

Assessing reskilling programs to manage the European green transition

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Supplementary Information

This document contains Figures S1—S3 and Tables S1—S8 for supplementary information.

Additional figures

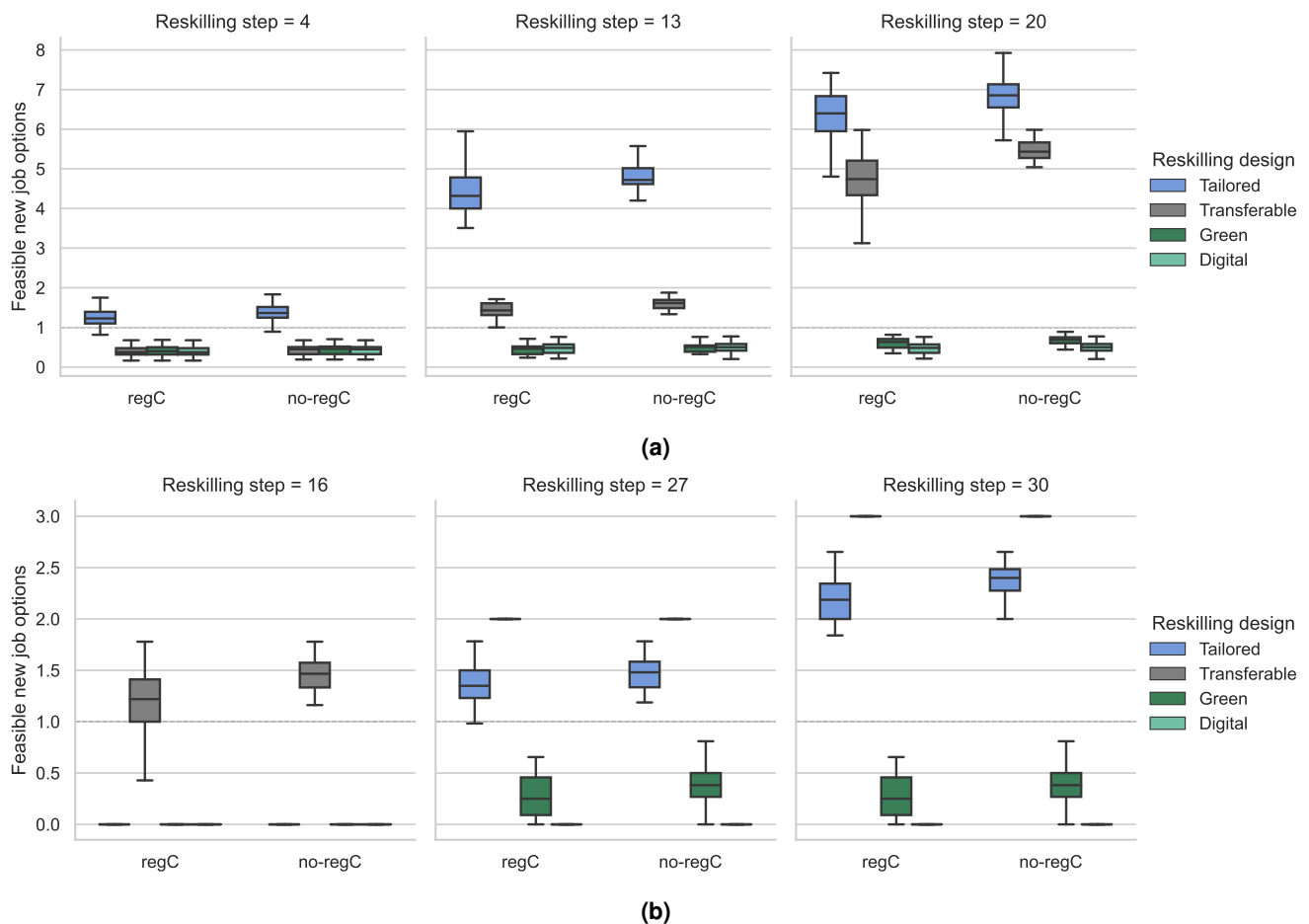


Figure S1. Distribution of required reskilling steps to unlock new job options by reskilling program and transition direction. (a) outward of at-risk jobs and (b) inward into low-carbon jobs.

