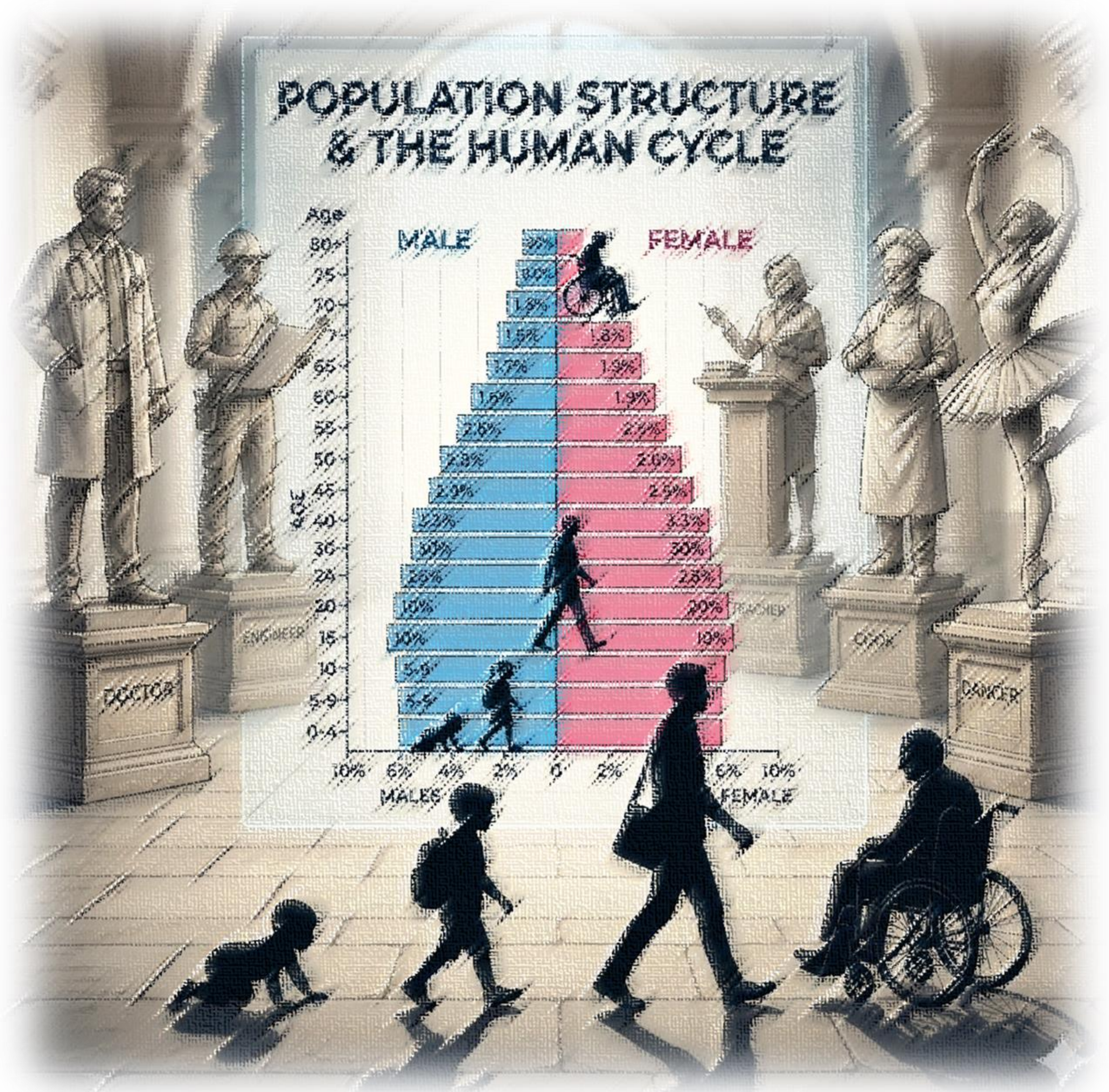

Advancing Dynamic CGE with demographically driven labour markets for short-term rigidity

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Summary & Abstract

Standard Computable General Equilibrium (CGE) models often overstate short-run factor mobility, underestimating the transitional costs of structural shocks. This paper introduces three structural extensions to the GTAP-Dynamic model to capture medium-run rigidities: (1) functional land decomposition (arable vs. pasture land); (2) an asymmetric 12-tier Muscle Labour System (MLS); and (3) a demographically driven labour mobility mechanism that links intersectoral worker reallocation to national age structures. Using Japan as an illustrative case study, we simulate targeted immigration shocks (+1,000 new workers) across distinct occupational categories. The results demonstrate that immigration targeting acute structural bottlenecks (e.g., skilled extraction and agriculture) yields significantly higher GDP and allocative efficiency gains than traditional high-income service paths. Furthermore, we outline a parsimonious methodology to translate national-level CGE factor rewards into sub-regional (prefectural) wage impacts, providing an empirically grounded alternative to explicit spatial modelling.

The model demonstrates the benefits of disaggregating the labour market to better reflect distinct skills types – allowing for the analysis of immigration policies - designed to resolve localized factor scarcities in deeply domestic supply chains. Lowered production costs in these critical nodes are passed down through domestic input-output links, enhancing national competitiveness. Furthermore, the parsimonious spatial mapping approach highlights that national immigration reforms carry highly divergent localized consequences, showing that urban-focused service visas compress metropolitan rewards while primary industry visas alter the purchasing power balance between rural producers and urban consumers.

Introduction

A central challenge in applied general equilibrium modelling is capturing the frictions and constraints that economies face when reallocating labour and land in response to structural shocks. Standard CGE models—including the Global Trade Analysis Project (GTAP) model and its dynamic extension—tend to assume relatively high short-run factor mobility, particularly for labour. Yet a growing body of empirical research shows that labour reallocation across sectors is often slow, uneven, and influenced by demographic structure, human capital specificity, and institutional settings. As a result, traditional models may understate the transitional costs of economic adjustment and may fail to reproduce persistent wage differentials or binding labour shortages observed in real economies.

Recent studies underscore the macroeconomic importance of population age structure and the demographic transition. Research on the **demographic dividend** shows that when the working-age share of the population expands, countries often experience accelerated growth due to improved labour supply, increased savings, and productivity gains (Bloom et al., 2024;

Lutz et al., 2019). Panel data evidence for India, for example, finds that favourable age-structure shifts contributed up to **1.9 percentage points of annual GDP growth** over 1981–2021, conditional on policies that support education and employment opportunities. Similarly, global quantitative modelling suggests that changing age structures explain nearly **10% of per-capita growth** during demographic transition periods across 101 countries (Zélity, Estimating the growth effect of the demographic dividend, 2025). Although the literature has historically emphasised aggregate growth effects, an emerging theme is that **youthful populations are more adaptable**: their higher educational attainment, lower switching costs, and flexibility allow labour to move more readily into emerging sectors, entrepreneurship, and innovation-driven activities (Williamson, 2013; Mehta & Awasthi, 2025). These findings point to a structural mechanism: *the younger the workforce, the greater the economy's ability to absorb shocks and reallocate resources to fast-growing sectors*.

Conversely, ageing economies—such as Japan, Germany, and Korea—face diminishing shares of young workers, rising dependency ratios, and entrenched sectoral labour attachment. The literature suggests that without targeted upskilling or migration policies, such economies may struggle to reallocate labour efficiently, resulting in slower structural transformation and persistent bottlenecks in high-skill or high-growth sectors (Porzio, Rossi, & Santangelo, 2022). This interaction between demographics and factor mobility has not yet been systematically embedded in mainstream CGE frameworks, leaving an important gap for policy analysis.

At the same time, agricultural modelling in CGE systems often represents land as a homogeneous factor, despite longstanding agronomic evidence that **arable land** and **pasture land** are not substitutable in practice (Wang, 2024). The distinction is central for analysing agricultural productivity, biofuels, climate impacts, and livestock transitions. Existing work on agricultural regions and agro-ecological zones within the GTAP ecosystem recognises environmental heterogeneity, but functional heterogeneity—specifically, the mutually exclusive uses of arable vs. pasture land—remains under-represented.

Motivated by these gaps, this paper introduces three major extensions to the GTAP-Dynamic model aimed at achieving more realistic medium-run adjustment dynamics and improving policy relevance:

1. Land Heterogeneity:
   The agricultural land endowment is decomposed into **arable land** and **pasture land**, treated as mutually exclusive and collectively exhaustive. This formulation aligns more closely with agronomic realities and allows the model to capture sector-specific constraints that shape the impacts of livestock expansion, crop intensification, biofuel mandates, and climate-related land shocks.

2. Labour Market Granularity:
   We expand the labour market from the standard skilled/unskilled dichotomy to **ten labour categories**: six skilled, three unskilled, and one fully mobile "multi-disciplinary" labour type. The skilled and unskilled categories reflect sector-specific human capital, and the multi-disciplinary category captures flexible

workers—typically young entrants—who can move across sectors with minimal frictions.

3. ### Demographically Driven Labour Mobility:
   We embed demographic dynamics directly into the model by calibrating each country's initial mobile-labour share using its population age structure. Youthful economies—where the working-age population is large and young—begin with greater labour mobility and experience more rapid convergence. Ageing economies—where sector-specific workers dominate—exhibit slower reallocation, more persistent wage differentials, and higher adjustment costs. This demographically grounded mobility mechanism aligns with economic evidence that the benefits of demographic transition depend critically on the economy's ability to convert youthful populations into productive, mobile workers (e.g., interaction effects in India's demographic dividend; Jain et al., 2025).

Together, these extensions provide a novel framework for studying medium-term labour shortages, occupational mobility constraints, and the macroeconomic effects of targeted immigration and retraining policies. They enable questions that standard GTAP versions cannot answer:

- How do ageing countries experience sector-specific bottlenecks as new sectors expand?
- How large are wage spikes in constrained labour categories?
- What are the GDP gains from targeted immigration (e.g., business-skilled visas vs. agricultural visas)?
- How does demographic transition shape structural transformation over 10–20 years?

By integrating demographic structure, labour heterogeneity, and land functional types into GTAP-Dynamic, this work aims to bridge the gap between CGE modelling and real-world adjustment challenges faced by policymakers in trade, labour markets, industrial strategy, and climate transitions.

While this paper operates within a national or multi-regional CGE framework, the proposed endowment-based extensions have direct implications for analysing sub-regional economic impacts. In practice, regional disparities in response to policy shocks are driven less by differences in long-run comparative advantage and more by localised adjustment frictions, particularly in labour markets characterised by sector-specific skills, demographic composition, and limited occupational mobility. By disaggregating labour into sector-aligned, demographically differentiated labour types, the model endogenously generates persistent wage and employment differentials that mirror the experiences of place-based labour markets within countries. These differentiated labour-market outcomes provide a reduced-form representation of sub-regional exposure to economic shocks, allowing national-level CGE results to be credibly interpreted through a spatial lens. In this sense, the methodology offers a tractable alternative to explicit spatial CGE modelling, enabling policy-relevant insights into regional adjustment dynamics while preserving the theoretical and data coherence of the GTAP Dynamic framework.

The remainder of the paper is structured as follows. Section 2 reviews the literature on demographic transitions, labour-market frictions, and land heterogeneity. Section 3 presents the conceptual framework for its modelling. Section 4 explains the model extensions. Section 5 outlines the experimental design. Section 6 presents results. Section 7 discusses policy implications, and Section 8 concludes.

Literature Review

This section synthesises the existing academic work relevant to three key dimensions of this study: (i) labour mobility and human-capital specificity in structural adjustment; (ii) demographic dynamics and the economic consequences of youthful versus ageing populations; and (iii) heterogeneity of agricultural land and its implications for CGE modelling. Taken together, the literature highlights important mechanisms that are not adequately captured in standard GTAP-Dynamic modelling frameworks, motivating the extensions developed in this paper.

Labour Mobility, Skills Specificity, and Structural Adjustment

A significant body of empirical evidence demonstrates that labour reallocation across sectors is neither instantaneous nor frictionless. With continued employment, workers accumulate sector-specific human capital, allowing them to climb hierarchies within their incumbent discipline, but also raising the opportunity cost for switching broad industry – generating ever-increasing barriers to labour mobility. Related findings on labour-market turbulence and structural change reinforce this interpretation. For example, work on Sub-Saharan Africa documents **large and persistent productivity gaps between sectors**, with labour movements often failing to shift toward the most productive industries—suggesting the importance of labour-market institutions and sectoral rigidities in shaping adjustment paths (Mensah , Owusu , McGregor, & Szirmai, 2023). These findings strengthen the argument that CGE models require a more detailed labour market structure to accurately represent labour frictions and medium-term bottlenecks.

Within this broader context, sector-specific labour classifications allow models to better reflect the real-world constraints faced by industries experiencing demand shocks, technological change, or global supply chain pressures. Expanding labour categories beyond the conventional "skilled/unskilled" divide—as done in this study—aligns with evidence that distinct occupational groups adjust differently, and that sector-specific shortages can meaningfully slow structural transformation.

