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Modelling labour market transitions: the case of productivity shifts in Brazil

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CASE STUDY:

Modelling Labour Market Transitions: The case of productivity shifts in Brazil

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Policy question: How would occupation-level unemployment be affected by growth paths with different drivers and emissions outcomes in Brazil?

Region: Brazil

Methods: A data-driven occupational mobility network combined with an agent-based model.

Key finding(s): The number of occupations facing higher unemployment due to limited mobility is lower in a manufacturing-driven (i.e. lower emissions) growth path (21 per cent of occupations) than in an agriculture-driven (i.e. higher emissions) growth path (49 per cent). So, more effort towards increasing productivity in manufacturing is both better aligned with the country's NDC targets and results in fewer labour market frictions.

Engagement: This case study emerged from a collaboration between the authors and the Brazil office of the World Bank. The data on labour movement, scenarios of interest and the CGE model they were developed with came from the World Bank team. The findings and framing were developed by the authors with input from the World Bank. In future work, this case study will be further developed with the World Bank, both in methodological terms, but also on refining the policy implications. Input from the Brazilian government will also be sought, via the EEIST community of practice in Brazil, to explore additional scenarios that may be of interest.

Summary: The authors combine macro-economic model outputs with a dynamic labour market simulation to study how, within a context of green transitions, productivity shifts in different sectors and regions may affect occupation-level unemployment in Brazil. Specifically, the study combines a data-driven occupational mobility network with an agent-based labour market model to account for limited mobility and second order frictions in the labour market. With this approach, they discuss how changes in labour demand affect occupations depending on how much mobility may be expected to and from other occupations. They find that increased productivity in manufacturing results in fewer labour market frictions than increased productivity in agriculture.

Introduction

Brazil is one of the major greenhouse gas emitters in the world,[186] with most emissions linked to agriculture, directly and indirectly as demand for agricultural land still drives deforestation (Ferreira Filho and Hanusch, 2022).[187] In 2021, emissions from land use change and forests accounted for over 49 per cent of the total, with emissions from agriculture almost 25 per cent.[188]

In 2020, Brazil updated its Nationally Determined Contribution (NDC) with a new intermediate target[189] and, compared to 2005 levels, wants to lower its emissions by 37 per cent in 2025 and by 43 per cent in 2030, with a long-term goal of carbon neutrality by 2060. Gurgel, Paltsev and Breviglieri (2019)[190] argue that the 2030 NDC goal could be achieved mostly through reducing deforestation and changes to agricultural practices. In the long-term, Soterroni et al. (2022)[191] argue that halting deforestation and promoting restoration will be critical to achieving net zero.

While Brazil's Forest Code is a key command-and-control policy for preserving and restoring native vegetation - and, therefore, reducing emissions - its stringency and sustained enforcement are subject to economic pressures. On the one hand, Brazil's highly competitive agriculture is still land-hungry. On the other hand, the restriction of land supply may cause welfare losses from lower agricultural employment and higher food prices (Ferreira Filho and Hanusch, 2022).

Within this context, Ferreira Filho and Hanusch (2022) consider different growth paths and how they would impact deforestation and emissions in Brazil. The authors show that transitioning to a manufacturing or services productivity growth model could reduce emissions and deforestation significantly while sustaining long-term GDP growth, with manufacturing having the biggest emissions savings. Conversely, agricultural productivity growth leads to higher emissions and can lead to both an increase and a decrease in deforestation depending on whether the productivity growth happens in the Amazon or elsewhere respectively (see Ferreira Filho and Hanusch, 2022, for more details).

In both cases, as productivity grows, the relative demand for labour in different occupations would likely shift, potentially requiring workers to switch occupations. Several economic models, including IO and CGE models, estimate the changes in labour demand of different industries during a transition. However, these estimates often do not account for labour market frictions that limit workers' mobility between jobs. Recent studies argue that limited labour mobility needs to be taken into account – generally, and when modelling the post-carbon transition[192] – as in reality some workers may find it harder, or even impossible, to switch into certain occupations and may face higher unemployment rates as a result. Similarly, firms may face more skill shortages and unfilled vacancies in occupations that grow during the transition.

