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► **To cite this version:**

Augustin Danneaux, Thomas Le Gallic, Julien Lefèvre. Employment Implications of Transitioning to Net Zero: Revealing Transition Risks through Downscaling. European Climate and Energy Modelling Platform 2023 (ECEMP), Oct 2023, Online, France. hal-04477711

**HAL Id: hal-04477711**

**<https://hal.science/hal-04477711>**

Submitted on 26 Feb 2024

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# Employment Implications of Transitioning to Net Zero: Revealing Transition Risks through Downscaling

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## Abstract

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The rapid phase-out of fossil fuels required to meet the ambitious targets of the Paris Agreement raises concerns about sectoral decline and socioeconomic impacts. This study addresses the need to refine the assessment of employment impacts associated in transition scenarios. We investigate two climate change mitigation scenarios and a baseline using an Integrated Assessment Model (IAM) and augment the overall analysis by incorporating a data science approach. We thus developed an enhanced coal nexus within the Imaclim-R framework and a sub-national economies dynamics module. The latter enables the results to be scaled down and provide qualitatively new information. The analysis quantifies job losses and their timing, highlighting regional disparities and vulnerability. The findings underscore the importance of integrating support policies for affected employees into carbon neutrality programs. Anticipation and rapid implementation of such policies are crucial. Understanding transition risks and developing appropriate support policies can enhance the feasibility and acceptance of transition pathways.

## Introduction and background

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If the Paris Agreement's ambitious targets for reducing greenhouse gas emissions are to be met, a rapid and massive phase-out of fossil fuels will be required (IPCC, 2022). By 2050, most scenarios forecast a steady decline in the use of coal at a rate rarely seen in the past, and in some cases unprecedented (Vinichenko et al., 2021). Doubts arise regarding the feasibility of achieving such high rates due to political and social resistance fueled by fears of significant impacts on employment (Ruppert Bulmer et al., 2021). Previous experiences in coal-mining regions have demonstrated such concerns (Isoaho and Markard, 2020; Kurz et al., 2010). This issue is therefore one of the well identified transition risks.

Some assessments of climate change mitigation scenarios by large-scale IAMs have sought to capture these impacts on employment, often highlighting the overall net benefits of a transition to a low-carbon energy system on employment at the regional or global level (Barker et al., 2016; Fragkos and Paroussos, 2018; Jacobson et al., 2019; Pai et al., 2021; Pollitt et al., 2015). However, it is not clear that the jobs created will be located in the same areas as those destroyed. In addition, the spatial resolution of the models dilutes effects that can be brutal at the scale of production basins. So when it comes to transition risk due to sectoral decline in the transition to carbon neutrality, space and location matter.

Only a small number of studies have looked at these transition risks and the vulnerability of producing regions in the context of long-term mitigation scenarios. The main exceptions are McDowall et al. (2023) who provide a mapping of regional vulnerability in Europe’s energy transition focusing on high carbon sector, and Alves Dias et al. (2018) focusing on coal in Europe.

In this study, we develop an innovative method to explore transition risks at sub-national level associated with coal decline in global decarbonisation pathways. Our study improves upon existing assessments in two ways. Firstly, we extend the geographical coverage to include major coal-producing regions, such as China and India, where coal transition challenges are especially prominent. Secondly, we develop a data-intensive approach to more accurately estimate the evolution of labour productivity in the coal sector, a crucial factor for such assessment.

## Methods

In this study, we investigate climate change mitigation scenarios using an Integrated Assessment Model (IAM) and augment the overall analysis by incorporating a data science approach.

We use the hybrid Imaclim-R model (see description in Méjean et al., 2019; Waisman et al., 2012). This model's multi-sector structure and general equilibrium framework make it possible (1) to align technological choices in coal-using sectors, particularly the electricity sector, with the choices governing the evolution of coal supply (e.g. investments); (2) to take into account of the labour productivity trajectories adjustments in the coal sector in the macroeconomic dynamics (Figure 1).