Demographic Structure, Youthful Populations, and Labour Mobility

A central insight of demographic economics is that changes in population age structure have major implications for labour supply, productivity, and economic growth. The "demographic dividend"—the boost to growth arising when the working-age population share increases—is well-documented across multiple regions and methodological frameworks. Recent evidence from India, for instance, estimates that demographic transition contributed **approximately 1.9 percentage points per annum** to GDP growth over 1981–2021, conditional on supportive policies in health, employment, and gender empowerment (Jain, Goli, & Jana, 2025). Similarly, a global modelling effort covering 101 countries finds that changing age structure accounts for nearly **10% of per-capita GDP growth** during periods of demographic transition, and that more rapid or extreme shifts in age structure produce larger economic dividends (Zélity, Estimating the growth effect of the demographic dividend, 2025).

Crucially for the present work, demographic literature emphasises that the **mechanisms through which youthful populations generate economic gains depend heavily on labour mobility, adaptability, and human-capital investment**. Studies of youth and demographic dividends show that younger cohorts tend to have higher flexibility, greater potential for entrepreneurship and innovation, and lower switching costs across sectors (Ahn, et al., 2019), making them more capable of moving into emerging industries and supporting structural transformation (e.g. India's youthful workforce, where productivity and innovation are identified as key drivers of future growth). The link between working age and mobility has been empirically proven across multiple regions. In the US, established workers were estimated to be 30% as likely as new workers to change roles (Mincer & Jovanovic, 1981), driven in part by the establishment of geographic routes, working routine, and family reprioritisation. This aligns with earlier demographic-transition theory, which links rising working-age shares to increased labour-market dynamism and human-capital accumulation throughout the labour force (Mehta & Awasthi , 2025).

Conversely, ageing economies face diminishing shares of young, mobile workers and rising shares of older workers with strong sectoral attachment. Ageing populations tend to exhibit slower structural adjustment, greater vulnerability to bottlenecks in expanding sectors, and heightened risks of productivity stagnation—trends widely observed in advanced economies such as Japan and Western Europe (Favero & Galasso, 2016). The demographic literature is clear that the **benefits of demographic transition are conditional**: without a labour market capable of reallocating workers into fast-growing, high-productivity sectors, demographic advantages may not materialise, and demographic disadvantages may be exacerbated.

These findings strongly support the need for a CGE modelling framework in which labour mobility is explicitly tied to demographic structure—a core innovation of this paper.

Land Heterogeneity and Agricultural Production Constraints

The treatment of land in CGE models has long been recognised as an area where greater realism could significantly improve policy analysis, particularly in agriculture, bioenergy, and climate-related applications. While the GTAP framework incorporates Agro-Ecological Zones (AEZs), which capture climatic and environmental variation, it typically treats agricultural land as a single factor of production. However, agronomic and environmental science emphasise that **arable land** (suitable for crops) and **pasture land** (suitable for livestock) serve fundamentally different functions, respond differently to shocks, and exhibit limited substitutability.

Although none of the retrieved sources directly discuss land heterogeneity, the broader literature on structural transformation—including work on Africa's sectoral shifts—highlights the importance of sector-specific resource constraints in shaping productivity and growth outcomes. Introducing a functional land split therefore aligns with empirical realities and provides a more credible platform for analysing sector-specific shocks, especially in livestock, cereals, and biofuel production (Mensah , Owusu , McGregor, & Szirmai, 2023).

Summary and Implications for CGE Modelling

Across the three strands of literature, several themes emerge:

- **Labour mobility is limited and highly dependent on demographic trends within the labour force**
- **Youthful populations create economic benefits not only through size but through greater labour flexibility and reallocation capacity**, an essential input to structural transformation.
- **Ageing economies face greater adjustment frictions and labour shortages**, particularly in high-skill sectors.
- **Land is heterogeneous, and sector-specific land constraints affect agricultural responses to shocks.**

Despite these well-documented empirical realities, standard CGE frameworks rarely combine demographic dynamics, labour-type specificity, and land-type heterogeneity within a unified dynamic model. This gap limits the ability of existing models to analyse medium-term labour shortages, the economic consequences of ageing, sector-specific labour bottlenecks, or the effects of targeted immigration and retraining policies.

The extensions introduced in this paper directly address these gaps by integrating labour heterogeneity, demographic-driven mobility, and functional land constraints into GTAP-Dynamic. In doing so, they bring CGE modelling closer to the empirical insights of the labour, demographic, and agricultural economics literatures and enable new policy-relevant analyses that would otherwise be out of reach.

Conceptual Framework

This section outlines the conceptual foundations of the proposed extensions to the GTAP-Dynamic modelling framework. The overarching purpose of these extensions is to represent more realistically the **constraints and frictions** that shape medium-term structural adjustment in modern economies. While GTAP provides a powerful multi-region, multi-sector CGE system, its standard endowment structure—particularly for land and labour—is highly aggregated. This aggregation limits the model's ability to capture the sector-specific bottlenecks, wage pressures, and demographic constraints that policymakers routinely face.

To address these limitations, this study disaggregates the standard GTAP land and labour endowments into new, economically meaningful categories. Crucially, these refinements are achieved **without modifying the structural equations or CES nesting** of the GTAP-Dynamic model. All changes are implemented at the **data and endowment split level**, preserving the core architecture of the model while reshaping the factor allocation environment in which sectors compete. The conceptual foundations for these changes are described below.

Land Heterogeneity: Splitting Arable and Pasture Land

In the standard GTAP database, agricultural land is treated as a **single, universal endowment** that can be allocated across all agricultural activities. This assumption implies two behavioural features:

1. **All agricultural land is implicitly substitutable**, regardless of whether it is actually suitable for crops or livestock.
2. **Land rents move uniformly**, preventing the model from capturing realistic divergence between land types facing different supply or demand conditions.

However, agronomic and economic evidence consistently show that land used for agriculture is functionally separated into at least two fundamentally different categories:

- **Arable land**, suitable for crop production
- **Pasture land**, suitable for livestock and grazing activities

These land types are **mutually exclusive and collectively exhaustive** for agricultural purposes, and in most regions they cannot be converted between forms at economically meaningful rates.

Implementation Approach:
To align with the existing GTAP database, I split land endowments rents from plant-based sectors into a new “arable land” type, and rents from animal farming sectors to a new “pasture land” type. This simple splitting of land expenditure is minimally evasive within the model, but importantly prevents plant based sectors to draw from pasture land in the baseline, and from any policy shock within the dynamic model. This also effectively allows the model to show divergence in economic rents between the two land types. As the GTAPE_AEZ model already has a detailed version of this principle, I will iterate that their refined model will invariably be more accurate and detailed that my proposed approach. However, as a means to quickly impose more accurate rigidity to the newest GTAP database, my approach is convenient and practical.

Labour Heterogeneity: The “Muscle Labour System”

The standard GTAP model divides labour into only **skilled** and **unskilled** categories. In practice, these broad categories mask substantial differences in the transferability of skills, sector-specific human capital, and mobility across occupations. This aggregation has two primary consequences:

1. **Wage impacts are averaged across overly broad labour groups**, limiting distributional analysis.
2. **Structural adjustment becomes unrealistically smooth**, as labour can reallocate too easily across industries.

GTAP allows for modelers to disaggregate labour down to as much as 5 labour types by skill type. This likely remains still overly aggregated for more accurate short-run rigidity. I propose my *Muscle Labour System* (MLS) to address these weaknesses by decomposing the broad labour categories into **ten distinct labour types**, reflecting differing degrees of skill specificity, mobility, and sectoral attachment:

- **Six skilled labour types**, each aligned with major skill clusters (e.g., business & finance, skilled public sector, light manufacturing, heavy manufacturing, agricultural skilled labour, and skilled extraction workers)
- **Three unskilled labour types**, differentiated by sectoral specialisation (e.g., unskilled services, unskilled industrial, and unskilled agriculture)
- **One multi-disciplinary labour type**, representing flexible workers such as young entrants who possess no sector-specific skills as of yet and are the most mobile labour type in the economy – offering a small pool through which all sectors can compete for this labour type.

This aggregation can be created off the back of GTAP skilled and unskilled data, allowing the easy deployment of this approach to any CGE dataset, with limited assumptions around labour substitutability.

Setting up the MLS

Starting with GTAP's own basedata (with skilled and unskilled labour types), one needs only impose 2 assumptions regarding the basedata used, and 1 assumption on the demographic projection within the dynamic model

1. **What % of the labour stock in each region is "multi-disciplinary" labour**. This figures is determined largely by the share of youthful workers within a region's labour market – the larger the share, the larger the percentage of this multi-disciplinary labour type. As a rule of thumb, I have used the percentage of people between the ages of 19-25 years, versus the population stock of people between 19-65 years, to determine the share of each nation's share of labour that is "multi-disciplinary". Once a share as been determined for each region, then apply this share for all labour expenditure for all region-sectors in the database. If the figures is 23% for the UK (for instance) it is prudent to assume that 23% of labour expenditure of skilled labour in the UK's fishing sector are "multi-disciplinary" labour, as is 23% of the UK's unskilled workers in other business services.

2. **The sectoral mapping for which skilled and unskilled workers** (who are not multi-disciplinary labour) will operate within the same broad-sector labour market. As a rule of thumb, skilled labour should be more disaggregated, reflecting the more nuanced

skills-set skilled labours have within their current sector of employment. Unskilled workers in contrast are more mobile between GTAP sectors as their skills sets are more applicable cross sectors – albeit less mobile that new workers (represented by the multi-disciplinary labour type).

3. **A region-specific rate of transformation by which the incumbent worker stock reduces and is replaced with an increasingly larger stock of "multi-disciplinary" labour stock each period**. This aims to reflect that every year after a policy shock, the ability for a region's labour market to adjust its labour stock to address sectoral demands increases as newer (extremely mobile) workers enter the labour force and chase normalise wage differentials between sectors, within a region. This rate of transformation should reflect demographics again, with highly aged population having very low rates of reduction for their incumbent workers – limiting the expansion of their mobile labour force in periods after a policy shock.

This disaggregation serves four main conceptual purposes:

(a) Capturing sector-specific human capital

Incumbent workers in manufacturing, livestock handling, business services, or public administration possess skills that are not easily transferable across broad-sectors of the economy. Incumbent workers also likely have developed an income premium due to their sector-specific skills and established way of life, which make it hard / impractical for these workers to switch occupation between sectors in the case of changes to wage differentials in future. Treating these groups separately allows the model to generate **distinct wage paths** when sectors are hit by shocks.

(b) Representing limited labour mobility in the medium run

Because each sector draws from different labour pools, and because those pools are not perfect substitutes, the model naturally generates:

- wage spikes in constrained labour categories
- slower labour reallocation
- bottlenecks in expanding sectors

This better aligns with empirical evidence on labour-market frictions.

(c) Introducing a role for multi-disciplinary labour

A single, flexible labour type—especially when linked to demographic composition—provides:

- a credible pathway for long-run wage equalisation
- a mechanism linking labour mobility to population dynamics

- a more realistic representation of young entrants who have not yet become sector-specific

(d) A more complex labour market narrative offering two types of substitution

Now for a sector to expand its labour stock, it must decide on whether to out-bid for incumbent (skilled/unskilled) labour used among its peer industry, or outbid for the multi-disciplinary labour type (youth workers) at the national level.

- Complex policy shocks can see some sectors electing to expand its labour through one of the mechanisms, and not the other – determined by the relative price change between the multi-disciplinary (youth-working population). And the incumbent sector-specific labour type.

Interpreting Labour-Market Heterogeneity as Sub-Regional Adjustment Dynamics

A well-established finding in regional and labour economics is that sub-regional economic disparities arise not primarily from differences in long-run productivity, but from heterogeneous adjustment processes following economic shocks (Rice & Venables, 2021). Regions differ systematically in their industrial composition, workforce age structure, skill specificity, and capacity to absorb displaced workers into expanding activities. Empirical evidence shows that negative sectoral shocks often lead to prolonged employment and wage losses in affected regions, with limited spatial or occupational mobility preventing rapid reallocation of labour (Blanchard & Katz, 1992) (Autor, Dorn, & Hanson, 2013). These dynamics are particularly pronounced where workers possess sector-specific human capital and face high retraining or relocation costs.

In this context, sub-regions may be understood as embedded labour markets, each characterised by a dominant mix of occupations, skill sets, and demographic cohorts. Manufacturing-intensive regions, agricultural areas, public-sector hubs, and metropolitan service centres are distinguished not merely by industry shares, but by the *mobility properties of their incumbent workforces*. Studies of regional resilience emphasise that areas with younger, more adaptable labour forces tend to recover more quickly from structural shocks (Martin, Sunley, & Tyler, 2015), while regions with ageing or highly specialised workers experience more persistent adjustment costs (Faggio & Overman, 2014).