The labour market model

To account for the labour market structure and frictions that can limit worker mobility, in this case-study we model occupation-level labour market dynamics using the data-driven occupational mobility network model developed by Del Rio-Chanona, Mealy, Beguerisse-Díaz, Lafond and Farmer.[193]

We begin by constructing our empirical occupational mobility network[194] (Figure 64) using the RAIS dataset (Relação Anual de Informações Sociais), which contains data on all worker-job-firm combinations of contracts active in Brazil at some point during each year, from 2011 to 2019. The resulting network consists of 2,591 nodes – representing six-digit occupations[195] – and an edge between two nodes reflects the probability that a worker will transition from one occupation to another, as recorded in RAIS.

[186] UNEP, UNEP Copenhagen Climate Centre (UNEP-CCC). Emissions Gap Report 2021. https://www.unep.org/resources/emissions-gap-report-2021.

[187] Ferreira Filho, J. and Hanusch, M. (2022). A Macroeconomic Perspective of Deforestation in Brazil's Legal Amazon. Policy Research Working Papers; 10162. World Bank. https://openknowledge.worldbank.org/handle/10986/38253.

[188] SEEG (Greenhouse Gas Emission and Removal Estimating System). Based on total emissions - CO2e(t) GWP-AR5.

[189] Although with a different baseline, making the target less, rather than more, ambitious in practice (UNEP, UNEP-CCC, Emissions Gap Report 2021).

[190] Gurgel, A. et al. (2019). The Impacts of the Brazilian NDC and their Contribution to the Paris Agreement on Climate Change. Environment and Development Economics, 24(4): 395-412.

[191] Soterroni, A. et al. (2022). Nature-Based Solutions are Critical for Putting Brazil on Track Towards Net Zero. Preprints 2022, 2022110054.

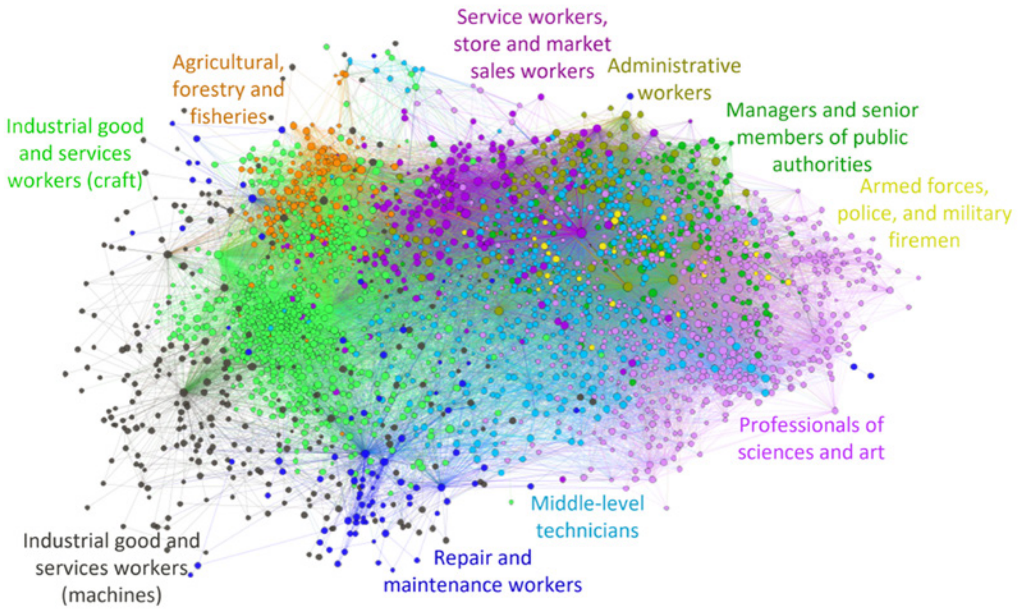
[192] Castellanos, K. and Heutel, G. (2019). Unemployment, Labour Mobility and Climate Policy. National Bureau of Economic Research. https://doi.org/10.3386/w25797

[193] del Rio-Chanona, M.R. et al. (2021). Occupational Mobility and Automation: A Data-Driven Network Model. Journal of the Royal Society Interface. https://doi.org/10.1098/rsif.2020.0898

[194] Mealy, P. et al. (2018). What You Do At Work Matters: New Lenses On Labour. SSRN Electronic Journal, Apr 2018.

