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Working Paper

The impact of climate change policies on employment in the coalmining industry

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Working papers are preliminary documents intended to stimulate discussion and critical comments

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Contents:

Summary

An agreement under the United Nations Framework Convention on Climate Change for developed countries to curb greenhouse gas emissions is in the pipeline. The impact on sectoral production from such an agreement is projected to be significant. In particular, lower fossil fuel use in Annex I countries, so that they can meet their emission abatement targets, is projected to result in a 30 per cent fall in global coal production at 2010 under the less stringent emission reduction scenario (Annex I countries stabilize their carbon dioxide emissions from fossil fuel combustion at 1990 levels by 2010) relative to the reference case of unabated emission growth. Global coal production is projected to fall by 42 per cent at 2010 under the more stringent (Annex I countries reduce their carbon dioxide emissions from fossil fuel combustion to 15 per cent below 1990 levels by 2010) relative to the reference case.

Falls in coal production lead inevitably to significant falls in coalmining employment. It is estimated that there will be between 1.5 million and 2.1 million fewer coalmining workers at 2010 under the less stringent and more stringent scenarios respectively, relative to the reference case.

A significant result from this paper is that, although non-Annex I regions are not required to undertake emission abatement action, trade links with Annex I regions result in lower non-Annex I coal production too. Non-Annex I coal production is projected to fall by about 8 per cent at 2010 relative to the reference case, as a result of Annex I abatement action. Annex I coal production is projected to fall by 43 per cent and 62 per cent at 2010 under the less stringent and more stringent emission abatement scenarios respectively, relative to the reference case.

With little substitution between labour and capital in the production of coal, especially in Annex I regions, changes in labour demand are projected approximately to mirror changes in coal production. It is projected, however, that the fall in non-Annex I labour demand (3 per cent at 2010 under the less stringent scenario relative to the reference case) will be less than the fall in coal production because of a small substitution away from capital, in favour of labour.

Changes in regional coalmining employment relative to the reference case depend on the number of workers employed in the coal sector and on the change in demand for labour in the coal industry arising from changes in production. For example, although the percentage decrease in labour demand in the former Soviet Union and Eastern European coal industries is relatively low, the projected number of jobs lost in these regions is the greatest among the Annex I regions because of the large workforce compared with other Annex I countries. Over 1.8 million workers are projected to be displaced at 2010 under the more stringent scenario relative to the reference case. In the European Union 295,000 coal workers are projected to be displaced at 2010 under the more stringent scenario (similar to the current proposal of the EU) as labour demand in the coal industry falls by 75 per cent relative to the reference case. In the United States, Australia and Canada the projected job losses are 115.800, 12,800 and 8,700 respectively.

The effect of emission abatement policies on regional coal production and labour demand also depends on the size of the negative trade effect. For instance, the negative trade effect is projected to result in over 17,000 workers being displaced from South African coal mines at 2010 under the more stringent scenario relative to the reference case, because South Africa exports a relatively large proportion of its coal production to Annex I regions. Alternatively, China and India export a very small proportion of their coal production, so that the positive domestic effect of carbon leakage is projected to be larger than the negative trade effect, resulting in a small increase in coalmining labour demand in these countries.

1. Introduction

Widespread concerns about the potential risks of global warming have motivated over 160 countries to become Parties to the United Nations Framework Convention on Climate Change. The Convention came into force in March 1994 with the aim of stabilizing the atmospheric concentration of greenhouse gases at a level that would prevent "dangerous anthropogenic interference with the climate system" (United Nations 1992).

A fundamental result of the Berlin Mandate, agreed at the first Conference of the Parties to the Framework Convention in 1995, was the commencement of negotiations to establish greenhouse gas emission reduction objectives and policies for Annex I countries for the period beyond 2000 (see box 1). The deadline for an agreement on these objectives and policies is the third Conference of the Parties to the Convention in Kyoto, Japan, in December 1997.

Under the Berlin Mandate the outcome of the current negotiating round will not require non-Annex I countries (developing countries) to adopt commitments to lower their emissions. Nevertheless, it can be expected that the economic development of non-Annex I regions will be affected through trade and investment links with Annex I parties. Non-Annex I countries are likely to be affected via these links when Annex I countries undertake emission abatement measures, with a consequential impact on their gross national expenditure. Estimates of the impact of emission reduction policies on Annex I economies can be found in Brown, et al. (1997). An important result from this research was that policies to reduce carbon dioxide emissions from fossil fuel combustion in Annex I regions lead to lower world demand for fossil fuels, especially coal which is highly emission-intensive. Further, details on non-Annex I countries can be found in Shneider, et al. (1997).

