Green wage premium: Worker-level evidence for Japan

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Introduction

- Japan is seeking to accelerate the greening of her economy also to address the challenges of climate change.
  - In October 2020, the former Japanese Prime Minister Suga declared that Japan will reduce greenhouse gas emissions to net zero by 2050
  - In December 2020, the government developed its 'Green Growth Strategy' which selected 14 sectors as new green industries including new energy, electricity, resource management, and transportation sector
  - The government estimates that the policy will increase GDP by 2 trillion USD and create 18 million jobs by 2050
- Reshaping the operational structure of the firms through green growth initiatives also mean profoundly transforming their workforce

Introduction

- Changing the future of work - greening the labor force
  - **New tasks**: New green job opportunities are being created
  - **New roles**: Many existing roles need to incorporate the skills required to integrate green and low-carbon technologies into existing production processes
- Little known about
  - The characteristics of the green workers,
  - How green is the labor force in an economy,
  - Whether the green jobs accrue a wage premium, and if so, how does this premium vary by the degree of greenness of a job (ILO 2022)
- This paper aims to document the recent green job landscape in Japan and to provide the first estimates of a green wage premium using worker-level data

Dynamic evolution of green jobs measurement

- From sector to tasks, broad to refinement

1. **Sector Approach**: EGSS (OECD 1999), LCREE (ONS, 2010)
2. **Product and Process Approach**: BLS (2010) (e.g., Elliott & Lindley 2017)
   - Jobs producing environmentally friendly goods/services
   - Workers' duties involve making their establishment's production processes more environmentally friendly
3. **Occupation Task-Based Approach**: US O*NET(e.g., Vona et al. 2019, Elliott et al. 2024)
4. **Keywords**: Labor demand side dynamics (e.g., Saussay et al. 2022, Curtis & Marinescu 2023, Sato et al. 2023, Curtis et al. 2024)
5. **Worker approach**: Worker-level data and measurement has been an obstacle we address in this paper (supply-side)

Defining a green job wage premium

- Workers' pay levels broadly depend on two main factors
  - One is their skills, specifically, the tasks they are able to perform;
  - The second is their scarcity; fewer the number of workers performing a particular task, the greater the wages that can be demanded from employees (Autor 2014)
- Hence, when the supply of skills does not keep up with the demand for those skills, a skill premium can emerge, i.e. wages rise
- Employers transitioning into green business and sustainability can further increase the pressure on wages

Defining a green job wage penalty

- However, it is also possible that green workers can experience a green wage penalty
  - Workers in green industries or occupations may have strong environmental values and put these values ahead of monetary gain (Krueger et al. 2022)
  - Labor market concentration can lead to wage suppression in certain industries, which phenomenon might also be reflected in green sectors, where firms are found concentrated that could exert market power over wages (Marinescu et al. 2021)

Research questions

- Nevertheless, existing studies increasingly support the existence of a green wage premium (e.g., Muro et al. 2019, Vona et al. 2019, Curtis & Marinescu 2023, Sato et al. 2023)
- Hence, we propose the following hypotheses:
  - H1(a): There is a wage premium for workers in green jobs relative to workers in non-green jobs
  - H1(b): The wage premium for green jobs increases with the green intensity of the job

Data - Survey methodology

- Sampling Strategy
  - Sample stratified into five regions across Japan
  - Six age groups for each gender (12 age groups per region)
  - Sample sizes determined by population ratios (Utilizing the Labor Force Survey as the sampling unit)
- Data Collection Process
  - The survey was conducted on a website constructed by Nikkei Research Company - the largest research company in Japan
  - The majority of respondents participated in multiple waves
  - New respondents were added for attrition keeping sample size constant
  - As of May 2024, a rotating panel of ten waves had been completed

Data - Survey methodology

Green job specific questions are asked in the fifth wave:

- To ensure that survey questions are as clear and specific as possible to minimize interpretative ambiguity, together with Okubo, NIRA, and Nikkei Research, we engaged in multiple discussions and review sessions
- We provided precise definitions and examples of 'green job activities' to help respondents understand and answer accurately
- Following the US BLS (2010) definition, individuals are identified as green workers if they respond that as part of their job they:
  1. produce green goods or provide green services or
  2. use environmentally friendly production processes and practices

Survey methodology

More specifically, the questionnaire includes the following questions:

- Q1. Does your job qualify as a green job? Please answer for each of the green job categories below either 'Applicable', 'Part of the work is applicable', or 'Not applicable'
  1. Compliance with environmental regulations, education and training, and enhancing public awareness
  2. Recycling and reuse, reduction of greenhouse gases, reduction and elimination of pollution
  3. Conservation of natural resources
  4. Improving energy efficiency
  5. Energy generation from renewable resources
- Q2. Please indicate the percentage of your total working time that is spent on green tasks in increments of 10 from 0 to 100
  - Answer: % (KEOO index)