[195] Every occupation is classified according to the Brazilian 2002 CBO (Classificação Brasileira de Ocupações) system. This is a nested classification, where each detailed occupation has a six-digit code. Occupations that share the same first digits can be grouped together. In this case study, we also use the three-digit and one-digit occupation codes. There are 2,591 six-digit occupations in our case study, which can be grouped into 196 three-digit occupations, or ten one-digit occupations. For example, six-digit code 913110 refers to Maintenance mechanics for mining equipment; this six-digit occupations is included in the three-digit code 913, which refers to all Maintenance mechanics for heavy machinery and agricultural equipment; the one-digit code 9 refers to all Repair and maintenance workers.

Figure 64: Occupational mobility network. Every node is a six-digit occupation, and wider edges between occupations signify more occupational mobility. Occupations are coloured by their one-digit level occupation (see labels), and sized by the log of total employment of the respective occupation.



Then we turn to an agent-based labour market model that comprises the number of workers employed, unemployed[196] and vacancies open in each occupation at each time step. Workers apply for jobs in accordance with the limitations given by the occupational mobility network; that is, they can only apply to vacancies in occupations that they are linked to in the occupational mobility network (their neighbouring occupations). Workers are fired and vacancies are opened via two processes; a random process and a state-dependent process which responds to the difference between the occupation-specific realised demand (i.e. employment plus vacancies) and the target demand of each scenario. If the realised demand is lower (or higher) than the target demand in the scenario, more vacancies are opened in that occupation and fewer workers fired (or vacancies are closed and more workers are fired).

Brazil's structural change to green growth

We use the product-level labour demand estimates from Ferreira Filho and Hanusch (2022) to simulate occupation-level labour demand and, with our labour market model, study occupation-level unemployment under the mobility frictions given by the occupational mobility network.

Policy scenarios

To investigate how structural change to growth may affect workers in different occupations, we apply two different policy scenarios from Ferreira Filho and Hanusch (2022): a boost to productivity in manufacturing and a boost to productivity in agriculture in Brazil, compared to a baseline that assumes no productivity change. Both of these lead to GDP growth, but agricultural productivity growth would lead to more greenhouse gas emissions.[197] Ferreira Filho and Hanusch (2022) find with their TERM-BR CGE model that a nationwide permanent annual increase of total factor productivity (TFP) of 0.5 per cent in manufacturing leads to a cumulative 3.9 per cent higher GDP over 12 years, 0.8 million hectares less deforestation, and over 67,833 kT less CO2 emissions in Brazil compared to the baseline scenario. Vice versa, an 0.5 per cent permanent annual increase in agricultural TFP in Brazil would lead to a cumulative 1.8 per cent higher GDP, 0.3 million hectares less deforestation, but 18,221 kT more CO2 emissions over the same period.