The aim of this report is to highlight the impact of Annex I country efforts to reduce carbon dioxide emissions from fossil fuel combustion on the demand for labour in the coalmining industry. Although unemployment is not explicitly modelled in this study, estimates are made of the number of workers that are likely to be displaced from the coal industry as a result of emission abatement policies.

The analysis presented in this report is based on applications of the MEGABARE model of the world economy (ABARE 1996). MEGABARE is a multi-commodity, multi-region, dynamic, computable general equilibrium model designed to conduct research on issues facing the global economy, including the impact of climate change policy (see, for example, Brown, et al. 1997). Documentation on the model, together with some working papers that illustrate its further development, can be found on ABARE's Internet site (http://www.abare.gov.au).

This report does not address the broader issue of assessing the overall cost of climate change itself compared with the cost of mitigation and adaptation. This subject is covered in the "environmental impact assessment" literature (see, for example, Weyant 1994; Weyant, et al. 1995; Reilly 1997). Also, only policies to abate carbon dioxide from fossil fuel combustion are considered in this report.

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2. Analytical framework

Given the pervasive use of fossil fuels in the global economy, policies designed to constrain carbon dioxide emissions from fossil fuel use will affect almost every aspect of economic activity. Computable general equilibrium models of the world economy such as MEGABARE are able to capture the impact of such policy changes on large numbers of economic variables. These include: the prices of consumer goods and inputs to production; sectoral and regional output, trade and investment flows; and, ultimately, national incomes and expenditure levels in Annex I and non-Annex I countries.

MEGABARE, as a tool to examine international climate change policies, contains detailed accounting of carbon dioxide emissions from fossil fuel combustion as a by-product of different economic activities. MEGABARE incorporates the fact that different fossil fuels release different amounts of carbon dioxide. This means that the projected emission level for a region in a given period is a function of the mix and quantity of fossil fuel consumption in that region in that period. Alternative emission abatement policies can be analysed by modelling the impact on economic variables of restrictions on growth in emissions.

MEGABARE is an intertemporal model which can track growth in variables over time. Population growth and capital accumulation are determined endogenously (within the model). This is in contrast to comparative static models which compare two equilibriums, one before a policy change and one following, but with no growth in the factors of production. The intertemporal nature of MEGABARE is important when analysing climate change policies, since both the timing of policy changes and the adjustment path that the economy follows are highly relevant in the policy debate (issues surrounding timing of policy changes and optimal hedging strategies can be found in Manne and Richels 1992).

A number of other global general equilibrium models have been developed and used extensively to analyse climate change policies. These include ERM (Edmonds and Reilly 1983), GREEN (Burniaux, et al. 1991), WEDGE (Industry Commission 1991), Whalley and Wigle (1991), Global 2100 (MR) (Manne and Richels 1992), G-Cubed (McKibbin and Wilcoxen 1992) CRTM (Rutherford 1993), Second Generation Model (Edmonds, et al. 1995), EPPA (Yang, et al. 1996) and the International Impact Assessment Model (Bernstein, Montgomery and Rutherford 1996).

At its most disaggregated level MEGABARE consists of equations and data that describe the production, consumption, trade and investment behaviour of representative producers and consumers in 30 regions across 41 sectoral groupings. The database used to simulate the impact of the various emission abatement policies in this report has been aggregated to the 16 commodity groups and 18 regions presented in table 1. This particular aggregation was chosen to allow a focus on the links between fossil fuel industries and energy-intensive sectors and to explore any impact on trade arising from greenhouse gas abatement.

A key feature of the MEGABARE model is the unique "technology bundle" approach to modelling fuel substitution possibilities. In MEGABARE electricity can be generated from coal, oil, gas, nuclear, hydro or renewable-based technologies, while iron and steel can be produced using blast furnace or less coal-intensive electric arc technologies.

Explicit modelling of the alternative methods of production available to them enables the electricity and iron and steel industries to substitute between technologies in response to relative price changes or restrictions on input use, including the use of fossil fuels. A more detailed description of this approach to modelling fuel substitution and its advantages over commonly used alternatives is found in appendix A of Brown, et al. (1997). Table 1. Regions and sectors contained in MEGABARE simulations

Regions	**Sectors**
Annex I	Coal
Australia	Oil
New Zealand	Gas
United States	Other minerals

Canada	Petroleum & coal products
Japan	Chemicals, rubber, plastics
European Union (15)	Non-metallic minerals
EFTA1	Primary iron & steel
Former Soviet Union & Eastern Europe	Primary non-ferrous metals
Non-Annex I	Fabricated metal produscts
Republic of Korea	Electricity, gas, water
China	Agriculture
Taiwan, China	Processed agricultural goods
Indonesia	Capital goods
Rest of ASEAN2	Manufacturing
India	Services
Mexico	
Brazil	
Rest of America	
Rest of world3	
1 European Free Trade Association: Iceland, Norway, Switzerland. 2 Association of South East Asian Nations: Malaysia, Philippines, Singapore, Thailand. 3 Referred to as South Africa in the regional analysis of this paper because most of the "Rest of the world's" coal is produced here.	

