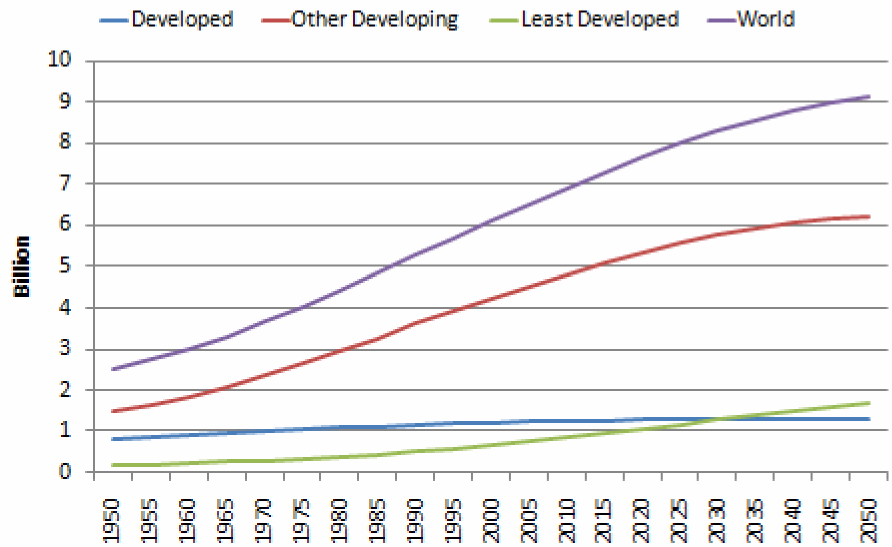
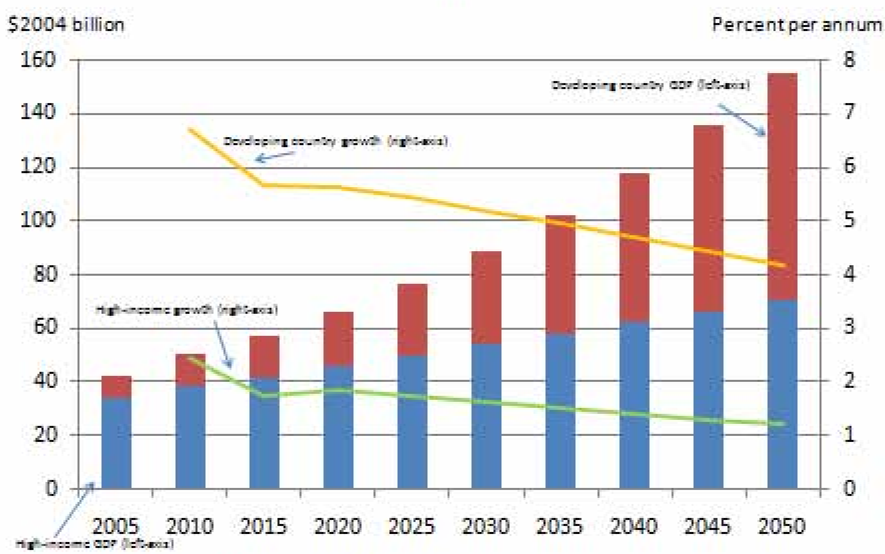
Figure 4.1 Population history and projection



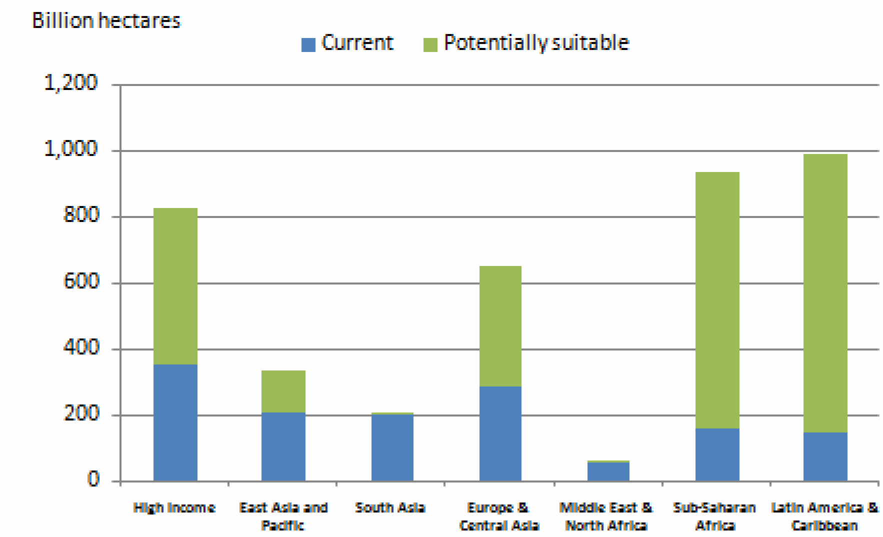
Source: UN Population Division (http://esa.un.org/unpp/index.asp).