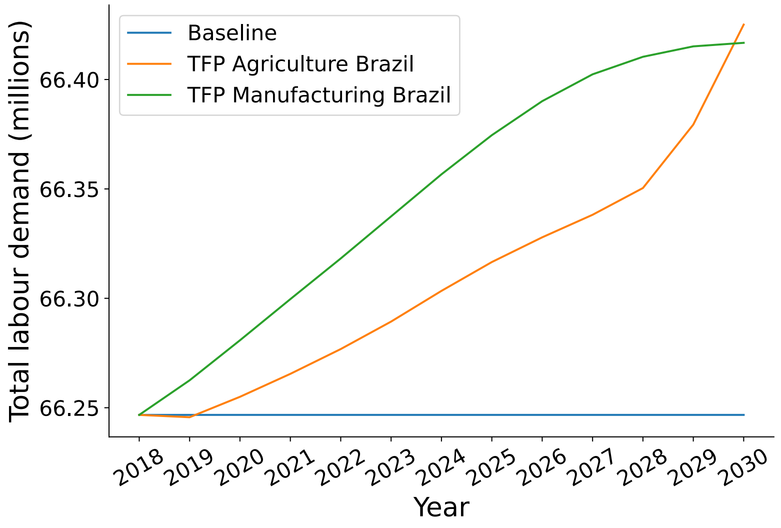
Projected labour demand by occupation

We translate the labour demand changes per commodity to labour demand change per occupation using 2018 RAIS data on industry-occupation composition. As our agent-based labour market does not model population growth, we renormalise the population growth from the labour demand projections by keeping the total labour demand constant in the baseline. We keep the variation in total labour demand for each productivity increase in relation to the baseline. In Figure 65, we show the adjusted total labour demand for the baseline and scenarios.

[196] An unemployed worker counts as unemployed in the occupation in which they were most recently employed.

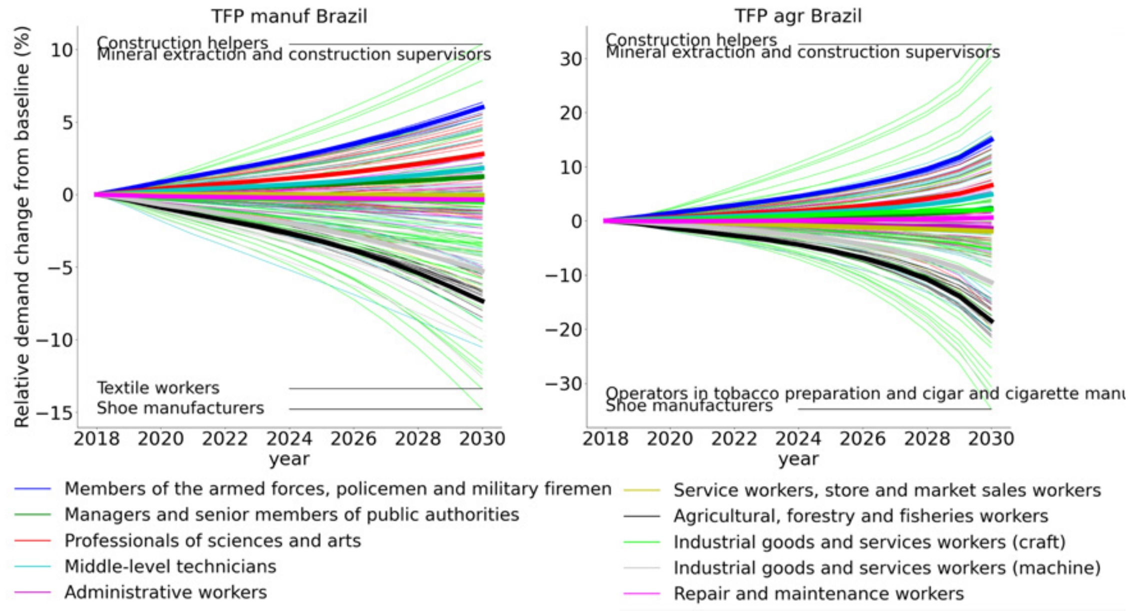
[197] Compared to agriculture, manufacturing is comparably less emissions-intensive due to Brazil's relatively clean power mix (see Ferreira-Filho and Hanusch, 2022).

Figure 65: Total labour demand for each scenario with the total labour demand for the baseline scenario kept constant from 2018 to 2030.



When we disaggregate labour demand by occupation, we find that in both scenarios demand for agricultural workers decreases, and demand for workers in public services and education increases (see Figure 66). The agriculture TFP growth scenario leads to much more occupational relative demand changes with respect to the baseline than the manufacturing TFP growth scenario: at the three-digit level, the groups of occupations with the largest growth (decline) in demand experience a +10 per cent (-15 per cent) change in the manufacturing TFP growth scenario, and +33 per cent (-35 per cent) change in the agriculture TFP growth scenario. Nonetheless, both scenarios see a decline in demand for agricultural workers and some manufacturing occupations compared to the baseline, whereas service workers and construction occupations experience a demand increase.