In the MEGABARE model, industries combine factors of production (land, labour and capital) and intermediate inputs (including energy inputs) to produce a single commodity. Substitution is permitted between labour and capital, thereby allowing industries to adjust the labour intensity of production in response to movements in real wages (relative to the price of capital). Substitution between other inputs is not permitted, to prevent unrealistic substitutions between, for example, energy inputs and labour.

The MEGABARE simulation of labour demand in the coal industry is shown in figure 1. Labour is not directly substitutable with intermediate inputs used in the production of coal (represented as commodities A to C) such as electricity, petroleum products and construction goods. Instead, labour is substituted with capital and land as part of the endowment factor bundle. It is assumed that land, capital and labour can be substituted according to a CES (constant elasticity of substitution) technology which assumes that the rate at which the three primary factors are substituted remains fixed. The elasticity of substitution between labour and capital is assumed to be low in the coal sector, reflecting the difficulty of real world substitution. The endowment factor bundle is applied with intermediate inputs in fixed proportions to produce coal (Leontief technology).

Although MEGABARE models labour demand at the industry level, it does not explicitly model unemployment over time. MEGABARE assumes that labour is perfectly mobile within a region, so that wage adjustment ensures equilibrium in the labour market (or a fixed unemployment rate over time).

Although labour demand in the reference case simulation is determined endogenously in the model, the magnitude of the labour demand changes are determined by macroeconomic projections that are fed exogenously into the model. The impact of emission abatement policies on labour demand in a particular industry is reported as deviations from the reference case simulation, which is a simulation assuming unabated emission growth. Labour demand in a particular industry under the reference case scenario depends on the assumed rate of GDP growth per person over the simulation period which is fed exogenously into the model. Labour productivity, as well as the productivity of other inputs, such as land and captial, are assumed to converge toward those of developed regions.

The MEGABARE simulations described in this paper embody the following assumptions about the economic environment:

* population and labour supply are determined endogenously by the demographics in the model and are linked to economic variables (particularly income) via birth and mortality rates; and a constant net migration rate is assumed;

* population growth and age structure are important determinants of each region's labour supply and level of savings;

* capital is mobile internationally -- it is assumed that savings will always finance investment in the region of origin before financing investment abroad;

* rates of return are equalized across sectors within a particular region;

* rates of return across regions are assumed eventually to equalize, allowing some imperfections in the international capital market;

* the unemployment rate across regions is assumed to remain constant through adjustments in wages;

* all prices in the model are determined relative to the global price of savings -- the global price of savings is termed the *numeraire*;

* nuclear and hydro power are assumed to be constrained to reference case levels because of both physical and potential political constraints to their expansion; other renewables, however, are assumed to be free to expand in response to emission constraints.

3. Policy simulation

At this point the level of emission reduction to be adopted and the method of implementing emission reductions remain a matter for international debate. The uniform targets approach to achieving emission reductions, proposed by the European Union and a number of other countries, requires each Annex I country to reduce its emissions by a given percentage of its emissions in a base period such as 1990. This contrasts with a differentiated targets approach under which countries' individual economic and trade circumstances would be taken into account when their quantitative emission limitation and reduction objectives (QELROs) are set.

For this analysis the following uniform abatement policies were chosen:

Less stringent scenario: Annex I countries stabilize their carbon dioxide emissions from fossil fuel combustion at 1990 levels by 2010.

More stringent scenario: Annex I countries reduce their carbon dioxide emissions from fossil fuel combustion by 15 per cent below 1990 levels by 2010.

The less stringent scenario is based on a ten-year delay in achieving the implicit commitment contained in Article 4.2 of the Framework Convention on Climate Change that Annex I Parties aim to reduce their emissions to 1990 levels by 2000 (at this point, few Annex I countries will achieve this aim). The more stringent scenario represents a policy consistent with that proposed by the Group of 77 and China Parties at the international climate change negotiations held in Bonn in October 1997. Developing countries are not required to restrict their emissions growth in either scenario. This assumption is based on the requirement that the outcome of the Berlin Mandate negotiations will not require developing countries to take on new commitments.