Figure 4.2: GDP growth scenario



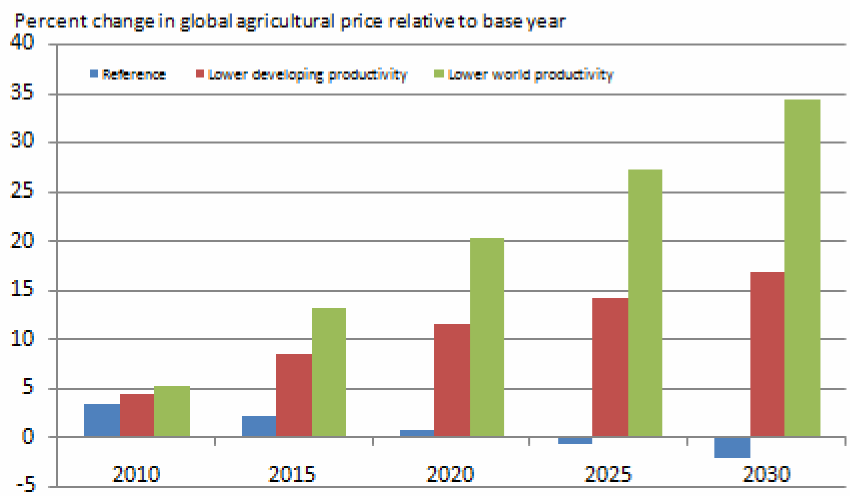
Source: Simulation results with World Bank's ENVISAGE model.

Figure 4.3: Land under cultivation and potentially suitable



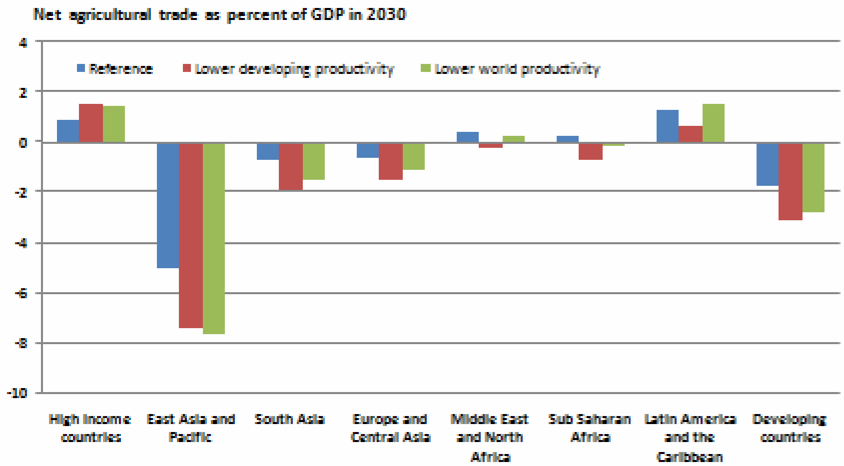
Source: FAO.