Figure 66: Employment demand per occupation compared to the baseline for the scenario with TFP growth in manufacturing (left), and with TFP growth in agriculture (right). The bold lines represent the average of occupations grouped by their one-digit level (see legend). The thin lines are occupations grouped at the three-digit level, coloured by their one-digit classification. The top and bottom two three-digit occupations by impact are labelled.



A boost of a sector's TFP implies less labour demand is required for the same output, but general equilibrium effects may cancel this out and increase a sector's labour demand. A productivity increase makes it cheaper to produce a certain product, which can lead to a lower equilibrium price. If demand remains relatively stable despite a lower price, employment needs to decline in order for supply to meet demand. If, however, a lower price increases demand a lot, more workers are required. This may explain part of the difference in the trajectories of demand for occupations in Figure 66.

The demand decline in both scenarios for Agricultural workers may thus be explained as follows. An agriculture productivity increase leads to more output with the same number of workers. This can result in higher wages for its workers and/or lower prices for agricultural products. In this case the demand increase due to lower prices is not enough to counterbalance productivity growth. As a result, demand for workers declines. For the other scenario, an increase in manufacturing productivity may lead to lower prices and higher wages in manufacturing. Wage increases are not restricted to manufacturing but also (partly) affect agriculture due to labour competition pressures. Higher wages in this case are not compensated by more demand as workers receive higher wages, and demand for workers in the agricultural sector declines.

Results

We ran the agent-based labour market model for the agriculture TFP scenario, for the manufacturing TFP scenario, and for the baseline, using the occupational mobility network and, as a comparison, a completely connected frictionless network, in which workers can switch between all occupations without any friction. In Figure 67, for each TFP shock we plot the (percentage) change in labour demand in 2030[198] (in relation to the baseline scenario) against the average (percentage-point) unemployment rate change from 2018 to 2030, also in relation to the baseline scenario. We do so using both the occupational mobility network and the frictionless network.

Using the frictionless network, the changes in labour demand have a similar impact on the unemployment rate for all occupations – around 0.13 percentage points lower than the baseline for the manufacturing TFP scenario and 0.08 percentage points lower for the agriculture scenario. This decrease in the unemployment rate is due to an overall increase in demand for the two TFP scenarios relative to the baseline (see Figure 65); there are more jobs available in the two scenarios and since unemployed workers are free to apply to any open vacancy in any occupation, they would do so until the vacancies opened due to the extra demand are filled. The small variations we see for occupations that have the same demand change in 2030 compared to the baseline are due to the different profiles of this demand change throughout the scenario from 2018 until 2030. This is what would happen if there were no labour market frictions.

When we consider a more realistic labour market structure by using the occupational mobility network, in both scenarios we see a negative correlation between changes in unemployment and worker demand, as we would expect; in general, an increase in labour demand relative to the baseline results in a decrease in the unemployment rate. We can also see that once we allow for mobility frictions, most of the occupations experience a smaller decrease – or even an increase – in the unemployment rate, and occupations that have a similar change in labour demand can see quite different changes to the unemployment rate. That is, the occupational mobility network shows how labour market frictions hinder some of the employment benefits workers would experience in a frictionless network.

In the top panel of Figure 67, we see the results for the TFP agriculture scenario. We can clearly see that network effects impact the unemployment rate of occupations with a similar change in labour demand quite differently. For example, agriculture managers and tree growers see a similar decrease in demand of 20 per cent and 21 per cent respectively, but agriculture managers have an increase in the unemployment rate of 0.24 percentage points, much lower than the increase of over 0.57 percentage points faced by tree growers. One cause of this difference is that the neighbours of tree growers face a greater decrease in demand than agriculture managers, so when the demand shock happens, there are fewer opportunities for tree growers to find employment in neighbouring occupations.

