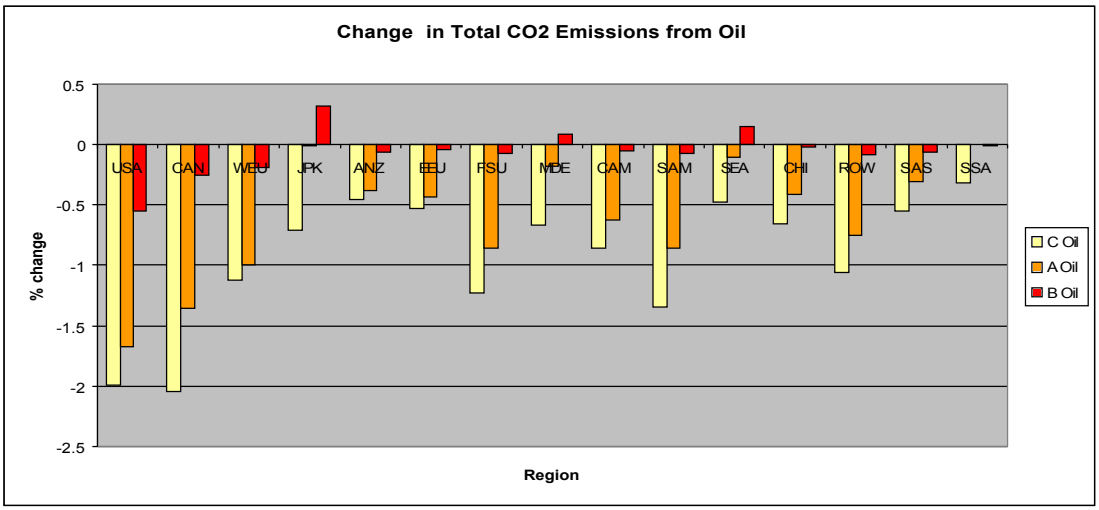

% Change in gas production
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
% change
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Gas
A Gas
B Gas

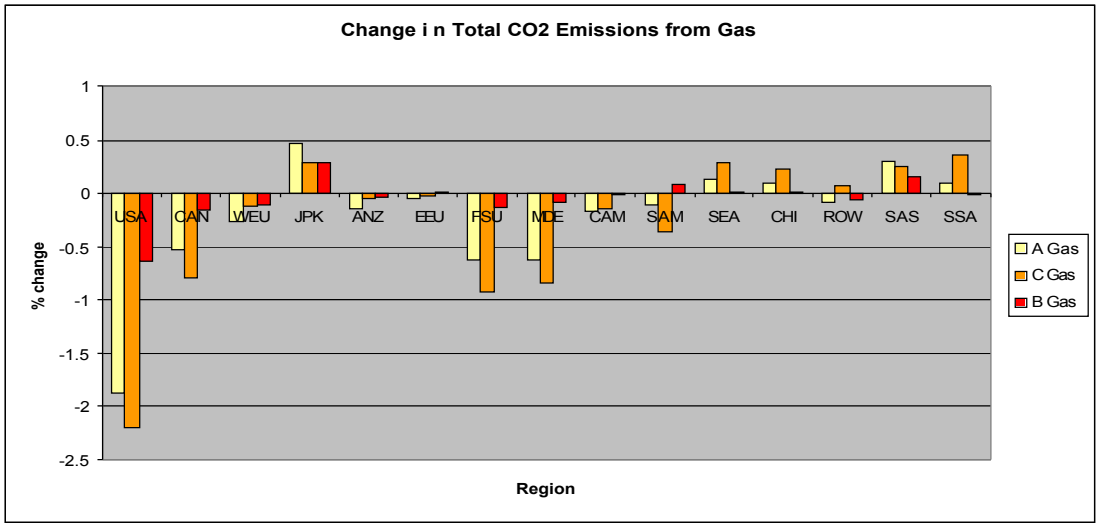

% Change in consume r goods pr oduction
% change
5
4
3
2
1
0
-1
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C CGDS
A CGDS
B CGDS


% Change in wheat production
% change
80
60
40
20
0
-20
-40
-60
-80
-100
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Wheat
A Wheat
B Wheat


% Change in fore stry production
% change
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
Region
C Forestry
A Forestry
B Forestry


Change in Total CO2 Emissions from Coal
1
0.5
0
-0.5
-1
-1.5
% change
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
C Coal
A Coal
B Coal
Region


Change in Total CO2 Emissions from Oil
0.5
0
-0.5
-1
-1.5
-2
-2.5
% change
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
C Oil
A Oil
B Oil
Region


Change i n Total CO2 Emissions from Gas
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
% change
USA
CAN
WEU
JPK
ANZ
EEU
FSU
MDE
CAM
SAM
SEA
CHI
ROW
SAS
SSA
A Gas
C Gas
B Gas
Region

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