It is assumed that, in achieving the emission reductions, governments adopt policy instruments that impose the smallest possible cost on their economies. In MEGABARE, least-cost modelling of emission abatement involves imposing a tax on emissions of carbon dioxide in each period for which emission restrictions apply. The tax increases the costs associated with carbon dioxide emission-intensive activities and encourages a shift of resources into less emission-intensive activities, thereby reducing emissions.

A carbon tax is representative of the broad class of economic instruments that could be used by governments to reduce emissions, including nationally based tradable emission quota schemes. In the context of the MEGABARE simulations, the carbon tax associated with achieving a given level of emission abatement can also be interpreted as the unit price of nationally traded emission quotas (Hinchy, Thorpe and Fisher 1993). In more general terms, the carbon tax can be interpreted as the marginal cost to the economy associated with any least-cost policy or set of policies designed to achieve a given level of emission abatement. Revenue from the tax is assumed to be returned to the economy in a lump sum fashion.

4. Aggregate impact of policies on economies

The assumed emission reductions are estimated to impose losses in real gross national expenditure (GNE) (box 2) on Annex I and non-Annex I regions (table 2). Global GNE (and therefore GDP) is projected to fall by 0.5 per cent and 1.0 per cent under the less stringent and more stringent scenarios respectively at 2010 relative to the reference case. Table 2. Change in GNE at 2010 due to emission reductions in Annex I regions

(Per cent relative to the reference case)

	Less stringent scenario	More stringent scenario
Annex I	-0.5	-1.0
Non-Annex I	-0.6	-1.1
Global	-0.5	-1.0
Source: MEGABARE projections.		

The key source of economic loss in Annex I countries is an increase in the costs of industrial production and in consumer prices as the assumed emission restrictions force producers and consumers in Annex I countries to move away from carbon-intensive fossil fuel use into more costly alternatives. The increased costs to industry tend to dampen economic activity. The resulting decline in demand for labour and capital reduces real returns to capital and labour (defined as the gains in output associated with adding an extra unit of capital and labour, respectively, to the economy), in turn leading to reduced income and economic losses.

The impact of Annex I policies on international trade can be significant for both Annex I and non-Annex I economies. For example, both Annex I and non-Annex I fossil fuel exporters can be expected to experience a decline in demand and prices for their fossil fuel exports. Also, Annex I countries with significant exports of fossil fuel-intensive products (such as iron and steel, or aluminium) could face a reduction in export demand as these industries begin to relocate to developing countries to take advantage of increased price competitiveness. While, on average, Annex I exporters of fossil fuel-intensive products lose competitiveness, non-Annex I exporters of these products gain in competitiveness, leading to carbon leakage and contributing positively to GNE changes in some non-Annex I countries.

Trade-related economic losses can also arise because the increased costs of production in Annex I countries (resulting from their efforts to restrict emissions) are passed to consumers of Annex I country products, including consumers in developing countries. For example, the prices of capital goods sold by Japan to all countries, including non-Annex I countries, will rise with the imposition of emission abatement policies in Japan. All other things being equal, countries with significant imports of emission-intensive products from Annex I countries can be expected to experience more significant economic losses than countries with less significant imports of those products.

A key feature of the results from the MEGABARE analysis is, that under certain policy simulations, trade effects lead to economic losses in a number of non-Annex I countries even though they do not take any direct action to reduce their emissions. Non-Annex I countries are projected to experience a loss of 0.6 per cent of gross national expenditure at 2010 under the less stringent policy (table 2). Under the more stringent policy, non-Annex I countries are projected to experience a larger (1.1 per cent) decline in gross national expenditure by 2010. In 2010 the intensified negative trade impact (larger Annex I losses) on non-Annex I regions under the more stringent scenario dominates the subdued positive effect of carbon leakage. There is insufficient time to allow factors of production to be transferred from Annex I to non-Annex I regions to facilitate the positive effects of carbon leakage (see Shneider, et al. 1997).

Carbon leakage and structural change

Reducing Annex I emissions to 1990 levels by 2010 (the "less stringent" of the two scenarios examined in this study) implies an emission reduction relative to reference case emissions in this region of around 20 per cent by 2010 (table 3). Reducing Annex I regions' emissions to 15 per cent below 1990 levels by 2010 (the "more stringent" scenario) requires a reduction in Annex I emissions of 32.1 per cent by 2010 compared with the reference case level.

Table 3. Changes in CO_2 emissions at 2010 due to emission reductions in Annex I regions

(Per cent relative to the reference case)

	Less stringent scenario	More stringent scenario
Annex I	-20.1	-32.1
Non-Annex I	2.7	4.5
Global	-9.3	-14.8
Source: MEGABARE projections.		