Figure 4.4: World agricultural prices are sensitive to productivity assumptions



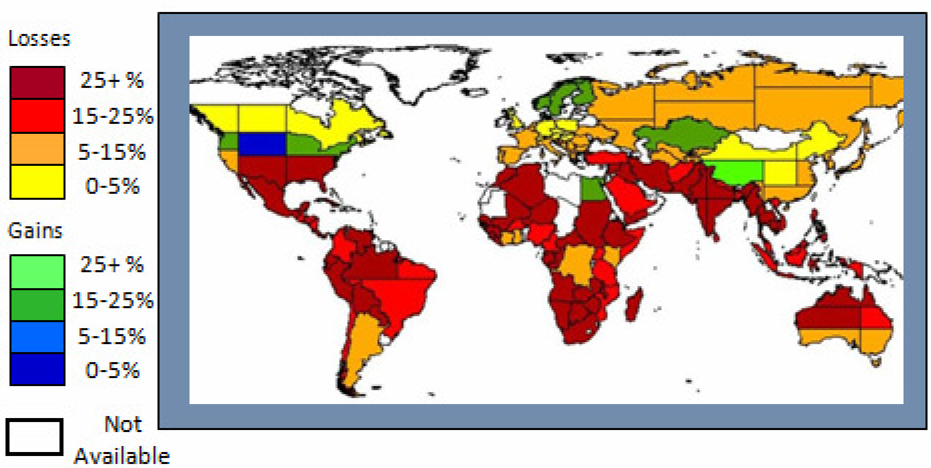
Source: Simulation results with World Bank's ENVISAGE model.

Figure 4.5: Net agricultural trade could change substantially for some regions



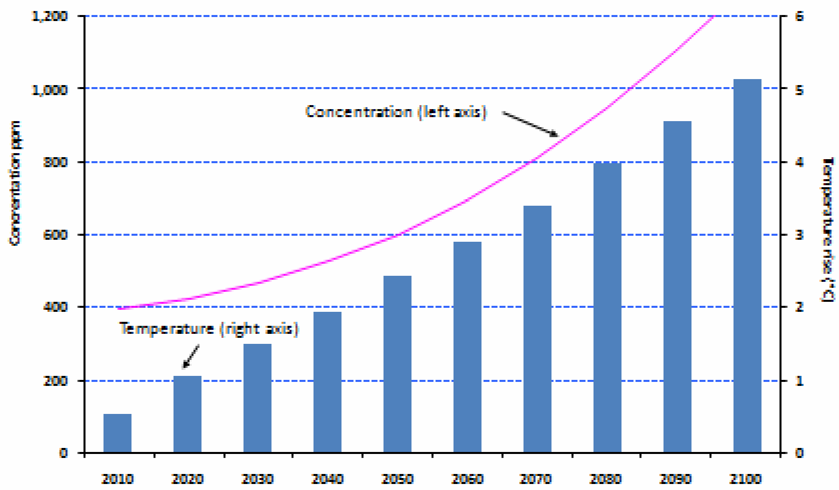
Source: Simulation results with World Bank's ENVISAGE model.

Figure 4.6: Potential impact on agricultural production due to climate change—without carbon fertilization effect



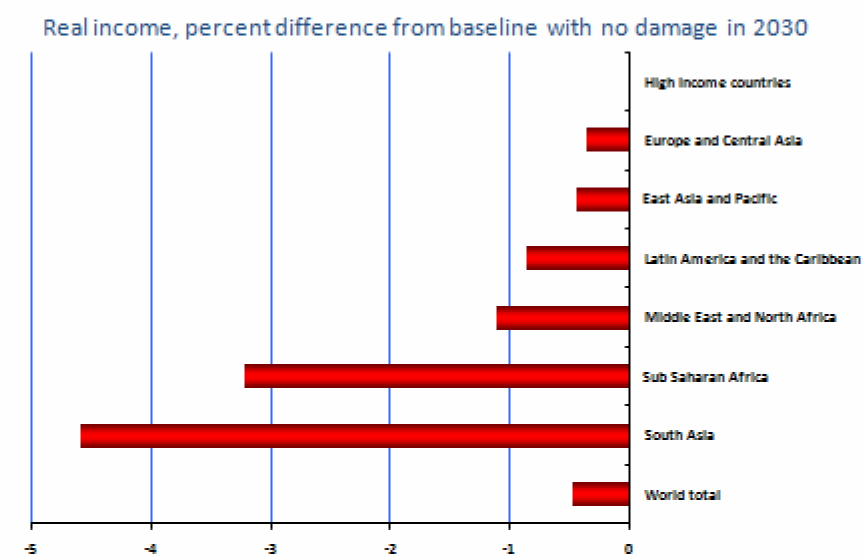
Source: Cline 2007.