Stylised facts

Table 1: Green job categories

Job categories	**Sub-categories**	**Number of workers**	**Percentages**
Total jobs		10,348	-
Green jobs		3,188	30.8%
Non green jobs		7,160	69.2%
Green activity 1	Compliance with environmental regulations, education and training, and enhancing public awareness	2,745	26.5%
Green activity 2	Recycling and reuse, reduction of greenhouse gases, reduction and elimination of pollution	2,179	21.1%
Green activity 3	Conservation of natural resources	1,585	15.3%
Green activity 4	Improving energy efficiency	1,761	17.0%
Green activity 5	Energy generation from renewable resources	1,478	14.3%
Very dark green jobs	$Time > 30\%$	731	7.1%
Dark green jobs	$20\% < Time \leq 30\%$	401	3.9%
Light green jobs	$10\% < Time \leq 20\%$	542	5.2%
Very light green jobs	$Time <= 10\%$	1,514	14.6%
Non green jobs	$Time = 0$	7,160	69.2%

Stylised facts

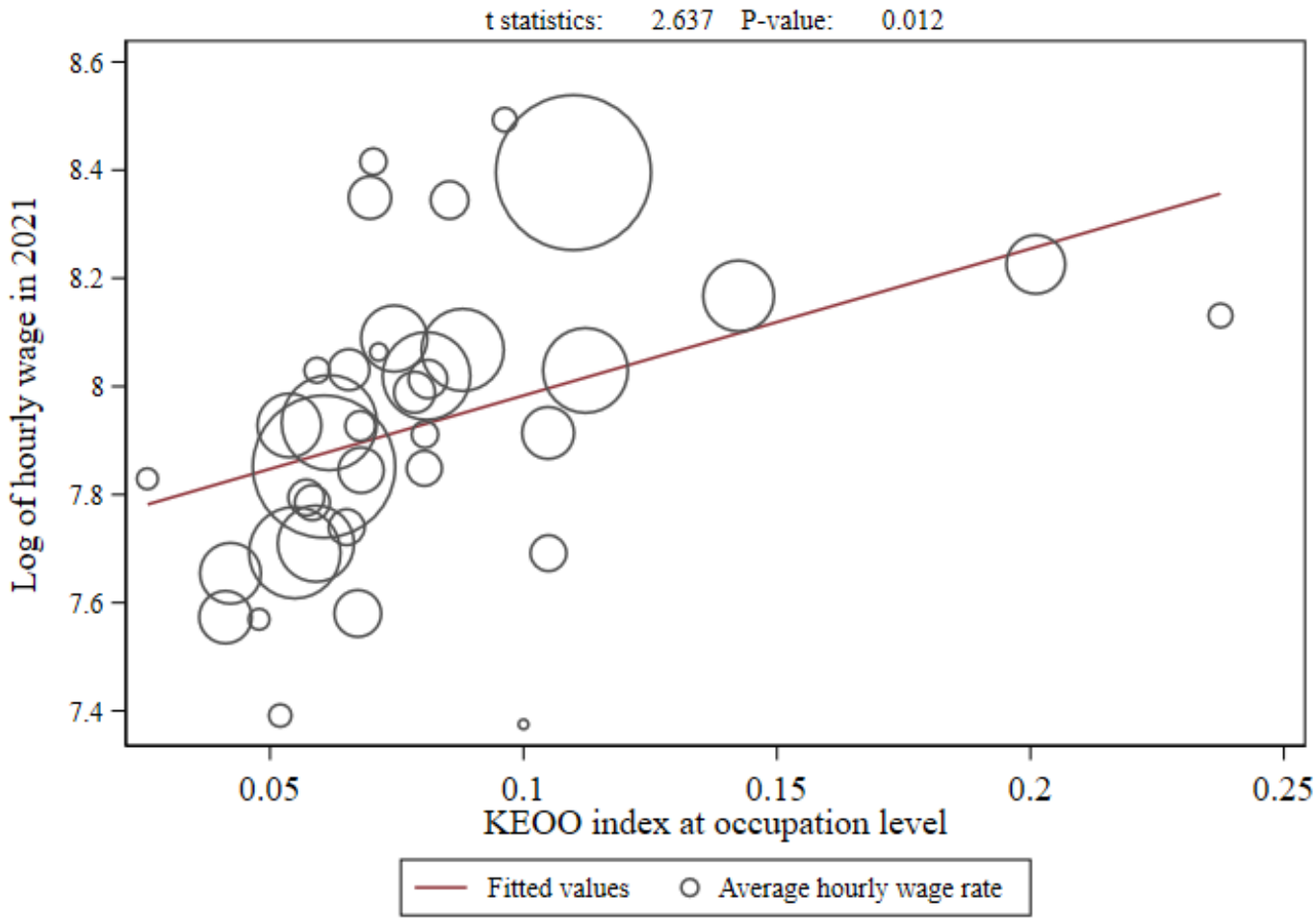

Figure 1: KEOO index and wages at occupation level

Stylised facts

Table 2: Average hourly wage for different job categories, in US Dollars (USD)