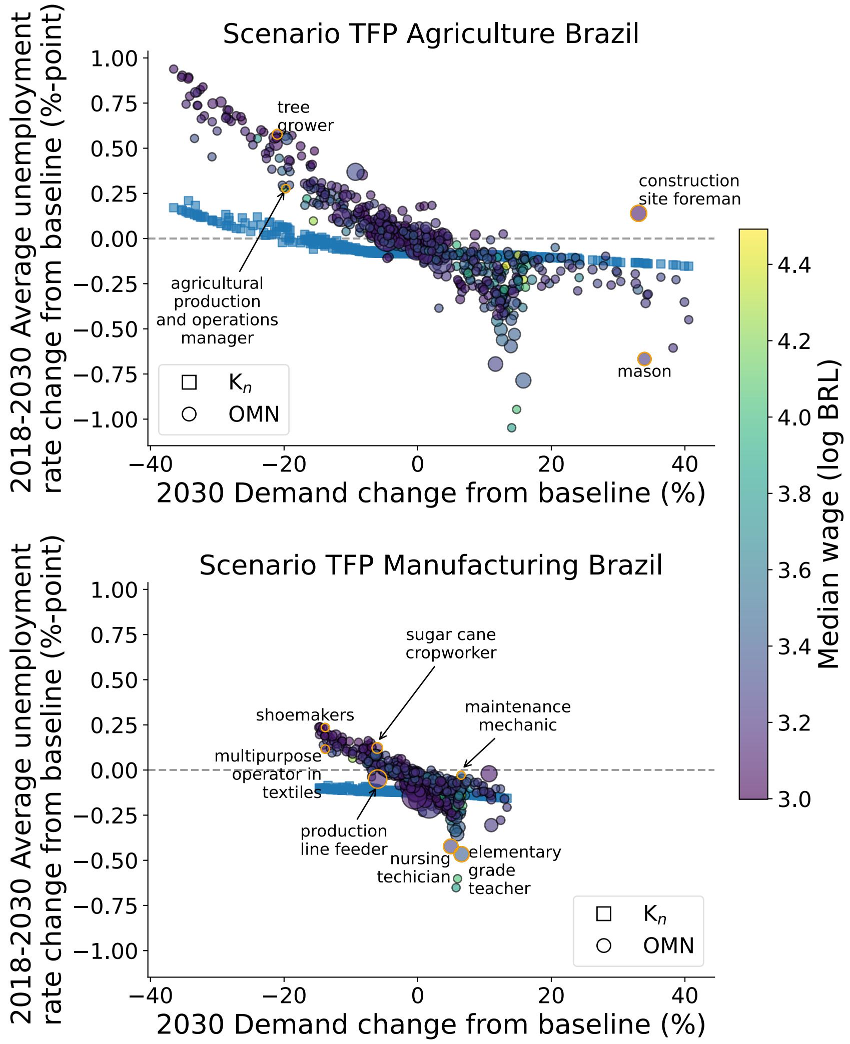
Similarly, both construction site foremen and masons experience an increase in demand relative to the baseline of around 34 per cent. Construction site foremen have more neighbours than masons, but more neighbours can mean that there is more competition for new jobs created by a demand shock, and hence the unemployment rate increases despite an increase in demand, as seen in Figure 67 for construction site foremen but not for masons. These nuanced secondary effects highlight the benefits of considering the occupational mobility network over the frictionless network.

[198] The actual demand change from 2018 to 2030 for each scenario agrees with the demand change in 2030 relative to the baseline almost entirely, with small variations.

Under the TFP manufacturing scenario, we also see the network effects. Shoemakers and multipurpose operators in the textile industry both feel about a 14 per cent decrease in labour demand, but have different unemployment outcomes. Similarly, elementary teachers and maintenance mechanics have an increase in labour demand of around 6 per cent, but elementary teachers see one of the largest declines in the unemployment rate compared to the baseline. In both of these pairs, the occupation that is better off compared to the baseline is the occupation with more neighbours.