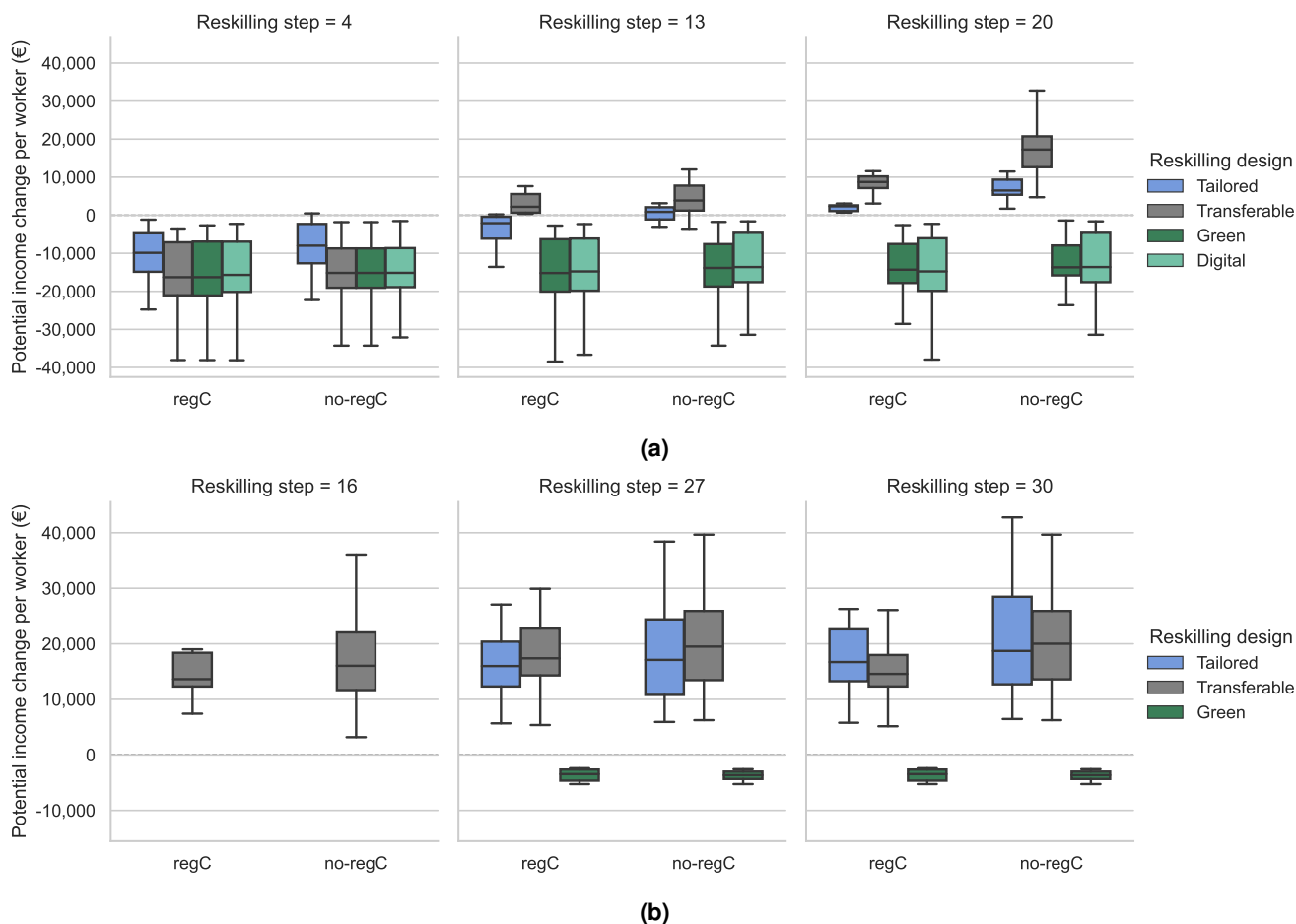


Figure S2. Distribution of potential change in average annual income by reskilling program and transition direction. (a) outward of at-risk jobs and (b) inward into low-carbon jobs.