At the same time, carbon dioxide emissions from non-Annex I countries are projected to rise by 2.7 per cent and 4.5 per cent at 2010 under the less and more stringent scenarios respectively relative to the reference case. This phenomenon is known as "carbon leakage".

Carbon leakage is the partial offsetting of emission abatement achieved in Annex I countries by increases in emissions from non-Annex I countries. In the MEGABARE simulations, Annex I countries impose policies to reduce fossil fuel use to reduce emissions. These policies increase production costs in fossil fuel- intensive industries such as iron and steel and nonferrous metals production in Annex I countries. As a result, non-Annex I countries obtain a competitive advantage over Annex I countries in fossil fuel-intensive production. In response, there is a partial shift of emission intensive industries from Annex I to non-Annex I countries. For example, iron and steel production is projected to fall in Annex I regions and increase in non-Annex I regions (table 4).

Table 4. Changes in iron & steel production at 2010 due to emission reductions in Annex I regions

(Per cent relative to reference case)

	Less stringent scenario	More stringent scenario
Annex I	-8.2	-13.8
Non-Annex I	18.4	26.9
Source: MEGABARE projections.		

The changes in global CO_2 emissions shown in table 3 are associated with changes in the global use of fossil fuels which, in turn, are driven by their reduced use in Annex I countries. Projected changes in the world's use of coal, oil and gas are shown in table 5.

Table 5. Changes in global primary energy use at 2010 due to emission reductions in Annex I regions

(Per cent relative to reference case)

	Less stringent scenario	More stringent scenario
Coal	-28.9	-41.2
Oil	-3.3	-5.3
Gas	-9.8	-21.5
Source: MEGABARE projections.		

Global coal use is projected to decline by 28.9 per cent and 41.2 per cent at 2010 under the less and more stringent scenarios respectively relative to the reference case. This significant decline in coal use can be attributed largely to a greater substitution of coal in electricity production than is the case for less carbon-intensive energy sources such as oil or gas. The projected decline in global oil use is less than that for coal and gas, mainly because oil products are used extensively in the transport sector where substitution possibilities are more limited than in the power generation sector where coal and gas use is more widespread.

Lower coal demand from Annex I regions is projected to have an impact on Annex I and non-Annex I coal production (table 6). Non-Annex I coal production is projected to fall by 7.6 per cent and 8.1 per cent respectively under the less and more stringent scenarios at 2010. Despite higher domestic demand from fossil fuel-intensive sectors, non-Annex I coal production is projected to fall because of a significant fall in coal exports to Annex I regions. Although exports comprise only 9 per cent of non-Annex I coal production, non-Annex I coal exports to Annex I regions comprise 65 per cent of total coal exports (1992), resulting in a 34.5 per cent fall in non-Annex I exports. Annex I coal production is projected to fall by more than non-Annex I coal production because of lower domestic demand from fossil fuel-intensive sectors associated with lower aggregate demand and fuel switching to meet emission abatement targets.

Table 6. Changes in coal production due to emission reductions in Annex I regions

(Per cent relative to the reference case)

	Less stringent scenario	More stringent scenario
Annex I	-43.4	-61.7
Non-Annex I	-7.6	-8.1
Global	-30.0	-41.7
Source: MEGABARE projections.		

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Part 3

Changes in labour demand from the coal industry

Global demand for labour in the coal sector is projected to fall by 36.8 per cent and 52.7 per cent under the less and more stringent scenarios respectively. A key result is that although non-Annex I regions are not required to undertake emission abatement measures, the demand for labour in the coal industry in these countries is projected to decline, but not to the same extent as in Annex I regions.

Climate change policies affect the demand for labour in the coal industry in two ways. First, changes in the production of coal reduce the demand for factors of production, including labour. Second, changes to the nominal wage relative to the price of capital induce coal producers to substitute labour for capital.

Table 7. Changes in labour demand in the coal industry at 2010 due to emission reductions in Annex I regions

(Per cent relative to reference case)

	Less stringent scenario	More stringent scenario
Annex I	-43.5	-62.5
Non-Annex I	-3.3	-3.8
Global	-36.8	-52.7
Source: MEGABARE projections.		