Category	All Jobs	Non-green Jobs	Green Jobs	Very Dark Green Jobs	Dark Green Jobs	Light Green Jobs	Very Light Green Jobs
High skill	29.6	27.3	33.7	43.3	34.2	33.6	29.6
Low skill	24.9	22.1	33.4	48.8	38.2	33.1	25.7
Male	30.2	27.4	34.7	44.3	37.3	34.3	30.3
Female	23.8	21.8	30.9	47.8	31.8	31.2	22.9
Young worker	27.8	23.7	37.4	48.3	39.4	36.7	27.5
Old worker	27.2	25.4	30.9	40.6	31.7	31.5	28.3

Empirical strategy

The baseline specification is given by:

$$ln\omega_i = \beta_0 + \beta_1 GreenJob_i + \beta_2 X_i + \gamma + u_i \quad (1)$$

$$ln\omega_i = \theta_0 + \theta_1 KEOO_i + \theta_2 X_i + \gamma + \epsilon_i \quad (2)$$

- $ln\omega_i$ is the log hourly wage of worker i (in JYP)
- $GreenJob_i$ is a dummy variable taking value of 1 if an individual's job involves at least one green task from Q1 described earlier
- $KEOO_i$ is our KEOO index which is a continuous variable between 0 to 1 which captures the amount of time a worker spends on green tasks
- X_i is a vector of control variables for worker i, including education, tenure, and other demographic characteristics
- γ is a vector of dummies that captures prefecture, industry, and occupation fixed effects

Baseline results: Testing H1(a)

	Dependent Variable: ln(wage)				
	(1)	(2)	(3)	(4)	(5)
Green job	0.305***	0.222***	0.164***	0.103***	0.097***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
Abstract				0.134***	0.127***
				(0.017)	(0.018)
Routine				-0.001	0.002
				(0.016)	(0.016)
Manual				-0.056***	-0.053***
				(0.012)	(0.012)
Extraversion					0.026***
					(0.010)
Agreeableness					-0.032***
					(0.010)
Conscientiousness					-0.005
					(0.011)
Neuroticism					-0.029**
					(0.011)
Openness					0.020*
					(0.011)
Standard controls	No	No	Yes	Yes	Yes
Prefecture FE	No	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes	Yes
Occupation FE	No	Yes	Yes	Yes	Yes
Observations	5,123	5,123	5,123	5,123	5,123

Table 3: Reduced form results of green wage premium: Testing H1(a)

Baseline results: Testing H1(b)

	Dependent Variable: ln(wage)				
	(1)	(2)	(3)	(4)	(5)
KEOO index	0.594***	0.612***	0.483***	0.353***	0.347***
	(0.097)	(0.100)	(0.102)	(0.102)	(0.102)
Abstract				0.152***	0.148***
				(0.025)	(0.025)
Routine				0.009	0.015
				(0.024)	(0.024)
Manual				-0.050**	-0.048**
				(0.020)	(0.020)
Extraversion					0.030*
					(0.016)
Agreeableness					-0.029*
					(0.016)
Conscientiousness					-0.013
					(0.018)
Neuroticism					-0.028
					(0.018)
Openness					0.020
					(0.018)
Standard controls	No	No	Yes	Yes	Yes
Prefecture FE	No	Yes	Yes	Yes	Yes
Industry FE	No	Yes	Yes	Yes	Yes
Occupation FE	No	Yes	Yes	Yes	Yes
Observations	2,058	2,058	2,058	2,058	2,058

Table 4: Reduced form results of green wage premium: Testing H1(b)

Endogeneity concerns

A concern is that estimates of equation (1) may not be unbiased estimates of the impact of job type on hourly wages

- Policies designed to promote green transitions, such as tax incentives or subsidies for firms that adopt environmental practices, is that they may create a more attractive job market for workers which in turn may encourage sorting of the most able workers to the more productive firms that are likely to pay higher wages that also invest more in the green transition
- As a results, workers could self-select into green jobs because of higher wages

Structural model setting

Endogenous Treatment Effect model (ETM) :