Figure 4.7: Concentration and temperature in baseline



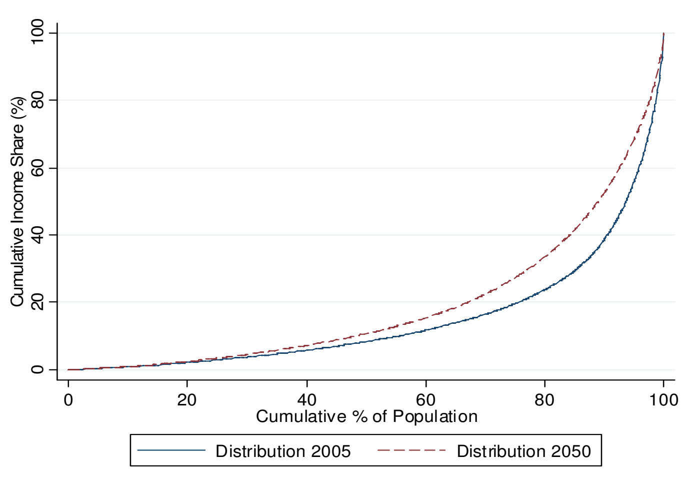
Source: Simulation results with World Bank's ENVISAGE model.

Figure 4.8: Potential impact of climate change



Source: Simulations with World Bank's ENVISAGE model.

Figure 6.1 Lorenz Dominance: Changes in the middle of the distribution



Source: Authors' calculations

Source: Authors' estimates

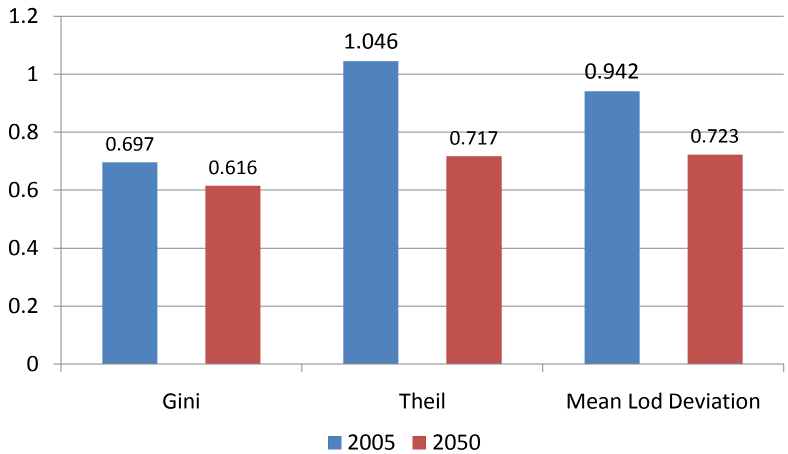
Table 6.1 Global Income Inequality

Index	2005	2050	Dispersion Only	Convergence Only
Gini	0.697	0.616	0.701	0.616
Theil	1.046	0.717	1.059	0.719
Mean Log Deviation	0.942	0.723	0.954	0.723

	Gini		**Theil**		**Mean Log Dev**	
Region	**2005**	**2050**	**2005**	**2050**	**2005**	**2050**
Developed Countries	*0.394*	*0.378*	*0.270*	*0.245*	*0.277*	*0.257*
Developing Countries	*0.552*	*0.588*	*0.623*	*0.664*	*0.529*	*0.629*
East Asia and the Pacific	0.421	0.479	0.311	0.399	0.293	0.411
Eastern Europe and Central Asia	0.394	0.513	0.257	0.441	0.280	0.490
Latin America and the Caribbean	0.599	0.605	0.714	0.707	0.699	0.719
Middle East and North Africa	0.399	0.405	0.284	0.298	0.261	0.271
South Asia	0.297	0.326	0.156	0.183	0.141	0.176
Sub Saharan Africa	0.495	0.488	0.499	0.481	0.425	0.410