The modelling approach developed in this paper captures these mechanisms without introducing explicit spatial boundaries. By disaggregating labour into sector-specific and multidisciplinary categories, and by linking the size and growth of mobile labour pools to demographic structure, the model generates adjustment patterns that closely align with observed regional dynamics. Labour types with strong sectoral attachment behave analogously to workers in specialised local economies, exhibiting limited intersectoral mobility and more persistent wage deviations aftershocks. Conversely, multidisciplinary labour—associated with younger cohorts and new labour-market entrants—provides a channel for reallocation across activities, mirroring the role of urban centres and growth regions in absorbing displaced labour.

Importantly, regional economics has long recognised that **imperfect mobility can sustain spatial wage differentials over extended periods**, even in integrated national economies (Moretti, 2011; Glaeser, 2008). Standard CGE models, which assume rapid factor reallocation within regions, tend to abstract from these forces, thereby understating the distributional and political economy consequences of policy reforms. By endogenizing labour-market segmentation through the endowment structure rather than behavioural assumptions, the present framework allows such differentials to emerge naturally.

The proposed methodology provides a coherent bridge between economy-wide CGE analysis and place-based policy evaluation. It enables the identification of regions likely to experience prolonged adjustment stress, labour shortages, or wage pressures, even in the absence of explicit spatial disaggregation. In this sense, the framework complements rather than replaces spatial CGE models. While full regional models remain essential for infrastructure or land-use planning, the approach developed here offers a parsimonious and empirically grounded means of incorporating **regional adjustment logic** into globally consistent dynamic CGE analysis—particularly valuable for trade, immigration, industrial strategy, and demographic policy applications.

Integrating the Extended Endowment Structure Into GTAP-Dynamic

The conceptual foundation of this work is that **greater realism can be achieved by modifying the endowment space alone**, without altering the core equations of GTAP-Dynamic. The following principles guide the integration:

1. **Disaggregate endowments; leave behavioural elasticities unchanged.** This preserves the internal consistency and calibration integrity of GTAP.
2. **Map each new endowment to the sectors that economically demand it.** Land types map to crop vs. livestock sectors; labour types map to the occupations required by each industry.
3. **Let competition for the new endowments generate heterogeneous price effects.** Wage differentiation emerges naturally from differentiated labour pools.
4. **Allow demographic projections to govern long-run labour mobility.** Regions evolve toward higher labour mobility only as their demographic structure changes.

Through this approach, the model produces realistic dynamics in:

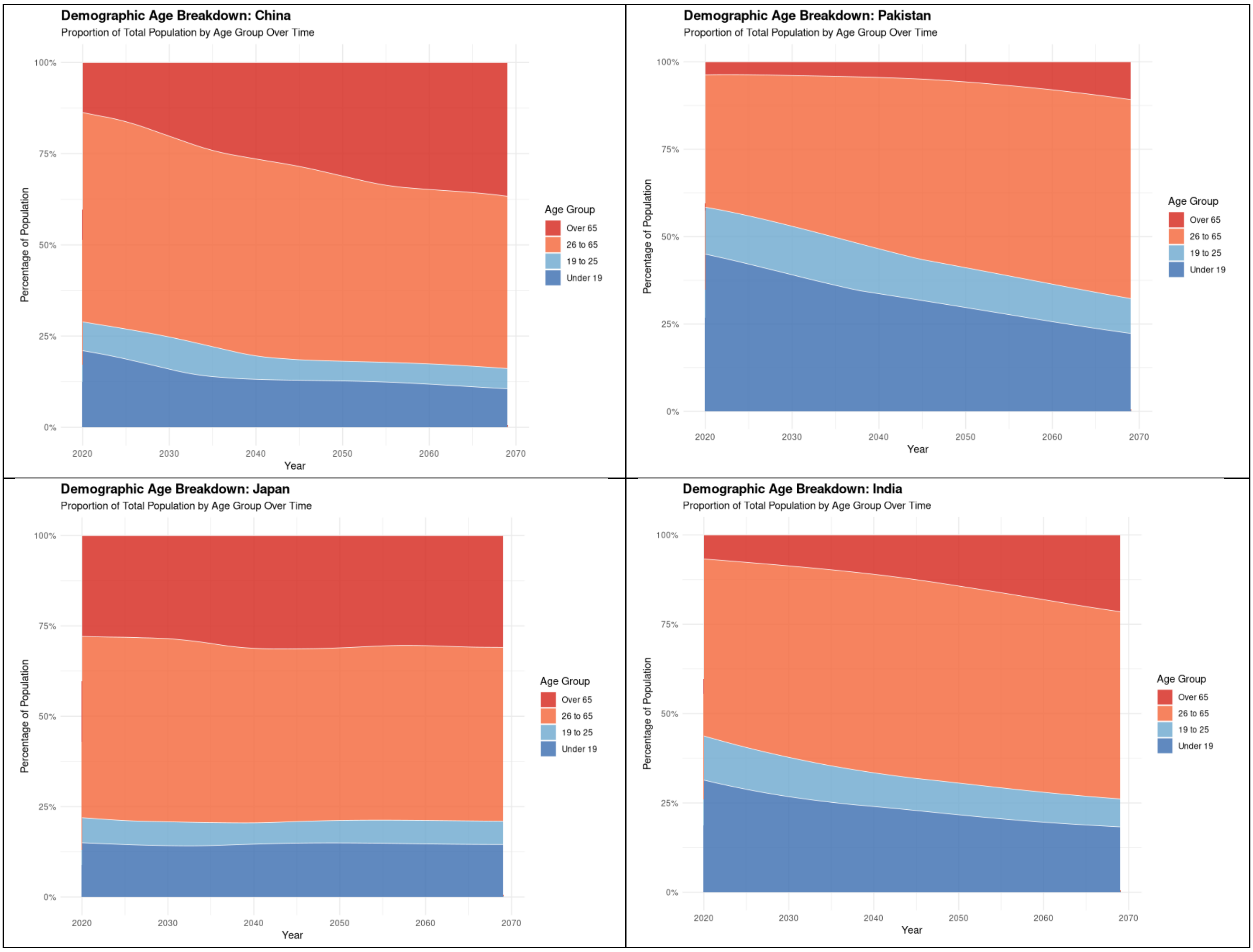
- sector-specific wages,
- labour shortages,

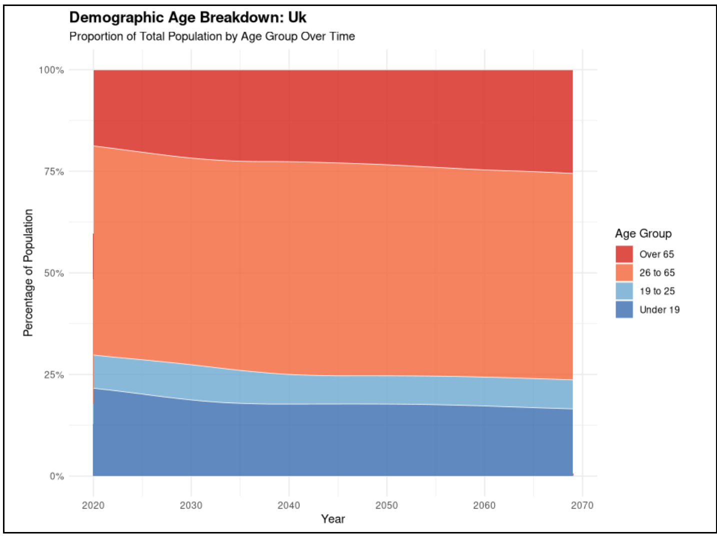
- immigration impacts,
- land rent divergence,
- sectoral growth constraints,
- distributional outcomes across workers.

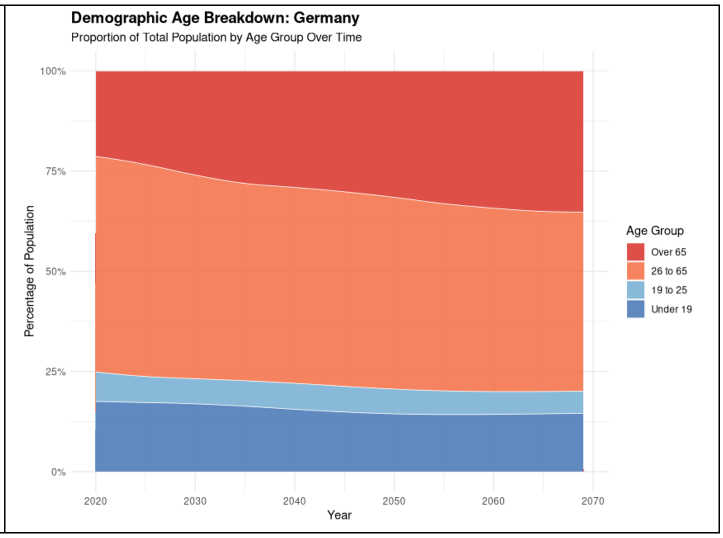
In short, the conceptual framework embeds structural economic realities into the GTAP-Dynamic environment with minimal disruption to the model's core architecture.

Results from CCM modelling and inputs into MLS for dynamic CGE modelling

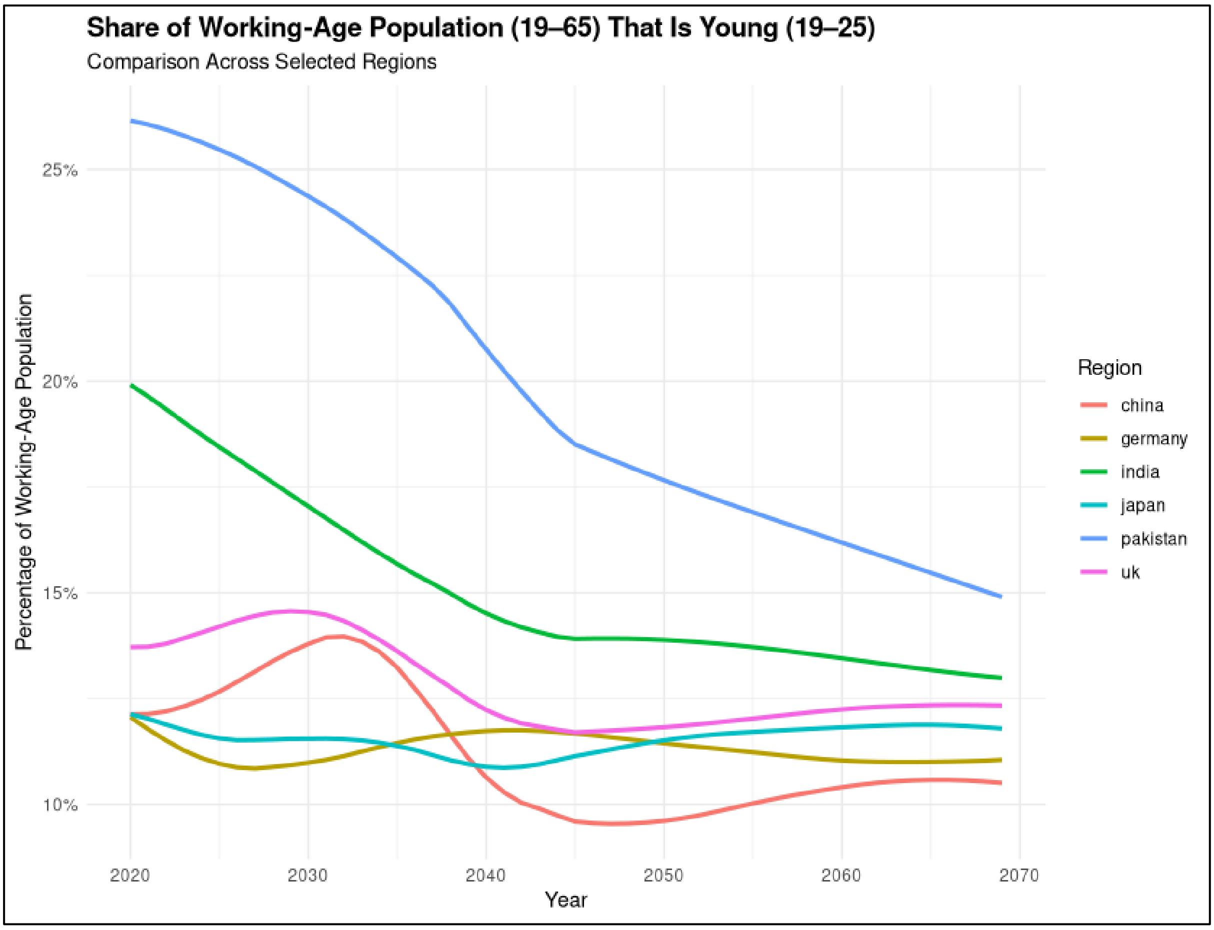
Below are projected shares of key population classes for regions from 2020 to 2070.