It is projected that the substitution effect on labour demand in the coal industry is minor under both the less and more stringent scenarios. Tables 6 and 7 show that the percentage change in coal production is similar to the percentage change in labour demand in the coal industry. Substitution of labour for capital is particularly low in Annex I regions because, as shown in table 8, there is only a small change in the price of capital relative to the nominal wage (both fall by similar amounts). In non-Annex I regions, wages fall relative to capital prices and there is a slight substitution toward labour. Under the less stringent scenario, for example, coal output is projected to decline by 7.6 per cent in non-Annex I regions, while the demand for labour is projected to fall by 3.3 per cent, indicating an increase in labour used per unit of output. Overall, changes in labour demand in the coal industry can be largely attributed to changes in coal production.

Table 8. Changes in factor costs at 2010 under the less stringent emission abatement scenario

(Per cent relative to reference case)

	Wage rate	Capital price
Annex I	-8.2	-7.6
Non-Annex I	-4.8	-7.2
Source: MEGABARE projections.		

The changes in regional coal production and the consequences for employment in the coal industry in the case of the less stringent scenario are outlined below.

Changes in Annex I regional coal production

Coal production in all the Annex I regions is projected to fall relative to the reference case at less stringent scenario (% deviation from reference case) 2010 (figure 2). The greatest fall in aggregate production occurs in the European Union and the United States -- falling by 55.5 per cent and 43.7 per cent respectively relative to the reference case. The percentage fall in coal production is relatively low in Australia, where production is projected to decline by 19.8 per cent relative to the reference case.

Annex I regional coal production is influenced by the negative export effect and the lower domestic demand effect. The negative export effect is a result of lower global coal demand (figure 3). Lower domestic demand is a result of lower fossil fuel-intensive production and a shift towards less fossil fuel-intensive iron and steel and electricity generation technologies. These two effects work in tandem, but the dominance of one effect over the other depends on whether domestic coal production is used mainly as a domestic or is exported.

Figure 3 shows that the trade effect is larger than the domestic effect in Australia, and Canada. Exports from Australia and Canada account for 82 per cent and 73 per cent of production (value weighted) respectively, which means that coal demand in these regions is highly vulnerable to changes in global demand. The trade effect is higher in Canada where it is expected to cause a 24.3 per cent reduction in demand, which is approximately half of the 47.9 per cent fall in total coal production (figure 2). In contrast, the United States, the former Soviet Union and Eastern Europe (FSU&EE) and the European Union use most of their coal domestically for producing iron and steel and electricity, so that the domestic effects exceed the trade effects.

The magnitude of the trade effects presented in figure 3 depend on the change in coal exports and the proportion of coal production that is exported. The fall in Annex I exports is dependent on the proportion of total exports that are destined for Annex I regions. Given carbon leakage, demand for, and hence production of, coal is projected to fall by more in Annex I regions than in non-Annex I regions (table 6). For instance, coal exports to Annex I regions as a percentage of total exports are relatively lower in Australia (figure 4), corresponding to a relatively smaller reduction in exports compared with Canada, the United States and the former Soviet Union and Eastern Europe (figure 5). Despite shipping a lower percentage of exports to Annex I regions, Canadian coal exports are projected to fall by more than in the United States and the former Soviet Union because approximately 50 per cent of Canadian coal exports are destined for Japan, which is projected to experience the greatest fall in coal demand.

Despite relatively large reductions in coal exports, the trade effect in the United States and the former Soviet Union and Eastern Europe is relatively small compared with the trade effect in

Australia (figure 3). Australia exports a higher proportion of its coal production, so that changes in coal production are more sensitive to changes in export demand.

The domestic impact of lower coal demand in the electricity and iron and steel sectors is projected significantly to affect coal production in every Annex I region (figure 3). Changes in coal demand from the iron and steel sector are driven primarily by changes in iron and steel production associated with carbon leakage. In contrast, changes in coal demand in the electricity sector are primarily a result of a shift toward less emission-intensive fuels in response to relative fuel price changes. The elasticity of substitution among electricity generation technologies is greater than between iron and steel technologies, allowing for greater technology substitution in the electricity sector.

The largest reduction in domestic coal use is projected to occur in the European Union (55.9 per cent at 2010 relative to the reference case) as a result of the increased use of natural gas in electricity production. The fall in coal demand is exacerbated in the European Union by a relatively high use of coal per unit of coal-fired electricity. The regional impact of less stringent emission abatement on coal demand in the electricity and iron and steel industries are discussed in more detail in the appendix.

Changes in non-Annex I regional coal production

Like Annex I regions, changes in non-Annex I coal production (figure 6) under emission abatement policies can be split into trade and domestic effects. Unlike in Annex I regions, however, there is a positive domestic effect associated with carbon leakage (figure 7). A significant proportion of Indian and Chinese coal is of low quality and is not traded. As fossil fuel intensive industries expand in India and China, demand for coal increases, leading to a projected increase in Chinese and Indian and coal output of 1.7 per cent and 0.7 per cent respectively relative to the reference case at 2010. In contrast, South Africa exports a relatively large proportion of its coal production [27 per cent in 1992 (MEGABARE database)], resulting in a 10.5 per cent fall in production from lower export demand and an overall fall in coal production of 8.6 per cent.