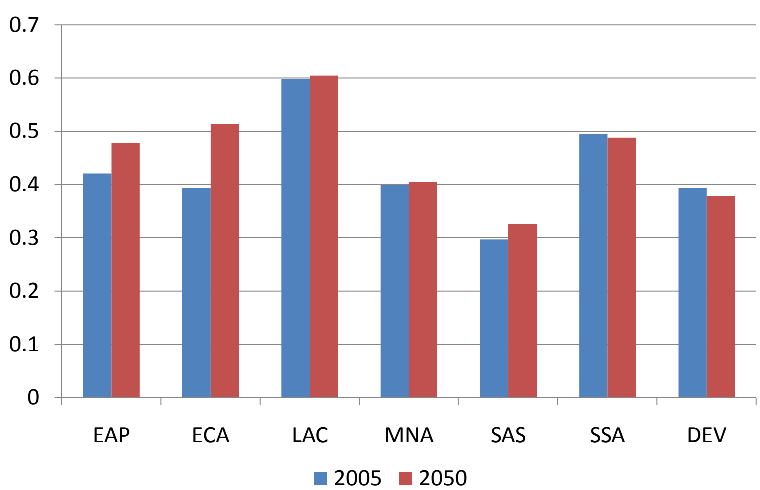
Data source: Authors' estimates

Figure 6.2 Global Income Inequality reduction, while…



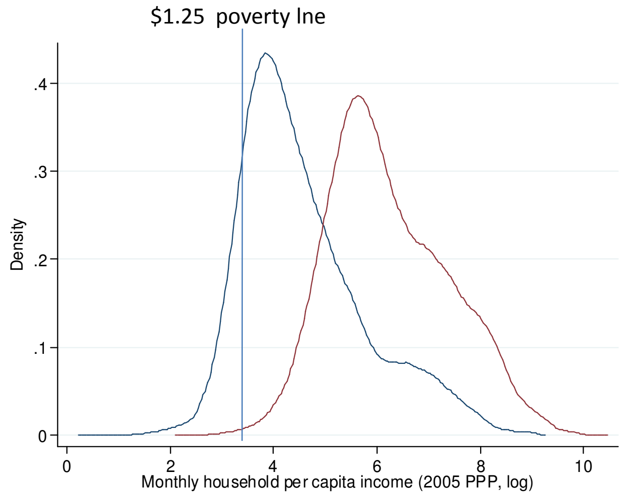
Source: Authors' calculations

Figure 6.3 Within-region income inequality on the rise



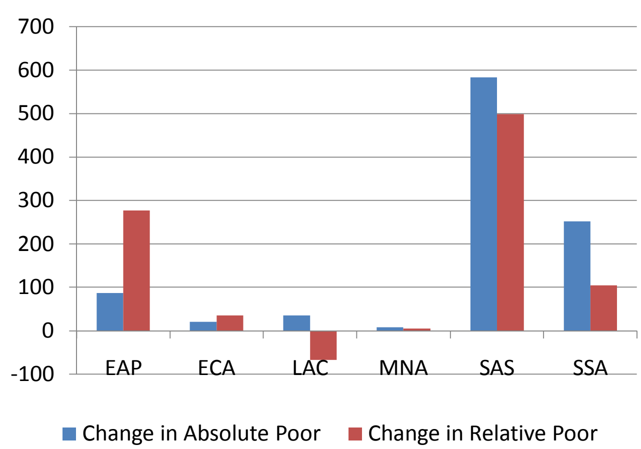
Source: Authors' calculations

Figure 6.4 Income distribution in 2005 and 2050:
Reduction of absolute poverty



Source: Authors' calculations

Figure 6.5 Reduction in absolute vs relative poverty



Source: Authors' calculations

Relative Poverty Measured as Ravallion and Chen (2009) *"Weakly Relative Poverty"*

Table 6.2 Poverty Estimates

	Absolute Poverty ($1.25 PPP)			Weakly Relative Poverty		
	Head Count Index (2005)	Head count Index (2050)	−Δ Poverty Millions	Head Count Index (2005)	Head count Index (2050)	−Δ Poverty Millions
All Developing Countries	21.9	0.4	1,185	31.96	12.4	843
East Asia and the Pacific	15.8	0.0	-87	30.4	12.1	277
Eastern Europe and Central Asia	4.4	0.0	20	12.6	5.5	35
Latin America and the Caribbean	8.1	1.0	35	33.3	31.3	(67)
Middle East and North Africa	4.1	0.0	8	19.0	10.5	5
South Asia	40.5	0.0	583	40.8	4.0	499
Sub Saharan Africa	51.7	2.8	252	55.5	20.3	104