Three scenarios are investigated: a baseline and two 2°C scenarios. The two mitigation scenarios are designed to explore two contrasted coal pathways in emergent countries (contrasted highest coal output and declining pace). They aim to assess the significance of the pathway concerning employment issues, and to measure any path dependency similar to that observed for infrastructure.

The data science-based approach is being used for two enhancements to the analysis (Figure 1). The first is the development of an enhanced coal nexus within the Imaclim-R framework. This is based on the exploitation of databases at facility level (Global Energy Monitor, 2023; Jasansky et al., 2022). The second produces a description of sub-national economies dynamics as part of an ex-post module, which enables the results to be scaled down and thus provide qualitatively new information.

In order to draw lessons for decision-making from the results, we have supplemented our analysis with a review of current and past support policies for employees in the coal sector.

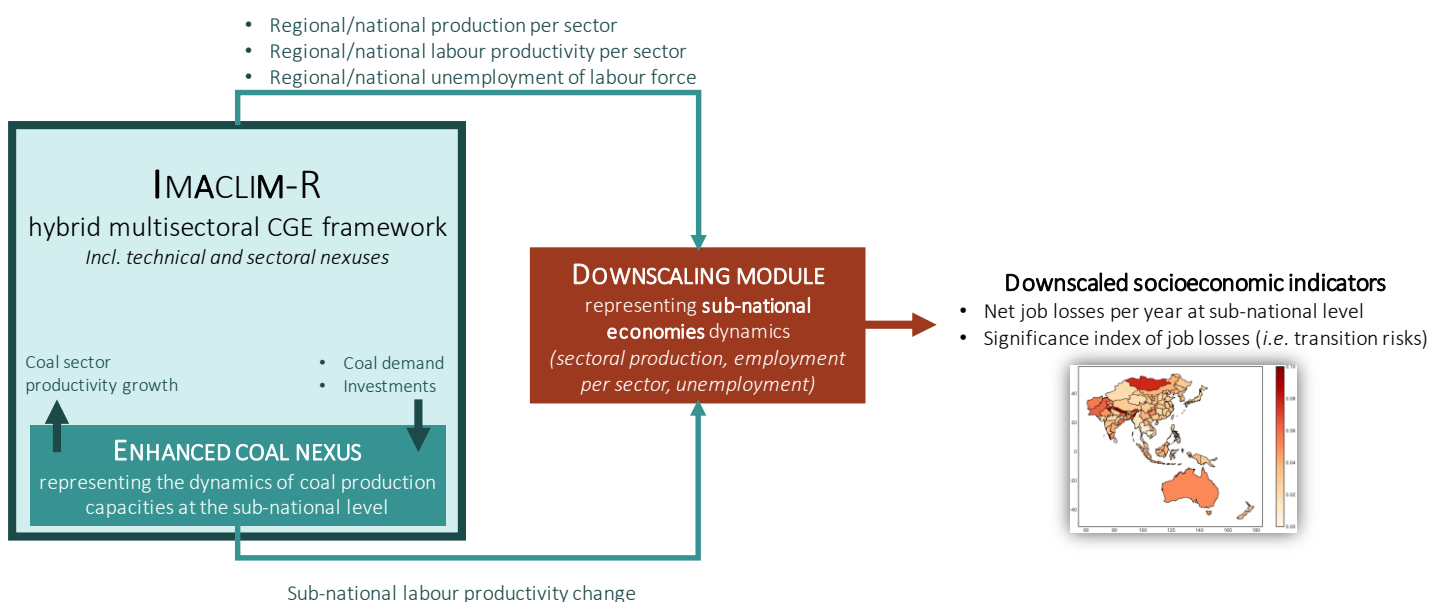


Figure 1. Overview of the innovative approach

## Results

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The analysis quantifies job losses and the timing of their occurrence in order to understand the impact on regional economies (see an extract of results in Figure 2). Unsurprisingly, there are significant disparities in the impact on job destruction between regions, reflecting regional production disparities. The Shanxi region in China is particularly vulnerable to a rapid transition, as shown in Figure 1. However, the analysis allows us to go further, by showing, for example, that production regions are unequally vulnerable to job destruction, because the characteristics of production are different. Employment intensity levels differ greatly according to the nature of the mines (majority surface or underground), as do the levels of intensity of mechanisation in the mines (differences in cumulative investment in equipment).