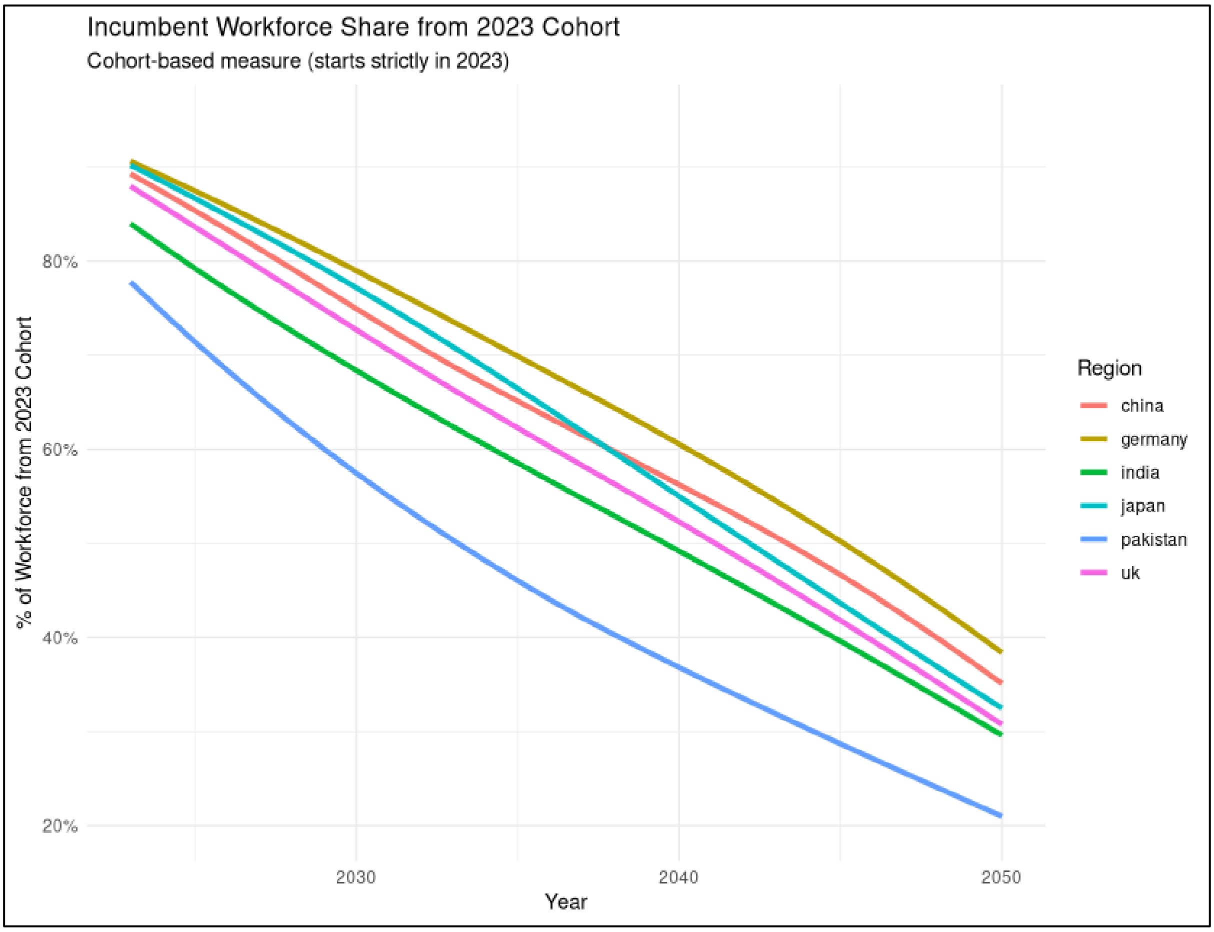
For the purposes of CGE modelling, total population change, and working population change have been the de-facto statistics used to projection demographic trends. This, however, omits the crucial impact of an aging population, or the labour market flexibility afforded to youthful working populations. As a simplifying assumption, I assume the ages between 19 and 65 years consist of the working population of a nation, and the ages between 19 and 25 years consist of the multi-disciplinary (fully mobile) stock of the working population – denoted in the above graphs in light blue. With the above assumptions it is possible to estimate how the stock of mobile works compares to the total working population over time.



Assuming younger workers are more mobile between industries than older workers, the above projections offer a new dimension for labour market modelling within a dynamic CGE framework. For example, Pakistan and India's labour market are significantly more youthful and thus mobile than region such as Japan, Germany, or China. Large shocks to the economies with rigid labour markets (older workforces) are likely to see more prolonged weakness and slower recovery than those whose labour stock can more quickly adjust to the wage impacts associated with sector-specific shocks.

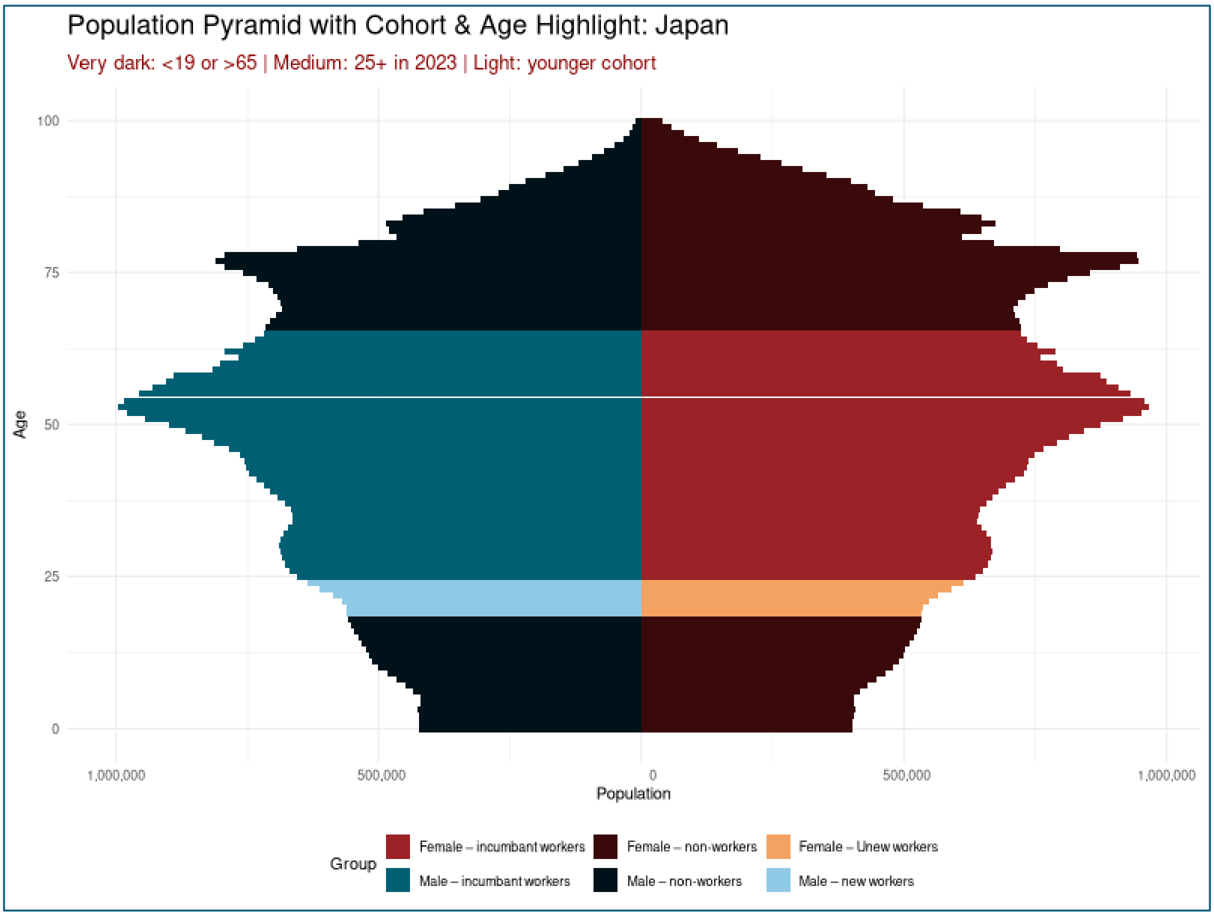
Despite both India and Pakistan likely seeing a steep fall in the share of their working population that are defined as youthful, they will likely retain their comparative edge against more developed, and aged nations in East Asia, and Western Europe. The UK represents a notable example of a regional labour force with strong annual immigration (comprising youthful workers and students) – likely offering a material benefit for the local economy by allowing a great mobility of labour stock to emerging industries – something likely more difficult for regions like China or Japan.

If you track the share of incumbent workers (workers who were over the age of 25 in 2023) as a proportion of the total working force, you see different speeds of *cohort usurpation* by younger workers. Regions like Pakistan and India see much quicker concentrations of new workers into their workforce, compared to Germany who is expected to see the slowest.



An alternative way of visualising these outcomes is shown below. The animation tracks the incumbent workers in Japan from 2023 onwards, until they exist the labour force at the age of

65. These workers are denoted in darker shades whilst the "new generation workers" are shown in light colours. Though all regions will see the complete removal of their 2023 incumbent working cohort 40 years after 2023 (or by 2063 – since it takes 40 years from a 26-year-old to age to 66), the percentage of the workforce that are incumbents can differ greatly between regions. And it is this differential that I intend to better reflect in regional labour market rigidities within the dynamic CGE model.



Modelling exercise 1 – impact of various immigration on macroeconomics

In the following section, I used a newly construction GTAP 2023 database that disaggregates labour stock more granularly between broad-sectors of the economy, and by skilled and unskilled types (see annex 1 and 2 for further details on approach and mapping). I deploy the MLS system for all regions in the model, allowing more youthful labour forces to adjust much more quickly and fluidly to shifts in labour demand, whilst leaving aging population more rigid for longer.

A first set of exercises I investigate is the impact on Japan's economy from the addition of 1000 permanent worker visa's by labour type. For completeness, and to prevent the generation of new global labour stock, I model this as a transfer of workers for India to Japan. India was chosen as its labour force size is so large that a fall of 1000 works produced the least aggregate wage price shock in the model – limiting the second and third order impacts on the global economy – allowing me to analyse the principal mechanisms affecting the Japanese economy alone. The one time increase in labour force by 1000 workers into Japan was imposed in 2027 (in the modelling exercise). Macroeconomic impacts were analysed to 10 years after that date – to analyse the short and long-run adjustments likely to take place from the policy.

Key conclusions

1. **Domestic supply chains amplify benefits:** increasing visas into sectors of the economy that principally spend on domestic endowments (mainly land and natural resources) generate the largest GDP benefits to the local economy.
2. **Scares labour types are priority areas for immigration:** Increasing visas into sectors with the smallest stock of domestic employment generates substantial reductions in wages – and can generate more GDP growth than visa to established and large employing sectors. Alternatively put, the suppression of domestic wages in sectors that produce raw materials (later used within the country for further processing) tend to generate the largest benefit to GDP.
3. **Gains to global economy:** the transfer to labour from regions with lower economic returns to labour to higher produces a net positive impact to the global economy – albeit with discrepancies between regions (especially emigration nation and third countries).

Modelling exercise and results

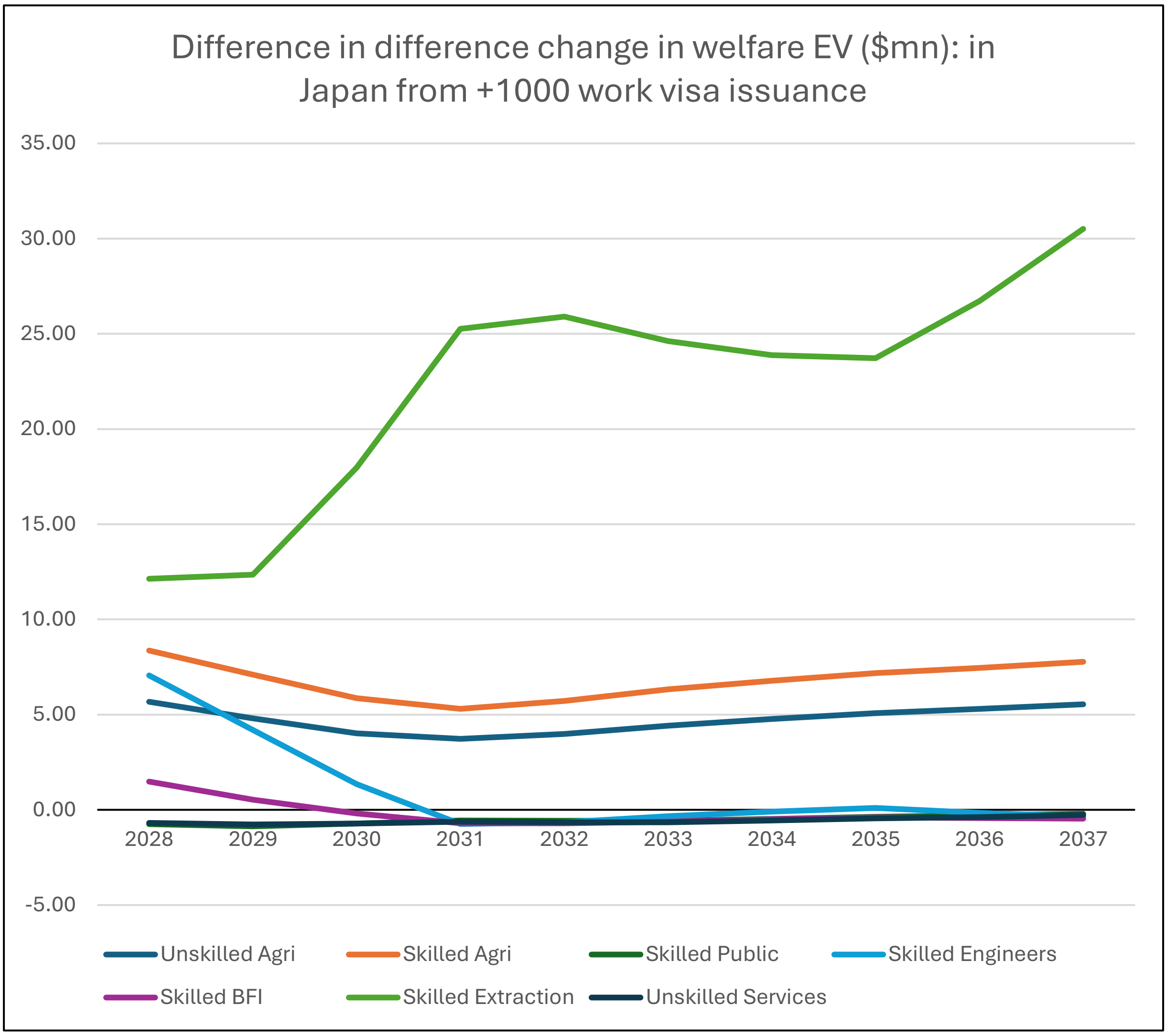
The policy shock ran for this experiment was a rise in workers by +1000, against the counterfactual in 2027[1]. The labour type was varies to see how immigration of different skills types will impact the local economy of Japan – and the mechanisms by which labour stock growth pass through to wages, and other macroeconomic impacts in the Japanese, and third country, economy.