Source: Authors' estimates

Table 6.3 Composition of the Global Middle Class

Region	**2005**		**2050**	
	Millions	**%**	**Millions**	**%**
Developed Countries	*190.8*	*33.0*	*27.1*	*4.3*
Developing Countries	*260.2*	*6.4*	*2,117.3*	*29.7*
- East Asia and the Pacific	41.1	2.3	785.7	35.0
- Eastern Europe and Central Asia	85.9	19.7	117.9	30.5
- Latin America and the Caribbean	107.5	20.3	245.9	31.8
- Middle East and North Africa	18.3	8.9	151.2	47.0
- South Asia	0.6	< 0.1	657.6	29.2
- Sub Saharan Africa	6.8	1.3	159.1	16.6
Total	*451.0*	*8.15*	*2,144.3*	*28.4*

Source: Authors' estimates

REFERENCES

Armington, Paul (1969). "A Theory of Demand for Products Distinguished by Place of Production," *IMF Staff Papers*, Vol. 16, pp. 159-178.

Baffes, John (2009). "More on the Energy/non-Energy Commodity Price Link." *Applied Economics Letters*, forthcoming.

Baffes, John (2007). "Oil Spills on other Commodities." *Resources Policy*, vol. 32, pp. 126-134.

Borensztein, Eduardo and Carmen M. Reinhart (1984). "The Macroeconomic Determinants of Commodity Prices." *IMF Staff Papers*, vol. 41, pp. 236-261.

Büyükşahin, Bahattin, Michael S. Haigh, and Michel A. Robe (2008). "Commodities and Equities: 'A Market of One'?" U.S. Commodity Futures Trading Commission, Washington, D.C.

Bussolo, Maurizio, de Hoyos, Rafael, Medveded, Denis, and van der Mensbrugghe, Dominique (2007). "Global Growth and Distribution: Are China and India Reshaping the World?" *World Bank Policy Research Working Paper Series 4392*, Washington, D.C.

Bussolo, Maurizio, de Hoyos, Rafael, and Medvedev, Denis (2008). "Economic Growth and Income Distribution: Linking Macroeconomic Models with Household Survey Data at the Global Level", *Background document for the Global Income Distribution Dynamics Tool*, The World Bank, Washington, D.C.

CFTC, Commodities Futures Trading Commission (2008). "Interagency Task Force on Commodity Markets Releases Interim Report on Crude Oil." Washington, D.C., July 22.

Cline, William R. (2007). *Global Warming and Agriculture: Impact Estimates by Country*, Center for Global Development and Peterson Institute for International Economics, Washington, DC.

Coelli, Tim J. and D. S. Prasada Rao (2005). "Total factor productivity growth in agriculture: a Malmquist index analysis of 93 countries, 1980-2000." *Agricultural Economics*, International Association of Agricultural Economists, vol. 32(s1), pp. 115-134.

Deaton, Angus (1999). "Commodity Prices and Growth in Africa." *Journal of Economic Perspectives*, vol. 13, pp. 23-40.

Dickey, David and Wayne A. Fuller (1979). "Distribution of the Estimators for Time Series Regressions with Unit Roots." *Journal of the American Statistical Association*, vol. 74, pp. 427-431.

Eckaus, Richard S. (2008). "The Oil Price Is a Speculative Bubarrele." Center for Energy and Environmental Policy Research Working Paper 08-007.

FAO (2002). *Commodity Market Review 2001-02*. Rome: Food and Agriculture Organization of the United Nations.

Gilbert, Christopher (2007). "Commodity Speculation and Commodity Investments." Revised version of the paper presented at the conference, *The Globalization of Primary Commodity Markets*, Stockholm, October 22-23.

Gilbert, Christopher L. (1989). "The Impact of Exchange Rates and Developing Country Debt on Commodity Prices." *Economic Journal,* vol. 99, pp. 773-783.

Hertel, Thomas W., editor (1997). *Global Trade Analysis: Modeling and Applications*, Cambridge University Press, New York.

Holtham, Gerald H. (1988). "Modeling Commodity Prices in a World Macroeconomic Model." In *International Commodity Market Models and Policy Analysis*, ed. Orhan Guvenen. Boston: Kluwer Academic Publishers.