- Treatment assignment model:

$$\text{GreenJob}_i = E(\text{GreenJob}_i|Z_i) + \nu_i \tag{3}$$

- The second stage continuous equation:

$$\text{Regime 1:} \qquad \ln(\omega_{1i}) = E(\ln(\omega_{1i})|X_i) + \epsilon_{1i} \tag{4}$$

$$\text{Regime 2:} \qquad \ln(\omega_{0i}) = E(\ln(\omega_{0i})|X_i) + \epsilon_{0i} \tag{5}$$

- ϵ_{0i} are error terms in regime 1 and 0, respectively, which are subject to:

$$E(\epsilon_{ji}|X_i, Z_i) = E(\epsilon_{ji}|X_i) = 0 \text{ for } j \in \{0, 1\} \tag{6}$$

$$E(\epsilon_{ji}|\text{GreenJob}_i) \neq 0 \text{ for } j \in \{0, 1\} \tag{7}$$

- Equation (7)$= 0$ indicates that there is no correlation between the treatment and outcome unobservable and that Rubin causal model estimators are obtained instead

Endogeneity test and Exclusion restrictions

- We first estimate the ETM using control function approach, which estimates the correlation between the unobservables of the treatment assignment and potential outcome models - if there is no correlation between the unobservables, then endogeneity is less of a concern
- We have considered two sets of exclusion restrictions in our regression analysis:
  - Fathers' moral non-cognitive test score from the 1941 Educational Survey on soldiers, that is aggregated at fathers' birthplace at prefecture level (pre-war period)
  - KEOO index of parental occupations
- Rubin Causal Model, also known as the potential outcomes model, is estimated

Structural model results: Including excluded variables

Table 5: Structure model results of green job wage premium: Testing H1(a)

	Dependent Variable: ln(wage)			
	(1)	(2)	(3)	(4)
Green vs Non-green				
Average Treatment Effect	0.078***	0.072***	0.071**	0.073***
	(0.028)	(0.028)	(0.028)	(0.028)
Treatment assignment equation				
Father's Moral Score	0.468*			0.477*
	(0.248)			(0.247)
Parent's KEOO index		0.911**		
		(0.362)		
Father's KEOO index			0.609	0.612
			(0.620)	(0.620)
Mother's KEOO index			1.124**	1.137**
			(0.508)	(0.508)
Personal controls	Yes	Yes	Yes	Yes
Task intensity	Yes	Yes	Yes	Yes
Big Five	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes
Observations	5,123	5,123	5,123	5,123

Heterogeneity test

Table 6: Green wage premium: Heterogeneity test

Panel A: Structural model results of green wage premium: Heterogeneity test						
	(1)	(2)	(3)	(4)	(5)	(6)
	High skill	Low skill	Male	Female	Young	Old
Green vs Non-green						
Average Treatment Effect	0.068**	0.070	0.084***	0.065	0.146***	0.011
	(0.030)	(0.044)	(0.027)	(0.052)	(0.045)	(0.036)
Personal controls	Yes	Yes	Yes	Yes	Yes	Yes
Task intensity	Yes	Yes	Yes	Yes	Yes	Yes
Big Five	Yes	Yes	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,781	2,342	2,978	2,145	2,095	3,028
Panel B: Reduced form results of green wage premium: Heterogeneity test						
	(1)	(2)	(3)	(4)	(5)	(6)
	High skill	Low skill	Male	Female	Young	Old
KEOO index	0.216*	0.560***	0.232**	0.502**	0.489***	0.197
	(0.124)	(0.192)	(0.112)	(0.240)	(0.145)	(0.151)
Standard controls	Yes	Yes	Yes	Yes	Yes	Yes
Task intensity	Yes	Yes	Yes	Yes	Yes	Yes
Big Five	Yes	Yes	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,287	771	1,448	610	855	1,203

Robustness check: Excluding agriculture

Table 7: Structural model results of green job premium: Excluding agriculture

	Dependent Variable: ln(wage)			
	(1)	(2)	(3)	(4)
Green vs Non-green				
Average Treatment Effect	0.082***	0.076***	0.075***	0.077***
	(0.028)	(0.028)	(0.028)	(0.028)
Treatment assignment equation				
Father's Moral Score	0.457*			0.467*
	(0.248)			(0.248)
Parent's KEOO index		0.861**		
		(0.366)		
Father's KEOO index			0.541	0.545
			(0.624)	(0.624)
Mother's KEOO index			1.088**	1.103**
			(0.511)	(0.511)
Personal controls	Yes	Yes	Yes	Yes
Task intensity	Yes	Yes	Yes	Yes
Big Five	Yes	Yes	Yes	Yes
Prefecture FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes
Observations	5,088	5,088	5,088	5,088