Type of migration change	Real GDP change in Japan ($mn) by 2037	Nominal GDP change in Japan ($mn) by 2037	Change to Japanese real exports to world	Change to Japanese real imports from world	Change in Welfare in 2037 ($mn - EV)
Unskilled Agri	113.28	119.93	-70.68	-4.59	108.03
Unskilled Services	22.33	13.58	0.63	3.41	13.70
Skilled Agri	157.06	167.17	-98.28	-6.17	151.74
Skilled Public	36.63	21.87	1.63	5.59	27.16
Skilled Engineers	97.24	176.37	1.65	35.41	67.07
Skilled BFI	57.68	52.56	-2.02	9.50	39.66
Skilled Extraction	482.33	1349.24	-328.34	223.79	474.10

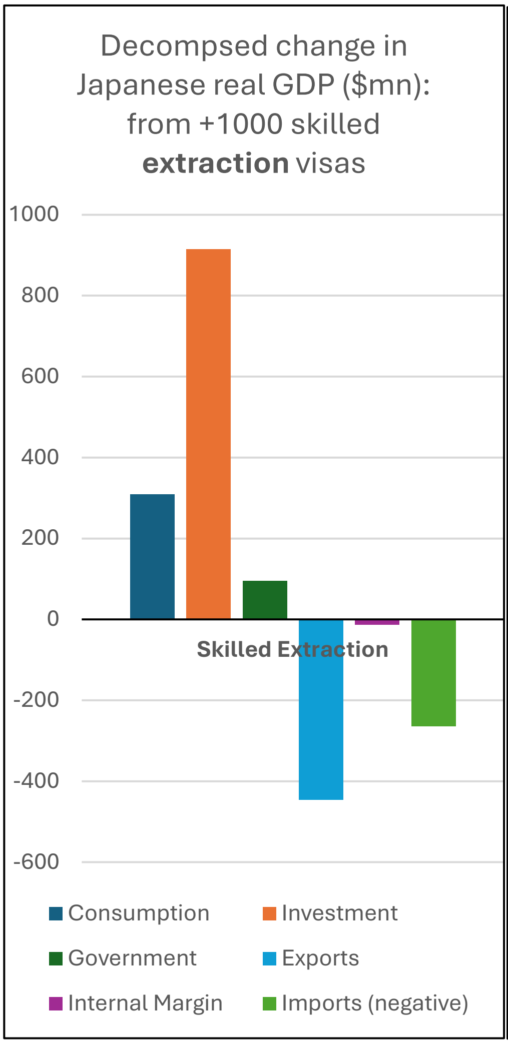
[1] Migration was assumed to be permanent – meaning Japan would have a permanent 1000 workers more in the labour type in question, whilst India would have a permanent fall of 1000 workers against the counterfactual.

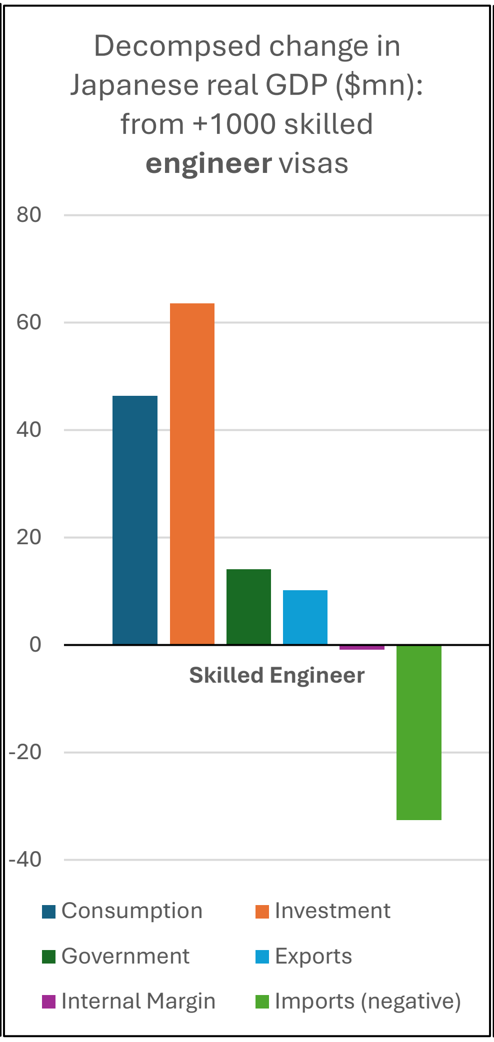
Despite modelling a common change in total work-force, the economic impacts vary significantly depending on the visa issued for the migration. Modelling shows minimal impact from Japanese immigration of skilled BFI (business, finance and insurance), skilled public sector employment, and unskilled service sector workers.

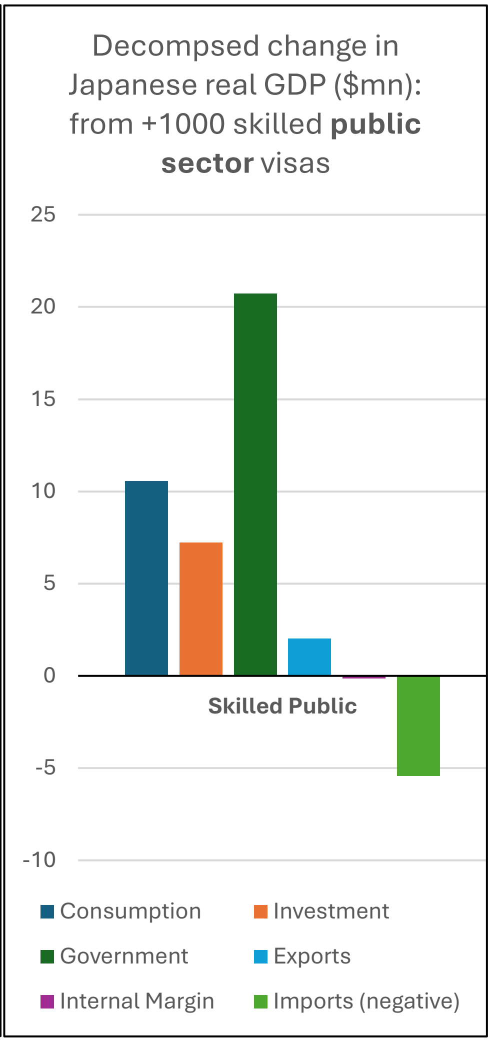
Of particular note was the notable benefits to Japan from agricultural worker visas (both skilled and unskilled) – generating permanent annual welfare enhancement to Japan of over $5mn.



Beside agricultural and extraction visas, modelling suggests the benefits from most immigration into Japan fades after 4 years – leading to a net negative impact from inward migration (including all services sector immigration, as well as engineers). Immigration of skilled extraction workers (mainly to work within the *mineral extraction* sector) is the large anomaly within the study – as welfare enhancement was particularly pronounced and ever-climbing beyond 2037. The growth in welfare for extraction, skilled agriculture, and unskilled agriculture immigration is mainly driven by allocative efficiency gains and the rise in endowment prices in Japan.







Analysis of the macroeconomic impacts of different visas show commonality among some immigration on components of GDP. Three categories stand out:

i. Immigration that **drives local investment** at the expense of Japan's trade balance
   - Includes immigration from skilled extraction, and skilled agriculture.
ii. Immigration that **drives private consumption** and investment
   - Includes immigration from skilled engineers, skilled business-finance-insurance, and unskilled agriculture.
iii. Immigration that **drives government consumption**
   - Includes immigration from skilled public sector workers, and unskilled services workers.

Wage impacts from immigration into Japan

Inward migration has the effect of lowering the economic returns to labour within that specific labour type. Over-time, this leads to general equilibrium effects which impact both the wages of other types of labour, and price levels into the economy – impacting purchasing power. In the following section, the paper explores these impacts to better assess who are the beneficiaries from immigration's economic impact at a more disaggregated lens.

The following analysis compares the marginal impact on real wages from the policy shock, defined by the difference in the change of nominal wages versus CPI, against the baseline.

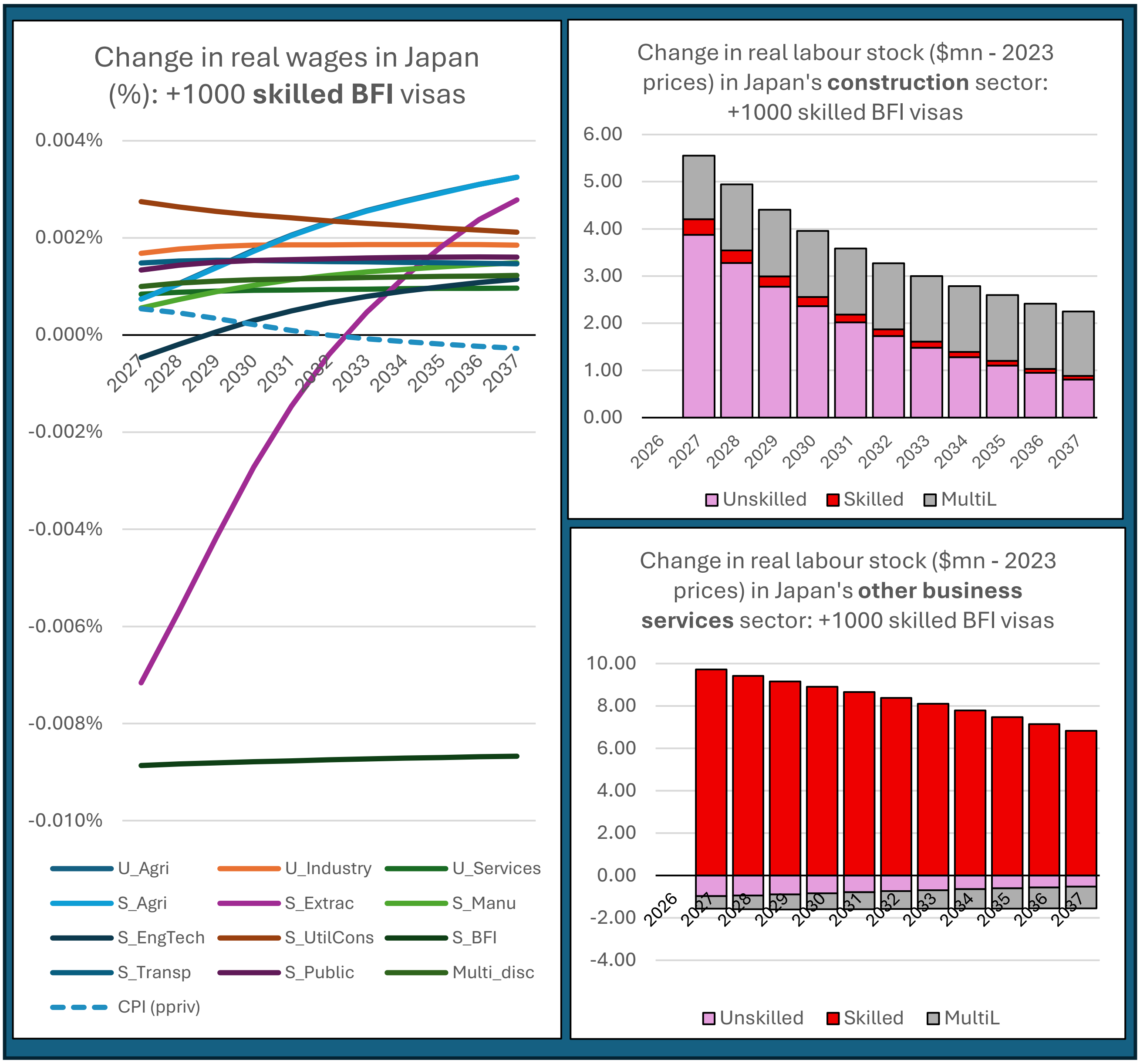
$$(Real\ Wage\ Change) = (Nominal\ Wage\ Change) - (National\ CPI\ change)$$