Houthakker, Hendrik S. (1975). "Comments and Discussion on 'The 1972-75 Commodity Boom' by Richard N. Cooper and Robert Z. Lawrence." *Brookings Papers on Economic Activity*, vol. 3, pp. 718-720.

IPCC (2007). *Climate Change 2007: Mitigation of Climate Change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, UK and New York, NY.

Lluch, Constantino (1973). “The Extended Linear Expenditure System,” *European Economic Review*, Vol. 4, pp. 21-32.

Masters, Michael W. (2008). “Testimony before the Committee of Homeland Security and Government Affairs.” United States Senate, Washington, D.C., May 20.

Nordhaus, William (2008). *A Question of Balance: Weighing the Options on Global Warming Policies*, Yale University Press, New Haven, CT.

Ravallion, Martin and Chen, Shaohua (2009). “Weakly Relative Poverty.” *World Bank Policy Research Working Paper Series No. 4844*, Washington, D.C.

Rimmer, Maureen T. and Alan A. Powell (1996). “An implicitly additive demand system,” *Applied Economics*, 28, pp. 1613-1622.

Soros, George (2008). “Testimony before the U.S. Senate Commerce Committee Oversight: Hearing on FTC Advanced Rulemaking on Oil Market Manipulation.” Washington, D.C., June 3. <http://www.georgesoros.com/files/SorosFinalTestimony.pdf>

Spraos, John (1980). “The Statistical Debate on the Net Barter Terms of Trade between Primary Commodities and Manufactures.” *Economic Journal*, vol. 90, pp. 107-128.

Plastina, Alejandro (2008). “Speculation and Cotton Prices.” *Cotton: Review of the World Situation*, International Cotton Advisory Committee, vol. 61, pp. 8-12.

Radetzki, Marian (2008). *A Handbook of Primary Commodities in the Global Economy*. Cambridge University Press, UK.

van der Mensbrugghe, Dominique (2009), “The ENVironmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model.” *Mimeo*, The World Bank, Washington, DC.

World Bank (2009). *Global Economic Prospects: Commodities at the Crossroads*. Washington D.C.

World Bank (various issues). Commodity price data. Development Prospects Group. Washington D.C.

Wray, Randall L. (2008). “The Commodities Market Bubble: Money Manager Capitalism and the Financialization of Commodities.” *Public Policy Brief 96*. The Levy Economics Institute of Bard College.

APPENDIX 1: THE MODEL USED FOR THE CLIMATE CHANGE SIMULATIONS

The quantitative analysis of the climate change section of this paper relies extensively on the World Bank's dynamic global computable general equilibrium model, ENVISAGE (ENVironmental Impact and Sustainability Applied General Equilibrium Model; See van der Mensbrugghe 2009). Underlying the model is the 2004-based Release 7 of the GTAP database that divides the world economy into 113 countries/regions (of which 95 are countries) and 57 commodities (More on the GTAP data can be found at www.gtap.org). For modeling purposes the underlying database is typically aggregated to a more manageable set of regions and sectors with a focused selection of both depending on the objectives of the particular study. In the case of the current study the focus has been on the agriculture and food sectors, but energy as well to capture the emergence of biofuels and the linkage between energy and agriculture. ENVISAGE has been designed for climate change studies and therefore the standard GTAP data is supplemented by several satellite accounts. These satellite accounts include energy data in volume, carbon emissions linked to the burning of fossil fuels, and emissions from the other Kyoto greenhouse gases, i.e. methane (CH_4), nitrous oxides (N_2O), and the fluorinated gases (F-gases). Both methane and nitrous oxides are linked to agricultural production. The other GHG differ from carbon emissions. First, they have a more exhaustive set of drivers since they can be associated with all intermediate inputs, not simply fossil fuels, as well as factor inputs (for example land in the case methane generated by the production of rice) and output. Second, there exist abatement technologies that are more complex than in the case of fossil fuel-based carbon emissions. With current technologies, the latter can only be abated by either lowering consumption of fossil fuels or substitution into lower- or zero-emission fuels. In the case of the other GHG, abatement technologies may exist that involve different production methods, though presumably at a higher cost.