Interestingly, the analysis also highlights the fact that the additional job losses in the coal sector caused by the transition to carbon neutrality are not occurring at unprecedented rates, unlike the decline in physical output highlighted by (Vinichenko et al., 2021). Indeed, gains in labour productivity at certain periods in coal-producing regions have in the past led to very high rates of job destruction, for example in the United States in recent decades. A drastic reduction in the number of jobs in coal production has also been observed in China since the 2000s. A large number of smaller, less productive mines that were less safe for miners were closed in order to concentrate investment in safety and productivity in a smaller number of facilities and thus make faster progress.

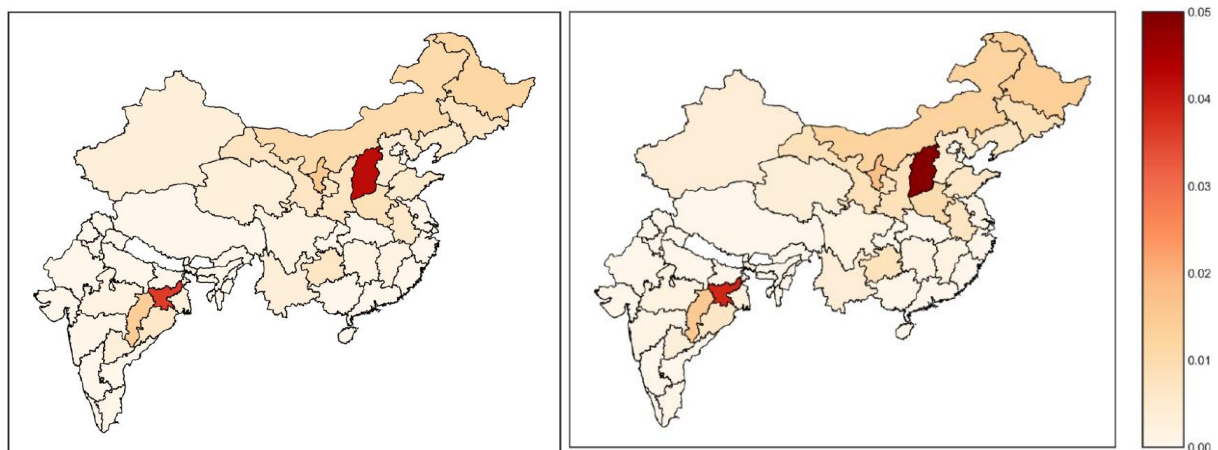


Figure 2 : Job destruction between 2020 and 2050 as a share of 2015 labor force in India and China (baseline on the left, 2°C on the right side).

## Discussion and perspectives

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The perspective of significant job destruction in several regions shows the importance of fully integrating support policies for employees leaving the coal sector into the programmes implemented to achieve carbon neutrality. Experience has shown the extent to which these policies need to be anticipated, as they can only produce effects in the medium term and must therefore be implemented rapidly. This is all the more important because if climate policies are perceived to be responsible for worsening the social environment, they will receive less support and more opposition.

These results make it possible to measure transition risks associated with different transition scenarios, and thus to better identify, plan and size up the policies needed to support people leaving the labour market, and thus to help make these pathways more socially and politically feasible.

Although a part of the modelling development are specific to the Imacim-R framework, a simplified version of the ex-post module is under development to be used with scenarios produced by the IAMs, such as the scenarios in the AR6 database. It is therefore intended to be made available to the community in open access.

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