In the case of unskilled agricultural visa, modelling shows that the policy is likely to lower national real wages for the labour type by -0.7% in the initial moments of the plan, before gradually falling further to as low as -1.00% after 10 years from the visas being issues. This notable fall in real wages for unskilled agricultural workers reflect the fact 1000 new workers represent +0.19% in labour stock[2]. An important conclusion that the modelling has identified is that this immigration will also likely *lower real wages for skilled agricultural workers* (by ask much as -0.3% after 10 years from visa issuance). This reflects the substitution story of agricultural sectors switching towards increasingly unskilled agri workers over the fluid stock of multi-disciplinary labour alternatives due to the growing wage differential. The changes in

[2] Estimated based on 2023 labour stock values in Japan.

labour stock in the largest agricultural sectors in Japan (paddy rice, and vegetable and fruits) are shown to see notable substitution between labour types in the model. Both sectors increase their quantity of unskilled labour in 2027 – with no significant impact in their employment of skilled labour stock. However, over time, the sectors reduce their over-employment of the multi-disciplinary labour type (against the baseline). By 2037 modelling shows almost a like-for-like substitution between unskilled (incumbent) and multi-disciplinary (youthful) labour movement within these sectors. The freeing of multi-disciplinary labour from the agricultural sector contributes to the wider GVA growth seen across manufacturing and services sectors throughout Japan.

In summary, the case of unskilled agricultural immigration into Japan is likely to raise Japanese GDP and welfare, supress agricultural real wages, and reallocate Japan's youthful workers away from agriculture and towards sectors like services and manufacturing.



In the case of skilled services immigration, modelling suggests the wage impacts to Japan's labour market will be significantly less drastic – with BFI workers only seeing a fall in real purchasing power of -0.01%. The real purchasing power of almost all other sectors are positive for both the short-run and long-run. The exceptions are in skilled extraction and skilled *engineering and technician* roles who face a negative real wage impact in the first few years before recovering towards real wage growth. Given the minimal impact on CPI in Japan, model suggests real wage growth for most Japanese workers come from nominal wage growth, over fall in consumer prices – at the expense of falling purchasing power for BFI workers in the nation.

When analysing the labour movement within the economy, modelling shows that the *other business services* (OBS) sector is the principal sponge that absorbs the influx of new workers, substituting away small amounts of unskilled services workers and multi-disciplinary labour. Japan's unskilled services, and multi-disciplinary, workers are shown to see small reallocation towards the construction sector – which expands to facilitate larger capital expenditure and maintenance in Japan.

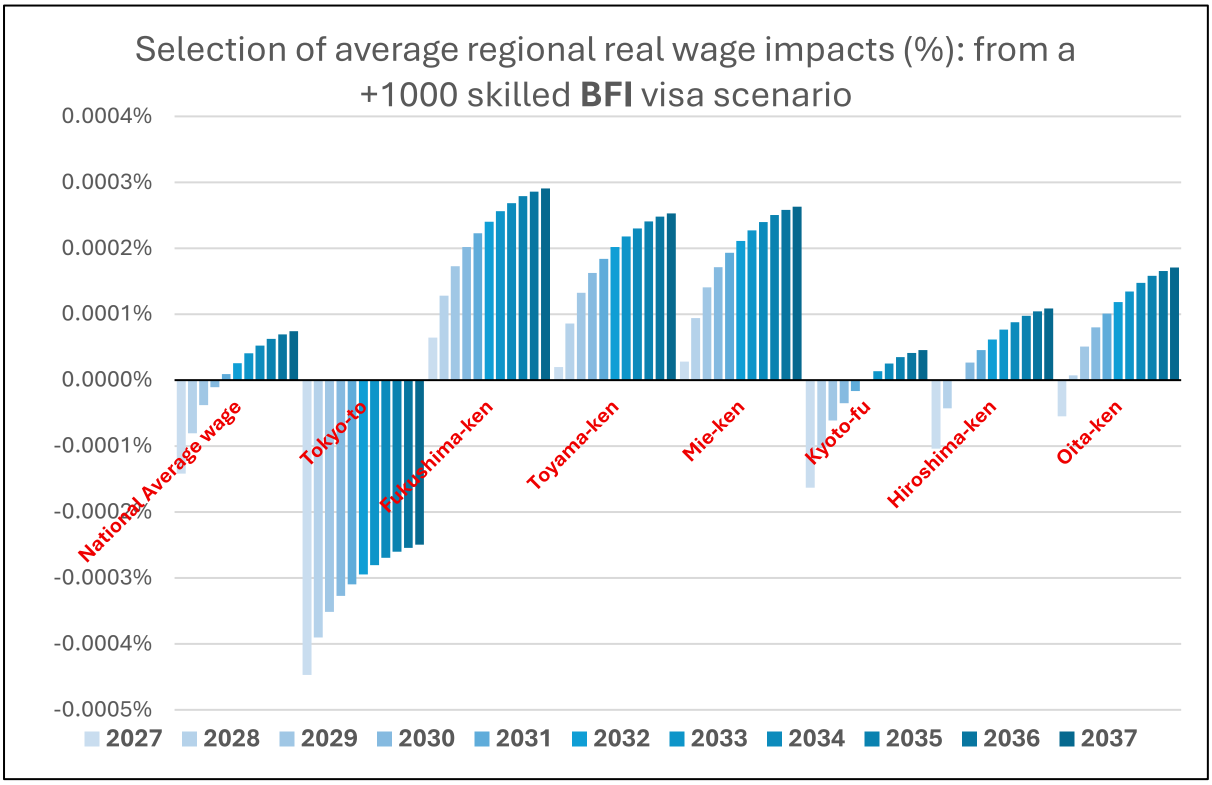
Assessing sub-regional impacts of immigration on Japanese prefecture's average wages

Assessing the heterogenous impacts of immigration, or any policy, on labour types offers an improves distributional awareness of economic impacts. To further refine this, one can explore relative concentrations of employment by regions – allowing analysts to determine geographical concentrations of impacts – which may lead to exacerbated impacts that create vicious and virtuous cycles of economic change.

Using official statistics from the Japanese Government Statistics agency, I have been able to estimate national employment shares by prefecture and by labour type developed for my CGE modelling (see annex 3).

In the following section of this paper, I take the wage impacts from the dynamic CGE modelling runs of different visa issuance, and apply it to labour stock weights for all prefectures of Japan. This new "average real wage impact" by prefecture is an effective tool to begin to assess the heterogeneous impacts immigration policy can have to different regions of Japan. Figures should not be confused by region GVA of GDP impacts.

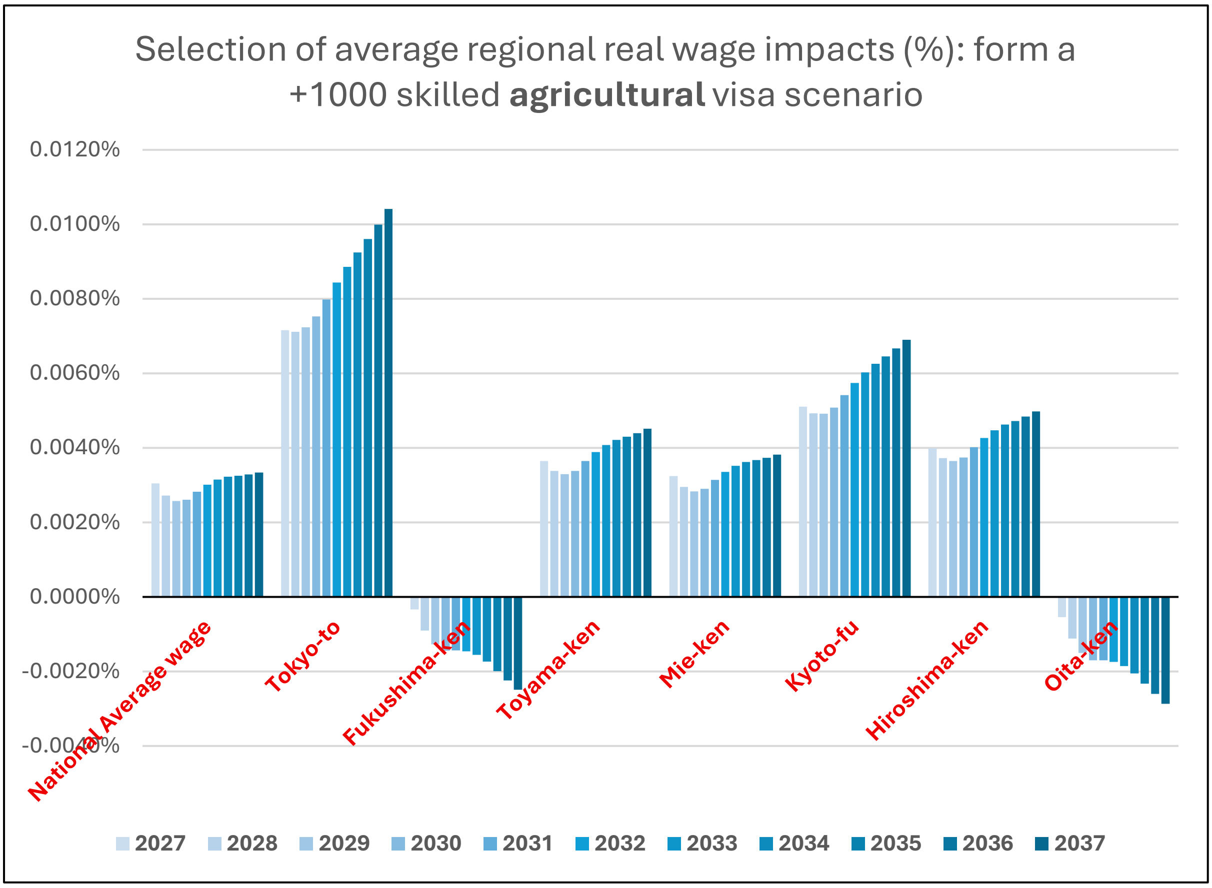
Average regional real wage impact from +1000 BFI visa to Japan



With the addition of skilled services visa, modelling expects a clear wage price fall within these roles in the short-term. Given Tokyo, and other major metropolitan areas in Japan, employ a disproportionate share of skilled services workers (versus the national average), modelling expects these regions to see the lowest real wage growth from the measure. Over time, and as the economy is allowed to adjust and reallocate economic resources, the average national fall in real wages begin to transitions to growth. This recovery in real wages is driven by wage growth for skilled engineers, and the youthful (multi-disciplinary) labour stock, in the following years after the immigration windfall.

The most rural parts of Japan are expected to be the largest beneficiaries in terms of their per capita purchasing power. Fukushima, Toyama, and Mie see the largest rise in average real wages in the country.

Average regional real wage impact from +1000 Skilled Agriculture visa to Japan



With the addition of skilled agriculture worker visa, modelling shows a large fall in agricultural wages, and growth in manufacturing and services wages. Unique to the agricultural narrative is that with time, modelling suggests the wage fall exacerbates– driven by a growing divergence in work force stock between the baseline and policy scenario. This policy results in localized real wage suppression within agricultural heartlands. This is most clearly visible when comparing localized real purchasing power losses in agricultural prefectures like Fukushima and Oita, while metropolitan consumption centres (Tokyo, Osaka) experience positive welfare pass-through via a mixture of growing services wages, and deflated food and agricultural commodity prices (lowering Japanese CPI)

Conclusion

This paper explores the question of "how best to model the short-run rigidities of labour within a dynamic CGE set-up" and in so doing applied the new model to evaluate immigration flows and distributional impacts associated with types of immigration for the case of Japan.

Japan represents an interesting test-case for this work, due to the unique aged work force, and the associated labour market rigidities associated with it. Given this limitation, the needs and demands for labour are most likely to be unmet in Japan, as the annual stock of mobile workers is limited, raising wages for this labour type, and raising wages for incumbent labour in fast growing sectors, generating sectors at risk from labour shortages (notably in agriculture).