Separately, we have supplemented the GTAP data with a more exhaustive set of electricity activities—splitting the single GTAP electricity sector into five production activities that include coal fired, oil and gas fired, nuclear, hydro-electric and other (including all existing renewables). For long-term scenario analysis we also introduce several new energy technologies that initially have low penetration, but that under certain circumstances could potentially replace conventional technologies. These new technologies include first and second generation biofuels as potential substitutes in the transport sector, and coal and gas carbon capture and storage (CCS) in the power sector.

In most respects ENVISAGE is a rather classical recursive dynamic global CGE with a time horizon spanning 2004-2100. Production is based on the capital-labor substitution with capital and energy near-complements in the short-term and substitutes in the longer-term. A vintage production structure is employed that allows for partial capital mobility across sectors in the short-term, or a putty-semi-putty technology. Vintage capital is associated with lower production flexibility, whereas new capital is more flexible thus aggregate flexibility depends on the share of vintage capital in total capital, with greater flexibility associated with those economies with the highest savings rate. Factor payments accrue to a single representative household in each region and the latter allocates income between savings and expenditures on goods and services. The model allows for significant flexibility in specifying consumer demand. The top level utility function can be specified using one of three demand systems—constant difference in elasticities (CDE, Hertel, 1997), extended linear expenditure system (ELES, Lluch, 1973), and (AIDADS, Rimmer and Powell, 1996). The top level utility function can be specified at a different commodity aggregation than production. A transition matrix—that allows for commodity substitution—converts consumer goods to produced goods. Energy demand is specified as a single bundle for each agent in the economy. Energy demand is then split into demand for specific types of energy using a nested CES structure. Trade is specified using the ubiquitous Armington assumption (Armington, 1969)—though the model allows for homogeneous commodities as well. Government plays a relatively passive role—collecting taxes and spending on goods and services. The government's fiscal balance is fixed in any given year (and declines towards 0 from its initial position by 2015), and the household direct tax schedule shifts to achieve the fiscal target (The base year imbalance converges towards zero at some later date currently set at 2015.). The latter implies that changes in indirect taxes (e.g. import tariffs or carbon taxes) are recycled in lump-sum fashion to households. Investment is savings driven and savings rates are influenced by the overall growth rate as well as demographic factors such as dependency ratios. The current account balance for each region is fixed in any given. The base year balances converge towards zero at some date (currently set to 2025). An ex ante shift in either import demand or export supply influences the real exchange rate. Thus, for example, if a country is forced to import more food due to climate damages to its agriculture, this would normally entail a real exchange rate depreciation that increases demand for its exports in order to pay for the additional food imports.

ENVISAGE has been developed as an integrated assessment model (IAM). Emissions of the greenhouse gases generated by the economic part of the model lead to changes in atmospheric concentrations. A simple reduced form atmospheric model converts changes in the stock of atmospheric concentrations into changes in radiative forcing and global mean temperature. The resulting changes in global mean temperature feedback on the economy through damage functions that affect various economic drivers. In the current version of the model the only feedback is through changes in agricultural productivity. The agricultural damage functions have been calibrated to the estimates from the recent study by Cline 2007.

Dynamics in ENVISAGE is driven by three key factors. The first is demographics, which describe population and labor force rates of growth. Following a common practice, our baseline uses the medium variant from the UN populations forecast, with the growth of the labor force equated to the growth of the working age population (defined as those between 15 and 65 years of age). The second key driver is formed by savings and investment which jointly determine the overall level of capital stock (along with the rate of depreciation). In ENVISAGE the savings function is partially determined by demographics. Generally speaking, savings will rise as dependency ratios (both under 15 and over 65) fall.

The third driver is productivity. ENVISAGE differentiates productivity across broad sectors: agriculture, energy, manufacturing, and services. Agriculture’s productivity growth has two components to be calibrated. On one hand, the exogenous component is calibrated to 2.1 percentage points per year, consistent with recent trends (World Bank, 2008). On the other, the endogenous component comes from a linear damage function which links increases in global temperature to declines in agricultural TFP and is calibrated according to Cline’s average estimates with and without carbon fertilization (Cline, 2007).

Productivity in other sectors is unaffected by climate change, and is calibrated through 2015 to match the World Bank’s medium- and long-term forecast. After 2015, productivity growth in the US is calibrated to achieve a long-term average (2004-2100) growth in real GDP per capita of 1.2 percent per year—with faster growth in the first half of the century—while productivity in other countries/regions is calibrated based on simple convergence assumptions.