We can also identify vulnerable occupations – i.e. those that will experience the greatest increase in the unemployment rate, compared to the baseline in 2030. At the four-digit occupation-level, which contains 621 occupations, vulnerable occupations in both scenarios include civil construction assistants, masonry structural workers, weaving machine operators and agricultural workers in oil-seed crops. Cigarette and tobacco processors are also vulnerable in the agriculture scenario while occupations in the shoe-making sector (handmade shoe and leather goods workers, and shoe-dressing preparatory workers) are at risk of increased unemployment in the manufacturing scenario. These vulnerable occupations would be good targets for re-skilling programmes to mitigate the labour market impacts of a green transition pathway.

Figure 67: Average percentage-point change in the unemployment rate from 2018-2030 for each occupation with at least 1,000 employees in 2018 for TFP Agr Brazil (top), and TFP Manuf Brazil (bottom) compared to the baseline scenario, against percentage change in demand for each scenario in 2030 compared to the baseline. The circles are the model output using the occupational mobility network (OMN) and the squares using the frictionless network (Kn). The size of each circle is proportional to employment in 2018 and the colour represents the log of the median monthly wage in BRL in 2018.



Discussion

Comparing the labour market effects in the TFP manufacturing and TFP agriculture scenarios, we see that the absolute changes in labour demand are lower in the TFP manufacturing shock. More importantly, in the TFP manufacturing scenario the number of occupations facing more unemployment (than in the baseline) due to difficulties in switching between occupations is lower (21 per cent) than in the TFP agriculture scenario (49 per cent). In other words, our results suggest that, overall, the changes in labour demand resulting from a sustained increase in manufacturing productivity allow more negatively affected workers to move from occupations with decreased demand than in the agriculture scenario. This is largely due to the difference in magnitude of the occupation-level labour market demand changes in each scenario, and also influenced by how adaptive workers are. Moreover, as mentioned above, while emissions in the TFP manufacturing scenario are lower than in the baseline, they are higher than the baseline in the TFP agriculture scenario. This indicates that increased attention to manufacturing productivity growth can help align Brazil with its NDC targets and grow the number of jobs, as well as affect fewer occupations negatively.

The network in our model is impacted by several factors such as differences in the skillsets needed or geographical constraints, but it is important to note that we do not address geography explicitly in this case-study. Instead, we assume that there is one job market for all workers to apply to jobs within, and while geographical constraints are implicit in the occupational mobility network (as occupations that are geographically concentrated will be more connected to one another), we cannot consider the role of geography separately from other effects such as skillsets, wage differences, racial and gender biases, etc. As relocation of workers is an important consideration for the CGE scenarios, adding geography into the model is an important direction for future work.

Another consideration for future research is to couple the labour market model with the model we use for demand – in this case the CGE and land-use model. At present, the CGE model is run independently of the labour market model and so the labour market frictions that slow down labour reallocation are not taken into account in subsequent time steps. A coupling of the two models will be able to show how much labour market frictions might slow down, or enable, the transition to net zero. Allowing for more realistic out-of-equilibrium behaviour in the macroeconomic model would be another route for future research.

The set of occupations we use in our analysis is constant; the model only deals with occupations that already exist, specifically within the 2002 CBO occupation classification system. The data we use also works within this classification system and so research into the creation of new jobs is another interesting future research question.

Finally, the RAIS data we use to calculate the occupational mobility network only captures the formal labour force, which in Brazil amounts to around 67 per cent of the total.[199] This should be taken into account when interpreting these results, and in future work we can reconcile the RAIS data with informal labour force data, such as using data from PNAD household survey.

In this case study, we combine scenarios proposed by Ferreira-Filho and Hanusch (2022) to investigate the impacts of total factor productivity increases on Brazil's economy with a more realistic labour market model to show the occupation-level impacts of these scenarios on unemployment. However, this modelling approach could also be used to inform many other aspects of low-carbon transition policies. For example, the occupation-specific labour market implications of increasing the speed of a net zero transition can be investigated. Similarly, our modelling approach could inform policymakers on the labour market implications of different technology choices, and the reskilling required for the different transition options.

[199] Ulyssea, G. (2018). Firms, Informality and Development. The American Economic Review 108.8 https://doi.org/10.1257/aer.20141745

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