Modelling has shown that Japan faces examples of acute labour shortages in critical sectors such as extraction (mining and minerals), as well as across agriculture – reflected by the large GDP and welfare enhancements possible from inward migration of these key labour types. However, other immigration are shown to generate the least returns for investment to the Japanese economy, and negative welfare – despite these sectors typically being seen as higher income sectors. This outcome highlights an area of further investigation and suggests that direction of immigration policymaking should aim to solve key national labour shortages, in deeply domestic supply chains (where the benefits of lower wages and competitiveness can be increasingly passed on within the economy, as opposed to internationally).

By disaggregating the labour market into more granular labour types, I have shown how to analyse the likely impacts to average purchasing power across sub-regions. Japan is generally a poor example for such distributional and sub-regional analysis – owing to its fairly homogeneous (services dominant) economy across all prefectures. However, in spite of this, modelling did produce clear evidence of regions who saw average wages diverge from each other – underscoring the heterogenous impacts of immigration to labour markets and then regional purchasing power.

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Annex 1- Disaggregation of GTAP labour types

Standard Computable General Equilibrium (CGE) models, including earlier iterations of the Global Trade Analysis Project (GTAP) database, often overstate labour mobility by assuming perfect intersectoral mobility, uniform wages, and an absence of institutional barriers. To generate realistic long-run outcomes—particularly regarding wage and employment shifts following sector-specific shocks—labour markets must be segmented to reflect real-world rigidities.

2. Empirical Evidence on Asymmetric Labor Mobility The academic literature consistently demonstrates that labour mobility is heterogeneous and fundamentally dictated by skill level and "sectoral proximity" (capability misfit).

- **Skilled Labor (Low Mobility):** The International Labour Organization (ILO) and World Bank evidence indicates that higher-skilled occupations have substantially lower cross-sector substitutability. The productivity of skilled workers is deeply tied to industry-specific human capital, making them inherently immobile and subject to high switching costs.
- **Unskilled Labor (High Mobility):** Conversely, unskilled labour relies on general competencies that are highly transferable across sectors. Because they require limited sector-specific knowledge, unskilled workers are far more mobile.

3. Balancing Realism with Model Tractability While mapping labour tightly to specific sectors increases realism, excessive disaggregation (e.g., splitting by every skill and sector combination) introduces severe modelling risks. The ILO explicitly warns that introducing too many partitioned labour nests can over-constrain the model, create artificial bottlenecks, and distort general equilibrium adjustments.

To capture critical heterogeneity without exploding the dimensionality of the nesting structure, this paper adopts an asymmetric, two-tier mapping strategy:

- **Broad pools for Unskilled Labor:** Grouped into 3 large categories to reflect high mobility.

- **Narrow pools for Skilled Labor:** Grouped into 8 specialized categories to reflect low mobility and sector-specificity.

4. Accommodating Structural Transformation: The Mobile Margin In static CGE modelling, locking workers into rigid sectoral classifications accurately reflects incumbent immobility; however, it risks artificially constraining long-run structural transformation in dynamic models. To resolve this, labour economics suggests utilizing a "mobile labour margin" representing new labour market entrants (e.g., graduates, migrants) who exhibit high horizontal mobility and respond elastically to wage differentials before accumulating sector-specific rigidity.

Consequently, we introduce a "Multi-disciplinary" (or Mobile) labour type. This general-purpose reservoir is not initially tied to historical sector affiliations, allowing booming sectors to dynamically draw on new labour supply without dismantling the realistic immobility of incumbent skilled workers.

5. **Final Labor Disaggregation Mapping** Based on the literature parameters outlined above, the standard GTAP labour stock is disaggregated into the following 11 structural categories (plus the generalized mobile pool):

Table A1: summary of new labour types for CGE modelling, and description of occupations

Aggregate Labor Type	Mobility Level	Represents / Key Occupations Covered
Unskilled Agriculture	Medium-High	Rural, low-skilled farm workers
Unskilled Industry	Medium-High	Laborers, machine operators, cleaners
Unskilled Services	Medium-High	Retail, hospitality, administrative support
Skilled Agriculture	Low	Agronomy, veterinary, forestry/fishery experts
Skilled Extraction	Low	Geology, mining/petrochemical engineers
Skilled Manufacturing	Low	Chemical, process, and mechanical engineers
Skilled Eng-Tech	Low	Electrical, mechanical, and automotive engineers

Aggregate Labor Type	Mobility Level	Represents / Key Occupations Covered
Skilled Utilities & Const.	Low	Civil engineers, infrastructure operators
Skilled Transport	Low	Logistics managers, aviation/navigation experts
Skilled Business & Finance	Low	Finance, consulting, ICT experts
Skilled Public Sector	Low	Educators, social care, public administration
Multi-Disciplinary / Mobile	High	New entrants, general-purpose labour margin

Annex 2 – approach to estimating workers by GTAP sector and labour type

To estimate the sector-specific labour force headcount across the 65 Global Trade Analysis Project (GTAP) sectors, we employ a top-down expenditure-allocation methodology, adjusted for sector-specific wage differentials, skill premiums, and cross-functional labour classifications.

1. Baseline Allocation and Wage Adjustment

We initialize the estimation by extracting total labour expenditure (combined skilled and unskilled, denoted as E_i) for each GTAP sector "i". An exogenous total regional workforce ($\overline{\mathcal{W}}$) is first naively apportioned to each sector based on its share of aggregate labor expenditure to calculate an initial, unadjusted headcount ($\widetilde{\mathcal{W}}_i$):

$$\widetilde{\mathcal{W}}_i = \overline{\mathcal{W}} \left(\frac{E_i}{\sum_{i=1}^{65} E_i} \right)$$

To account for heterogeneous compensation rates across industries, this baseline allocation is subsequently adjusted using a sector-specific relative wage ratio ω_i, representing the sector's estimated wage relative to the national average. We correct the worker count downward in high-wage sectors—reflecting that a given unit of expenditure purchases fewer workers at higher wages—to yield an intermediate, unscaled worker count ($\widehat{\mathcal{W}}_i$):

$$\widehat{\mathcal{W}}_i = \frac{\widetilde{\mathcal{W}}_i}{\omega_i}$$

To ensure internal consistency, these intermediate values are proportionately scaled so that the final wage-adjusted sector headcount ($\mathcal{W}_i$) exactly sums to the exogenous regional total ($\bar{\mathcal{W}}$) :

$$\mathcal{W}_i = \bar{\mathcal{W}} \left(\frac{\widehat{\mathcal{W}}_i}{\sum_{i=1}^{65} \widehat{\mathcal{W}}_i} \right)$$

2. Skill Disaggregation and the Skill Premium

Next, the sector-level workforce is disaggregated into absolute headcounts for unskilled ($\mathcal{U}_i$) and skilled ($\mathcal{S}_i$) cohorts. Because the initial GTAP data provides the expenditure shares for unskilled $(\mathcal{V}_{u,i})$ and skilled $(\mathcal{V}_{s,i})$ labour within a sector, we must convert these financial shares into physical worker proportions.

We introduce an exogenous skill premium, assuming that skilled labour commands a wage premium of $\rho = 1.5$ relative to unskilled labour:

$$\frac{\omega_s}{\omega_u} = \rho$$

By reweighting the expenditure shares using this wage differential, we calculate the physical share of unskilled workers ($\theta_{u,i}$) in sector i.

$$\theta_{u,i} = \frac{\mathcal{V}_{u,i}}{\mathcal{V}_{u,i} + \left(\frac{\mathcal{V}_{s,i}}{\rho} \right)}$$

This equation correctly accounts for the fact that lower-paid unskilled workers represent a proportionally larger share of the physical headcount per unit of expenditure. The absolute number of unskilled and skilled workers is then derived as:

$$\mathcal{U}_i = \mathcal{W}_i \cdot \theta_{u,i}$$

$$\mathcal{S}_i = \mathcal{W}_i \cdot (1 - \theta_{u,i})$$

3. Labor Type Mapping and Multi-Disciplinary Reallocation

Finally, the estimated skilled and unskilled workers in each GTAP sector are mapped to specific, broader labour classifications. To account for roles that span multiple traditional classifications, we introduce a "multi-disciplinary" labour type. We assume an exogenous, uniform proportion of the workforce across all sectors (α) belongs to this category[3].

The headcount for all standard assigned labour types ($\mathcal{U}_i^*$ and $\mathcal{S}_i^*$) is consequently discounted by the remaining non-multidisciplinary share:

$$\mathcal{U}_i^* = \mathcal{U}_i \cdot (1 - \alpha)$$

$$\mathcal{S}_i^* = \mathcal{S}_i \cdot (1 - \alpha)$$

[3] In the case of Japan, given its aged population, alpha is estimated at 9.82% of the entire labour force. In the case of India, given its youthful population, alpha is estimated at 16.03% of the entire labour force.

Simultaneously, the extracted proportion α from every sector is aggregated to form the total absolute stock of the regional multi-disciplinary labour pool ($\mathcal{M}$):

$$\mathcal{M} = \sum_{i=1}^{65} (\mathcal{W}_i \cdot \alpha) = \bar{\mathcal{W}} \cdot \alpha$$

This summation across all modified classifications provides the final, internally consistent distribution of the regional labour stock by specific labour type.

The below table presents my estimates for employment for Japan and India's labour market, broken down by newly created labour types – described in Annex 1.

Table A2: labour force split for Japan & India in 2023

Labour types	Japan (mn)	India (mn)		+1000 workers represents % change in Japanese workers
U_Agri	0.52	164.87		0.193%
U_Industry	9.04	76.50		0.011%
U_Services	29.54	157.01		0.003%
S_Agri	0.02	0.35		4.696%
S_Extrac	0.02	0.22		6.027%
S_Manu	1.43	5.00		0.070%
S_EngTech	1.75	2.41		0.057%
S_UtilCons	1.18	42.19		0.060%
S_BFI	6.54	38.74		0.012%
S_Transp	4.61	16.54		0.041%
S_Public	6.19	36.31		0.016%
Multi_disc	6.62	103.15		0.015%
Total	**67.47**	**643.30**		0.001%

Annex 3 – estimates of Japan's employment by prefecture and labour type

Table A3a: first half of table showing Japanese prefectures and labour type as a share of total Japanese labour force

Prefecture	U_Agri	U_Industry	U_Services	S_Agri	S_Extrac	S_Manu
Hokkaido	0.06%	0.40%	1.93%	0.00%	0.00%	0.05%
Aomori-ken	0.03%	0.12%	0.46%	0.00%	0.00%	0.01%
Iwate-ken	0.02%	0.15%	0.45%	0.00%	0.00%	0.02%
Miyagi-ken	0.02%	0.24%	0.85%	0.00%	0.00%	0.03%
Akita-ken	0.02%	0.11%	0.36%	0.00%	0.00%	0.02%
Yamagata-ken	0.02%	0.15%	0.38%	0.00%	0.00%	0.02%
Fukushima-ken	0.02%	0.26%	0.63%	0.00%	0.00%	0.04%
Ibaraki-ken	0.03%	0.38%	0.97%	0.00%	0.00%	0.06%
Tochigi-ken	0.02%	0.28%	0.66%	0.00%	0.00%	0.05%
Gumma-ken	0.02%	0.28%	0.67%	0.00%	0.00%	0.05%
Saitama-ken	0.02%	0.77%	2.58%	0.00%	0.00%	0.12%
Chiba-ken	0.03%	0.54%	2.25%	0.00%	0.00%	0.08%
Tokyo-to	0.01%	0.87%	4.38%	0.00%	0.00%	0.13%
Kanagawa-ken	0.01%	0.83%	3.15%	0.00%	0.00%	0.13%
Niigata-ken	0.02%	0.31%	0.82%	0.00%	0.00%	0.05%
Toyama-ken	0.01%	0.17%	0.37%	0.00%	0.00%	0.03%
Ishikawa-ken	0.01%	0.15%	0.42%	0.00%	0.00%	0.02%
Fukui-ken	0.01%	0.12%	0.28%	0.00%	0.00%	0.02%
Yamanashi-ken	0.01%	0.11%	0.29%	0.00%	0.00%	0.02%
Nagano-ken	0.03%	0.29%	0.72%	0.00%	0.00%	0.05%
Gifu-ken	0.01%	0.31%	0.71%	0.00%	0.00%	0.05%
Shizuoka-ken	0.02%	0.57%	1.28%	0.00%	0.00%	0.10%
Aichi-ken	0.03%	1.12%	2.51%	0.00%	0.00%	0.21%
Mie-ken	0.01%	0.26%	0.61%	0.00%	0.00%	0.05%
Shiga-ken	0.01%	0.21%	0.47%	0.00%	0.00%	0.04%
Kyoto-fu	0.01%	0.25%	0.91%	0.00%	0.00%	0.04%
Osaka-fu	0.01%	0.81%	2.87%	0.00%	0.00%	0.13%
Hyogo-ken	0.02%	0.59%	1.88%	0.00%	0.00%	0.10%
Nara-ken	0.01%	0.13%	0.47%	0.00%	0.00%	0.02%
Wakayama-ken	0.01%	0.09%	0.34%	0.00%	0.00%	0.01%
Tottori-ken	0.01%	0.06%	0.21%	0.00%	0.00%	0.01%
Shimane-ken	0.01%	0.07%	0.26%	0.00%	0.00%	0.01%
Okayama-ken	0.01%	0.23%	0.66%	0.00%	0.00%	0.04%
Hiroshima-ken	0.01%	0.34%	1.01%	0.00%	0.00%	0.05%
Yamaguchi-ken	0.01%	0.16%	0.49%	0.00%	0.00%	0.02%
Tokushima-ken	0.01%	0.08%	0.25%	0.00%	0.00%	0.01%
Kagawa-ken	0.01%	0.11%	0.34%	0.00%	0.00%	0.02%
Ehime-ken	0.02%	0.14%	0.47%	0.00%	0.00%	0.02%
Kochi-ken	0.01%	0.05%	0.25%	0.00%	0.00%	0.01%
Fukuoka-ken	0.02%	0.44%	1.81%	0.00%	0.00%	0.06%
Saga-ken	0.01%	0.09%	0.30%	0.00%	0.00%	0.01%