Because non-Annex I regions are not required to undertake mission abatement measures, there is no carbon tax applied to non-Annex I fossil fuels. As a result there are only minor changes in relative fuel prices and little technology substitution in the electricity and iron and steel sectors. Changes in coal use in these sectors are largely attributable to changes in iron and steel and electricity production. For instance, the relatively large increase in domestic coal demand in China is a result of an increase in domestic demand for iron and steel and electricity driven by projected gains in GDP. The increase in domestic coal demand in South Africa is from a 17 per cent increase in iron and steel production associated with carbon leakage.

Changes in employment in the coal industry

Changes in coalmining employment are closely related to changes in coal production and the extent of the changes is driven by the number of people employed in the coal industry. The projected change in regional labour demand in the coal industry at 2010 is presented in table 9.

Table 9. Changes in coalmining employment at 2010 under emission abatement policies

(Deviation from reference case)

	Less stringent (No.)	More stringent (No.)
Annex I		
Australia	-9 630	-12 829
United States	-97 096	-115 834
Canada	-8 043	-8 691
European Union	-257 514	-295 232
FSU & EE	-930 330	-1 440 533
Total1	1 304 626	-1 874 457
Non-Annex I	-212 667	244 889
Global	-1 517 293	-2 119 346
1 Includes all Annex I regions. Source: MEGABARE projections.		

Table 10. Coalmining employment, 1992

Annex I	
Australia	36.7
United States	153.1
Canada	11.0

European Union	322.7
FSU1 & EE	2 196.6
Total	2 725.0
Non-Annex I	6 310.2
Global	9 035.2

1 Includes Russian Federation; Ukraine.

Source: ILO: Recent developments in the coalmining industry (Geneva, 1994).

Table 10 shows that coalmining employment is higher in non-Annex I coal-producing countries than in the Annex I coal industry. The amount of labour per unit of output is greater in non-Annex I regions, especially in China and India, thus changes in global labour demand from the coal sector are more sensitive to changes in non-Annex I labour demand. Most coalmining employment in the Annex I coal industry is in the former Soviet Union and Eastern Europe, where labour applied per unit of output is the highest among Annex I regions.

The most significant displacement of labour from the coal industry is projected to occur in the former Soviet Union and Eastern Europe, with over 900,000 fewer jobs in coalmining under the less stringent scenario at 2010 than under the reference case. The number of jobs displaced is large despite a relatively low projected fall in coal output because of the high absolute size of the coal industry workforce in these countries. In contrast, labour demand in the Canadian coal industry is projected to fall significantly in percentage terms under emission abatement policies but, because there are relatively few workers employed in the Canadian coal sector, the number of displaced workers is relatively small.

It is important to note that, despite not having to undertake emission abatement actions, some non-Annex I regions are projected to face a fall in coal employment levels relative to the reference case. South Africa, for example, is projected to face between 14,000 and 17,000 job losses in the coal industry under the less stringent and more stringent scenarios respectively because of lower coal production relative to the reference case.

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Part 4

5. Conclusions

This report shows that the implementation of emission abatement policies is likely to have a significant impact on employment in the coal industry. Global coal employment could fall by 53 per cent under the most stringent emission reduction scenario.

Coal is relatively emission-intensive compared with other fuels, so that emission abatement policies are projected to cause a large reduction in global coal demand and hence in production. There is very little substitution of labour for capital projected in the coal industry under emission abatement policies, so that changes in labour demand are expected to be caused by lower production levels.

Overall, the extent of regional changes in employment under emission abatement polices relative to the reference case depends on the number of workers employed in the coal industry and on changes in coal production. The most labour shed from the coal industry (assuming no wage adjustment) is over 1.4 million from the former Soviet Union and Eastern Europe under the most stringent scenario because of the high number of workers in this sector. These countries use labour more intensively than any other Annex I region.

It is also important to note that there is a projected labour displacement from the coal industry in non-Annex I regions caused by lower coal production there. Despite a higher domestic demand for coal, non-Annex I regions that extensively export coal (especially to Annex I regions) are likely to encounter a large negative impact on exports resulting from lower Annex I coal demand. South Africa, for example, which exports a large proportion of its coal production is projected to encounter over 14,000 displaced workers in the coal sector in 2010 under the less stringent scenario relative to the reference case.