DFL decomposition analysis

- To provide an insight into the factors that may be driving the green wage premium, we first apply a DiNardo-Fortin-Lemieux (DFL) which constructs a semi-parametric estimation of the wage distribution, enabling us to analyze the entirety of the wage distribution
- A counterfactual distribution is constructed using a reweighting method that adjusts the weights of individuals in the sample to reflect the distribution of characteristics in the other group
- This involves the calculation of a counterfactual density function that represents the distribution of wages in one group under the hypothetical scenario where that group had the same characteristics distribution as the other group (DiNardo et al. 1996)

DFL decomposition results

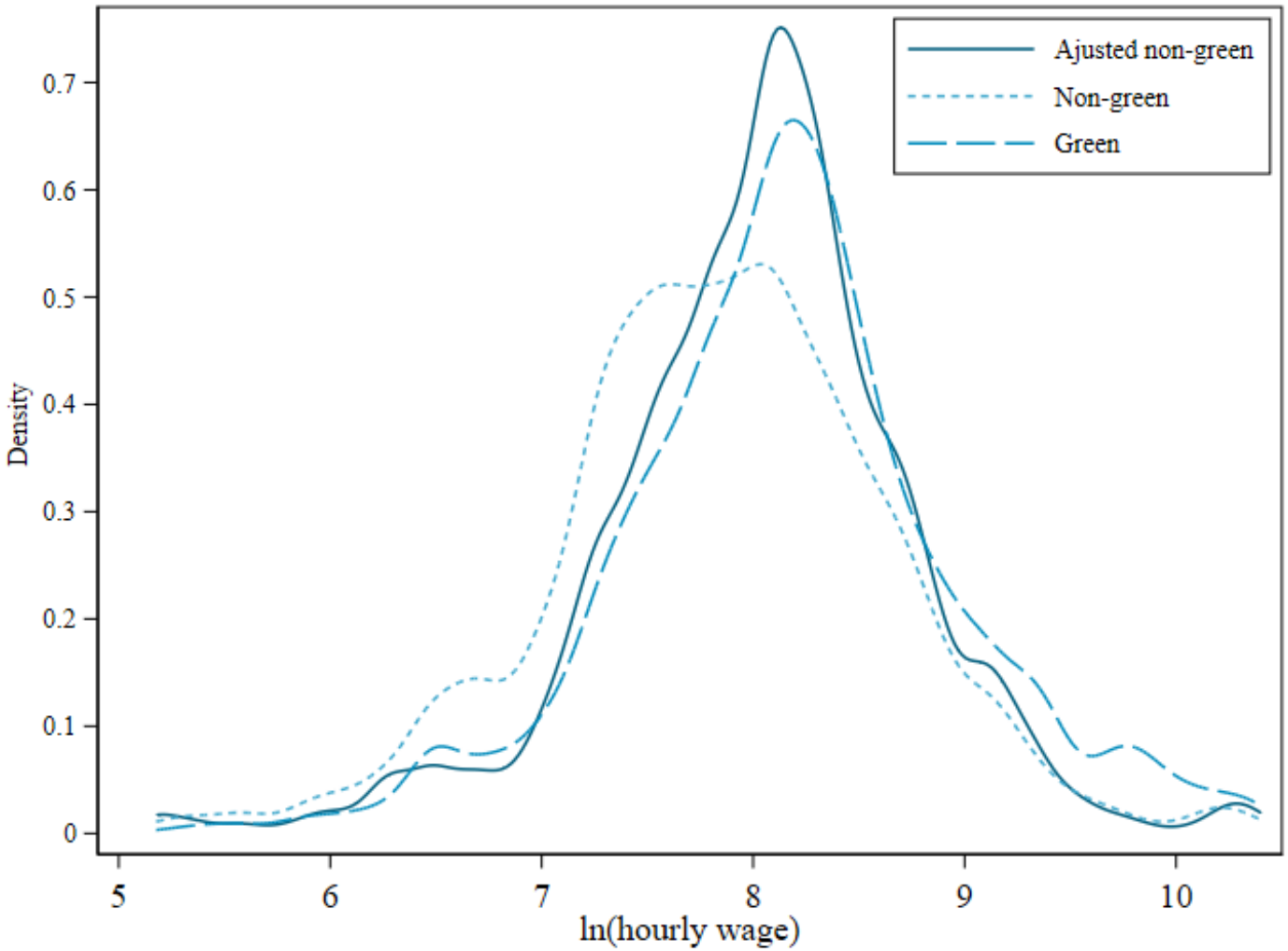

Figure 2: DFL decomposition of log of hourly wage

FFL decomposition analysis

- To provide an insight into the factors that contribute to the green wage premium, we apply the FFL decomposition method introduced by Firpo et al. (2007) who propose a two-stage procedure to decompose changes or differences in the distribution of wages (or of other variables)
- Based on the reweighting method introduced by DiNardo et al. (1996), the first stage divides the distributional changes or differences into a **wage structure effect** and a **composition effect** by constructing counterfactual wage distributions
- The second stage further decomposes the two parts into the contribution of each explanatory variable using recentered influence function (RIF) regressions