Nagasaki-ken	0.02%	0.12%	0.51%	0.00%	0.00%	0.02%
Kumamoto-ken	0.03%	0.16%	0.64%	0.00%	0.00%	0.02%
Oita-ken	0.01%	0.12%	0.41%	0.00%	0.00%	0.02%
Miyazaki-ken	0.02%	0.10%	0.39%	0.00%	0.00%	0.01%
Kagoshima-ken	0.02%	0.14%	0.60%	0.00%	0.00%	0.02%
Okinawa-ken	0.01%	0.08%	0.48%	0.00%	0.00%	0.01%
TOTAL (National employment)	0.77%	13.40%	43.79%	0.03%	0.03%	2.12%

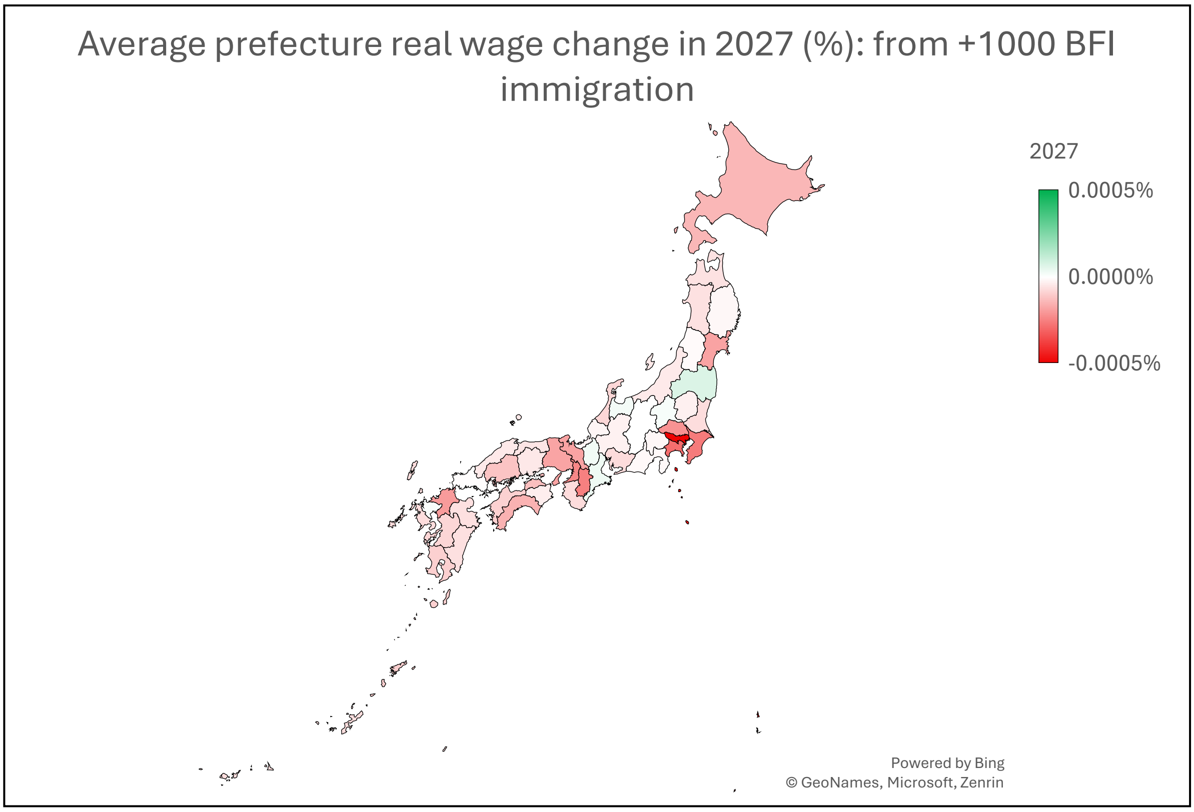
Table A3b: second half of table showing Japanese prefectures and labour type as a share of total Japanese labour force

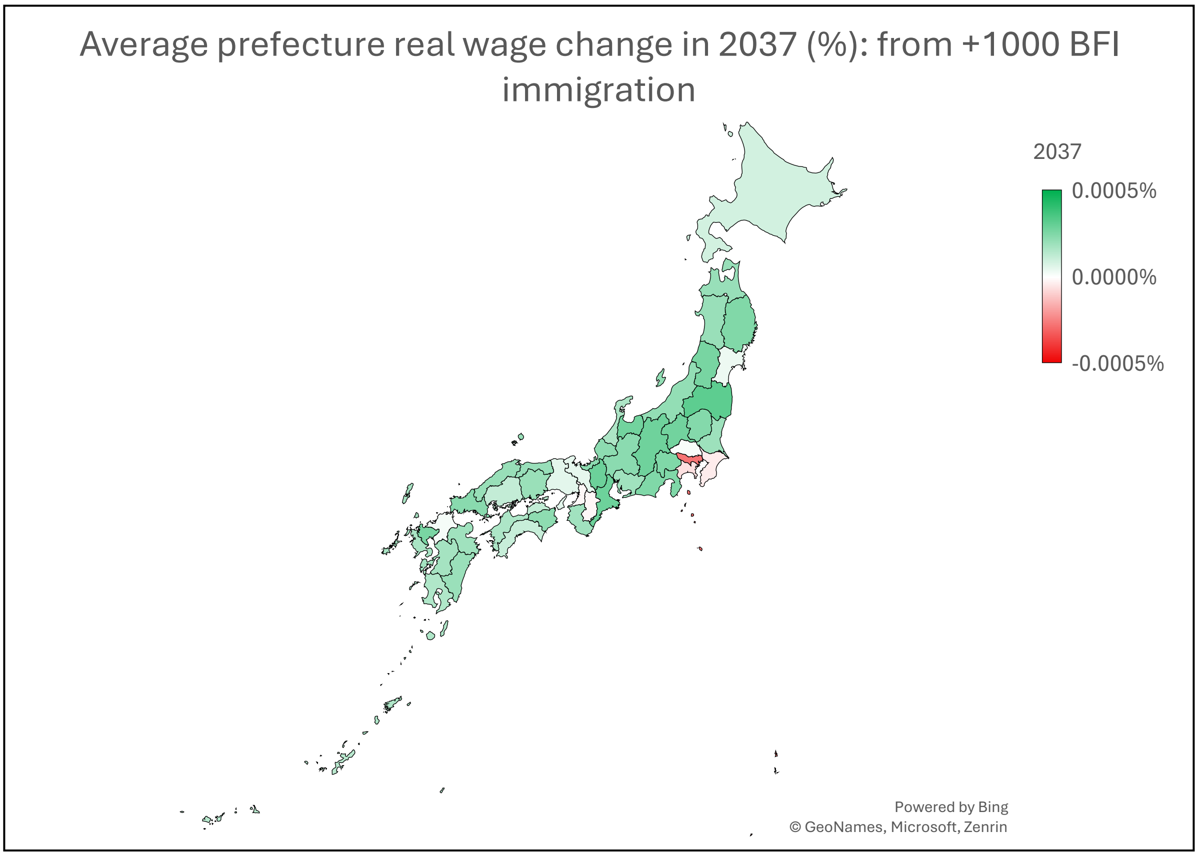
Prefecture	S_EngTech	S_UtilCons	S_BFI	S_Transp	S_Public	Multi_disc
Hokkaido	0.06%	0.12%	0.49%	0.15%	0.43%	0.41%
Aomori-ken	0.02%	0.03%	0.12%	0.03%	0.10%	0.10%
Iwate-ken	0.02%	0.04%	0.12%	0.04%	0.10%	0.11%
Miyagi-ken	0.04%	0.07%	0.24%	0.08%	0.17%	0.18%
Akita-ken	0.02%	0.03%	0.09%	0.02%	0.08%	0.08%
Yamagata-ken	0.03%	0.03%	0.10%	0.02%	0.09%	0.09%
Fukushima-ken	0.04%	0.06%	0.16%	0.05%	0.14%	0.15%
Ibaraki-ken	0.07%	0.06%	0.27%	0.09%	0.20%	0.23%
Tochigi-ken	0.05%	0.04%	0.18%	0.06%	0.14%	0.16%
Gumma-ken	0.06%	0.04%	0.18%	0.06%	0.14%	0.16%
Saitama-ken	0.16%	0.14%	0.75%	0.27%	0.50%	0.58%
Chiba-ken	0.11%	0.12%	0.65%	0.24%	0.44%	0.48%
Tokyo-to	0.24%	0.17%	1.39%	0.31%	0.85%	0.98%
Kanagawa-ken	0.19%	0.16%	0.93%	0.28%	0.63%	0.69%
Niigata-ken	0.05%	0.06%	0.22%	0.06%	0.18%	0.19%
Toyama-ken	0.03%	0.03%	0.10%	0.03%	0.08%	0.09%
Ishikawa-ken	0.03%	0.03%	0.11%	0.03%	0.09%	0.10%
Fukui-ken	0.02%	0.02%	0.08%	0.02%	0.06%	0.07%
Yamanashi-ken	0.02%	0.02%	0.08%	0.02%	0.07%	0.07%
Nagano-ken	0.06%	0.05%	0.19%	0.05%	0.16%	0.18%
Gifu-ken	0.06%	0.05%	0.20%	0.05%	0.15%	0.17%
Shizuoka-ken	0.11%	0.08%	0.35%	0.11%	0.27%	0.31%
Aichi-ken	0.23%	0.14%	0.73%	0.23%	0.50%	0.61%
Mie-ken	0.05%	0.04%	0.16%	0.06%	0.13%	0.15%
Shiga-ken	0.04%	0.02%	0.12%	0.04%	0.10%	0.11%
Kyoto-fu	0.05%	0.04%	0.25%	0.06%	0.20%	0.20%
Osaka-fu	0.16%	0.14%	0.82%	0.26%	0.58%	0.63%
Hyogo-ken	0.12%	0.09%	0.53%	0.16%	0.39%	0.41%
Nara-ken	0.03%	0.02%	0.13%	0.03%	0.10%	0.10%
Wakayama-ken	0.02%	0.02%	0.09%	0.02%	0.08%	0.07%
Tottori-ken	0.01%	0.01%	0.05%	0.01%	0.05%	0.05%
Shimane-ken	0.01%	0.02%	0.07%	0.01%	0.06%	0.06%
Okayama-ken	0.04%	0.04%	0.17%	0.06%	0.14%	0.15%
Hiroshima-ken	0.06%	0.06%	0.28%	0.08%	0.21%	0.22%
Yamaguchi-ken	0.03%	0.03%	0.12%	0.04%	0.11%	0.11%
Tokushima-ken	0.01%	0.02%	0.06%	0.02%	0.06%	0.06%

Kagawa-ken	0.02%	0.02%	0.09%	0.03%	0.07%	0.08%
Ehime-ken	0.02%	0.03%	0.13%	0.04%	0.10%	0.11%
Kochi-ken	0.01%	0.01%	0.06%	0.01%	0.06%	0.05%
Fukuoka-ken	0.08%	0.10%	0.49%	0.16%	0.38%	0.38%
Saga-ken	0.02%	0.02%	0.07%	0.02%	0.07%	0.07%
Nagasaki-ken	0.02%	0.03%	0.13%	0.03%	0.12%	0.11%
Kumamoto-ken	0.03%	0.04%	0.16%	0.04%	0.15%	0.14%
Oita-ken	0.02%	0.03%	0.10%	0.03%	0.09%	0.09%
Miyazaki-ken	0.02%	0.02%	0.10%	0.02%	0.09%	0.09%
Kagoshima-ken	0.02%	0.04%	0.15%	0.04%	0.14%	0.13%
Okinawa-ken	0.01%	0.03%	0.11%	0.03%	0.12%	0.10%
TOTAL (National Type Share)	2.59%	2.48%	12.20%	3.60%	9.18%	9.81%

Annex 4: average prefecture real wage impacts from various immigration policies

Results from BFI immigration





Results from Skilled Agricultural Immigration