Appendix: Coal demand changes

Annex I countries

Change in coal demand from the electricity sector

Changes in the demand for coal in the electricity sector are shown in figure 8; it is projected to fall in all Annex I regions. The largest fall is projected to occur in the European Union (74.1 per cent under the less stringent scenario). These changes result mainly from fuel substitution in electricity generation. Electricity production is only projected to fall marginally (for example 0.8 per cent in former Soviet Union and Eastern Europe) owing to low income and own price elasticities of demand.

The size of the substitution effect depends on the marginal cost of abatement in each region and the intensity of coal use in electricity production. The greater the marginal cost of abatement, the greater the carbon tax required to meet a 2010 emission reduction target. In turn, the larger the carbon tax, the greater the relative cost increase of coal-fired electricity (coal is more carbon-intensive) and the greater the substitution away from coal-fired electricity. The marginal abatement cost is low in the former Soviet Union and Eastern Europe because the reference case emissions are not expected to return to 1990 levels until 2007 as a result of economic restructuring. Thus, the carbon tax, and the substitution of coal-fired electricity required to meet the 2010 target are not as large in these countries as it is in the European Union and the United States under the less stringent scenario.

There is a large replacement of coal-fired electricity in Canada because of a low marginal abatement cost in the electricity sector. Restrictions on the growth of hydro and nuclear electricity in the MEGABARE reference case scenario mean that much of the electricity demand growth in Canada must be met by a greater proportion of coal-fired electricity in 2010. Thus, there are ample low cost opportunities for emission abatement in this sector.

The share of coal-fired electricity generation is projected to fall by approximately the same amount in the European Union and the United States (33 per cent and 31 per cent respectively) by 2010 under the less stringent scenario. None the less, coal-fired electricity generation is projected to fall by more in the European Union than in the United States because the European Union uses more coal per unit of coal-fired electricity.

Change in coal demand from the iron and steel sectors

Changes in coal demand in Annex I iron and steel-producing industries depend on changes in iron and steel production and, to a lesser extent, the substitution between electric arc furnaces and more coal-intensive blast furnaces. The changes in coal demand from the iron and steel sectors in figure 9 are generally lower than in the electricity sector because the elasticity of substitution between electric arc and blast furnaces is smaller than that between coal-fired and other electricity generation technologies.

The direction and magnitude of changes in the demand for coal by the iron and steel industry reflect the marginal cost of abatement in each region. The demand for coal in the Australian iron and steel industry is projected to fall by the largest amount of all the Annex I regions because of a 23 per cent reduction in iron and steel production and, to a lesser extent, a substitution away from blast furnace-based iron and steel production. The substitution occurs because the carbon tax (marginal cost of abatement) required to achieve the emission abatement target is relatively high. In contrast, a relatively low carbon tax applied in the former Soviet Union and Eastern

Europe gives this region a competitive advantage over other Annex I regions in the production of iron and steel, resulting in an increase in iron and steel export demand and overall production.

Non-Annex I countries

Change in coal demand from the electricity sector

Because non-Annex I regions are not required to undertake emission abatement, there is little substitution of fuel sources for electricity generation. Changes in coal demand from the electricity sector are thus driven by changes in production. China, India and South Africa are projected to increase their use of coal for electricity generation by 2.3 per cent, 1.6 per cent and 1.3 per cent respectively under the less stringent scenario (figure 10), owing to a 2.3 per cent, 1.4 per cent and 1.3 per cent increase in electricity production respectively. Electricity production is projected to increase in these countries because of GDP gains relative to the reference case which increase the demand for factors of production, including electricity. Electricity production in China is projected to increase by more than in other Annex I regions because of a relatively larger projected GDP gain under the less stringent scenario.

Change in coal demand from the iron and steel sectors

Coal demand in the non-Annex I iron and steel sectors is projected to increase under the less stringent scenario relative to the reference case in response to higher levels of non-Annex I country iron and steel production associated with carbon leakage. Demand for coal in the iron and steel sectors is projected to increase by 9.6 per cent, 7.6 per cent and 17.2 per cent in China, India and South Africa respectively under the less stringent scenario relative to the reference case (figure 11). As was the case for electricity production, there is very little technology substitution in the production of iron and steel in non-Annex I regions. As a result, changes in coal demand in the iron and steel sectors are closely linked to changes in production. The increase in iron and steel production in South Africa is projected to be relatively high because South Africa exports a higher percentage of production than do China and India, producing a larger positive trade effect. The increase in iron and steel production in China and India is driven mainly by increased domestic demand associated with GDP gains.

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