FFL decomposition results - Total decomposition

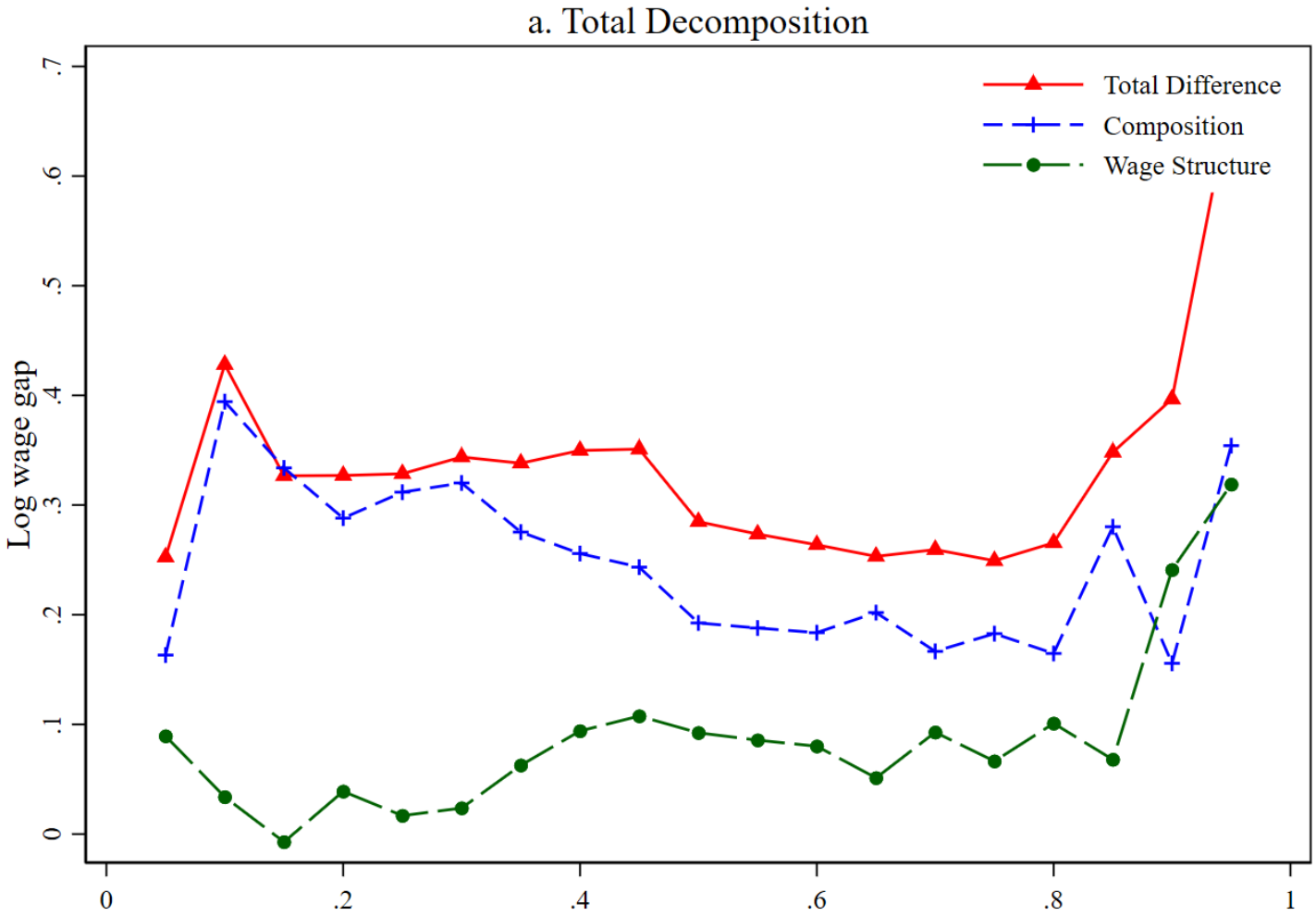

Figure 3: FFL decomposition of log wage gap: Total decompoistion

FFL decomposition results - Aggregate composition effects

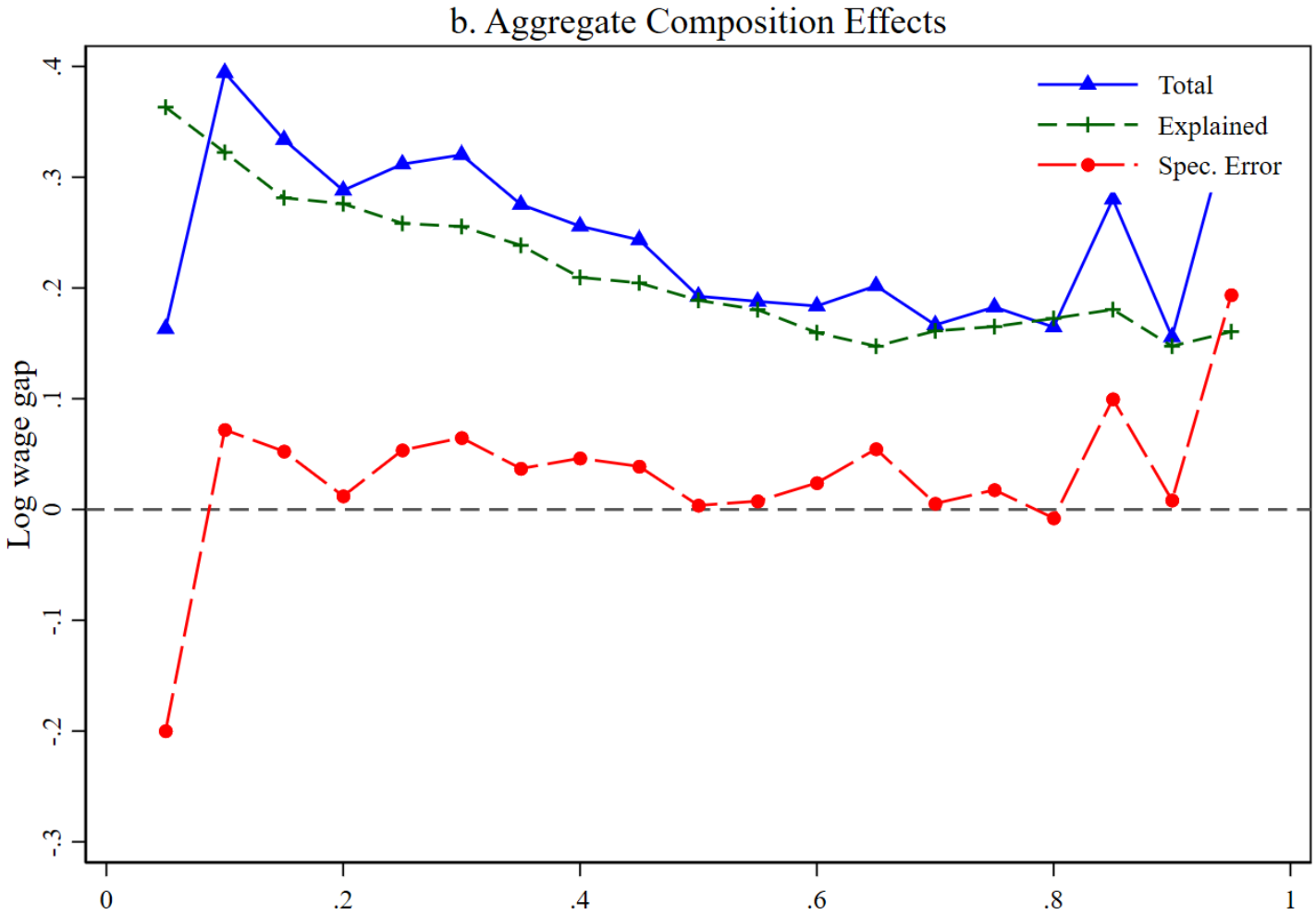

Figure 4: FFL decomposition of log wage gap: Aggregate composition effects

FFL decomposition results - Detailed composition effects

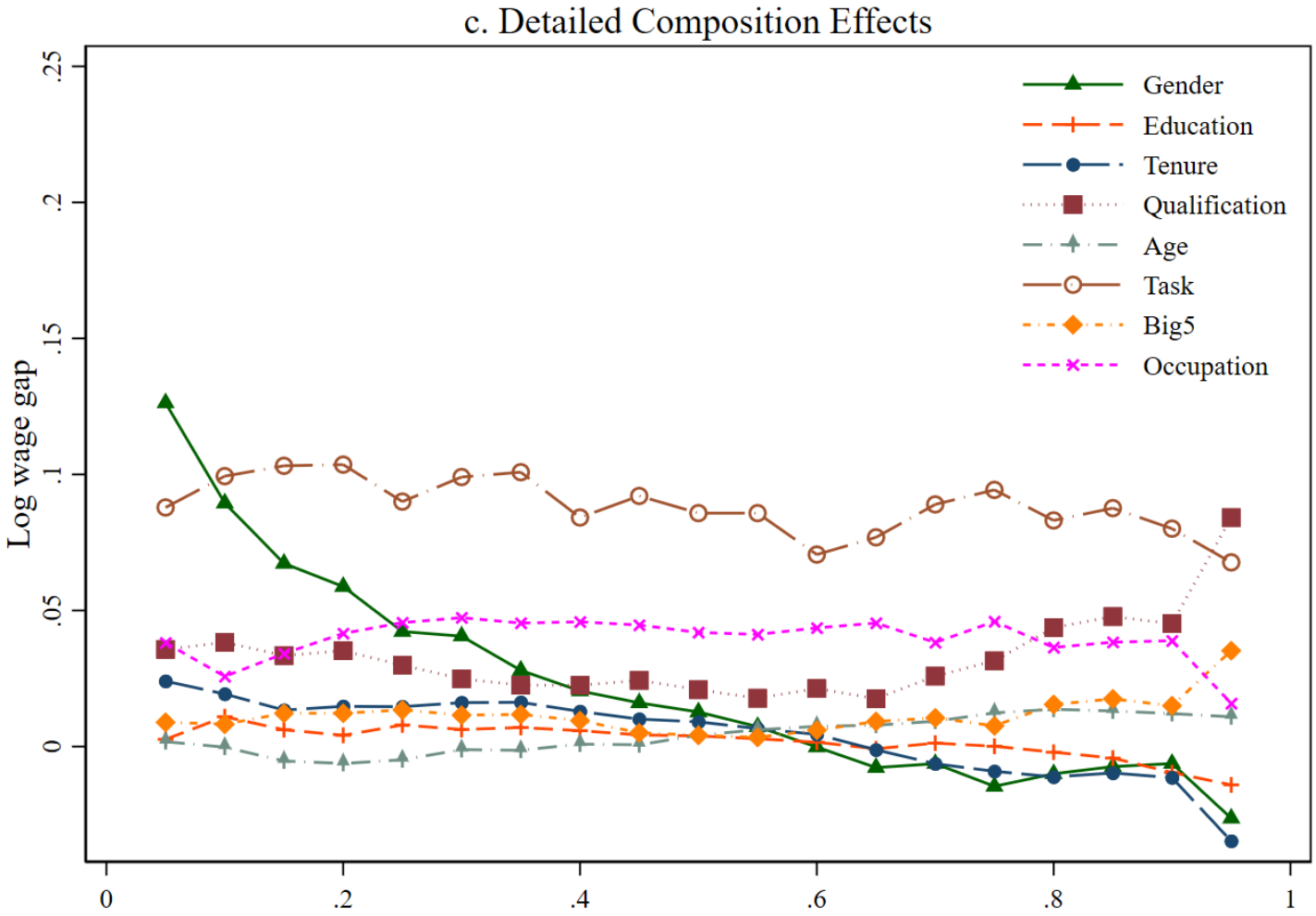

Figure 5: FFL decomposition of log wage gap: Detailed composition effects

Conclusion

- Using a representative survey of workers in Japan that includes questions on the activities that are undertaken as part of a job and can be considered green, we document the recent green job landscape in Japan and to provide the first estimates of a green wage premium using worker-level data
  - Green jobs earn a 7.8% wage premium compared to non-green jobs
  - A 10% increase in the level of a workers KEOO index is associated with an approximate 0.8% increase in the average hourly wage
  - The green wage premium differs by skill level, gender and age
  - Decomposition results suggest for higher income groups, the labour market assigns greater value to identical worker attributes in green jobs compared to non-green jobs
  - The explained wage gap is primarily driven by task differences, gender disparities (in lower percentiles), and occupation types, while factors such as education and tenure play relatively smaller, yet consistent roles

Discussion

- The green wage premium, which is found across various demographic groups, reflects the increasing importance of environmental sustainability in business and industry, and the recognition that workers who contribute to these efforts may be more valuable and in-demand than those in traditional or less sustainable jobs
- Given the fact that workers often base their decisions on anticipated earnings when making career choices (Arcidiacono et al. 2020), the existence of such a green wage premium could magnify the attractiveness of green jobs, thereby speeding up the transition towards a more sustainable economy as the workforce becomes increasingly endowed with the skills needed for a green transition
- However, whether this premium is temporary and will adjust in response to shifts in supply and demand dynamics remains an open question for future research