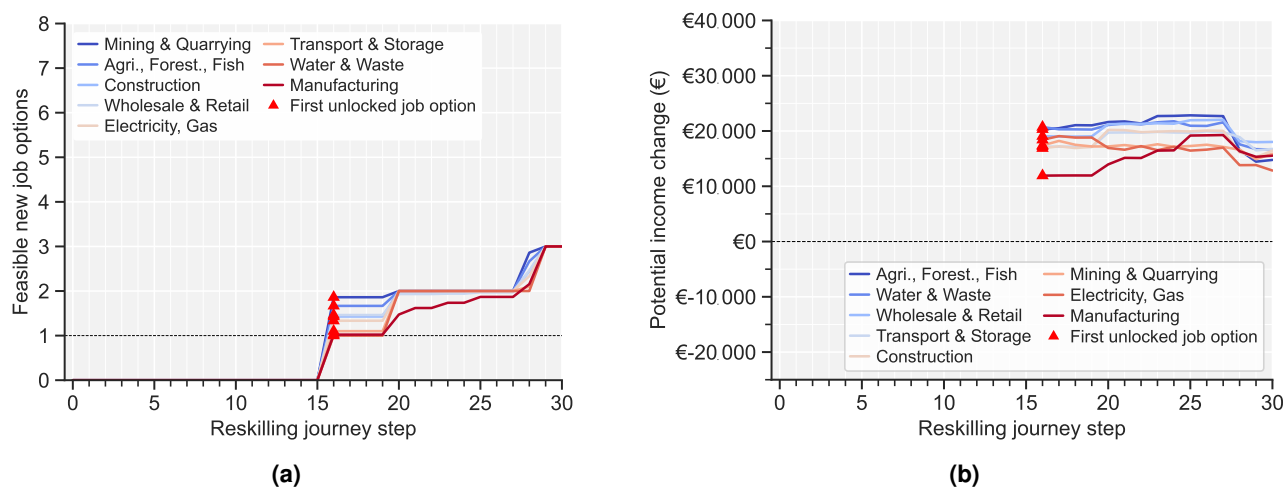


Figure S3. Transferable reskilling journeys into low-carbon jobs, by sector. (a) Number of skill-feasible job options unlocked at each reskilling step. (b) Potential annual income change (€) among switching workers.

Additional tables

Table S1. Occupational categories and labor market shares in Europe

Occupation category	ESCO (ISCO-4 Occupations)		EU-LFS (Jobs, Millions) 2019		Coreness
	Number	Share	Number	Share	Number (mean)
Neutral	2,710	90.1%	200.9	95.1%	2.8×10^{-4}
Low-carbon	91	3.0%	4.2	2.0%	3.6×10^{-4}
High-carbon, stable	144	4.8%	3.9	1.8%	2.3×10^{-4}
High-carbon, at-risk	63	2.1%	2.3	1.1%	1.9×10^{-4}

Source: Zaussinger, F., Schmidt, T. S., Egli, F. (2025). Skills-based and regionally explicit labor market exposure to the low-carbon transition in Europe. *Joule* [https://www.cell.com/joule/fulltext/S2542-4351\(24\)00549-X](https://www.cell.com/joule/fulltext/S2542-4351(24)00549-X)

Table S2. Essential-skill coverage in ESCO

(a) ISCO-3 skill coverage			(b) Top ISCO-3 groups by essential-skill counts			
	# skills	# essential	Top ISCO-3: Green essential skills			
			Occupation (ISCO-3)	# green	# digital	# ISCO-4 occs
Digital	21	5	Engineering professionals (214)	177	0	125
Green	570	475	Life science professionals (213)	140	1	40
			Physical technicians (311)	104	1	134
			Process control technicians (313)	55	0	35
			Market gardeners (611)	35	0	15
			Top ISCO-3: Digital essential skills			
			Social professionals (263)	2	2	66
			Software developers & analysts (251)	5	1	49
			Life science professionals (213)	140	1	40
			Database professionals (252)	0	1	20
			Electronics installers/repairers (742)	4	1	16

Table S3. Origin occupations of workers who could switch jobs under green reskilling, by transition flow.

Origin occupation (ISCO-3)	Potential switchers (%)	Max. success rate (%)	Green skill share (%)
<i>(a) Out of at-risk jobs</i>			
Engineering professionals (excl. electrotechnology)	19.0	63.0	13.3
Machinery mechanics and repairers	12.8	58.1	3.1
Mining, manufacturing and construction managers	10.9	63.1	8.6
Mining, manufacturing and construction supervisors	9.5	56.8	5.7
Mobile plant operators	7.2	43.8	6.6
Material-recording and transport clerks	6.6	39.4	4.0
Sheet and structural metal workers, welders & related	5.6	58.5	1.6
Electrical equipment installers and repairers	4.6	43.6	9.1
Building finishers and related trades workers	4.3	44.2	12.8
<i>(b) Into low-carbon jobs</i>			
Material-recording and transport clerks	59.2	27.7	4.0
Machinery mechanics and repairers	36.2	22.4	3.1
Handicraft workers	3.1	9.9	1.8
Textile, fur and leather machine operators	1.5	4.8	1.9

Notes: *Potential switchers* is the percentage of workers with a new job option originating from that occupation; *Max. success rate* is the share of workers from that occupation who unlock at least one new job option under green reskilling; *green skill share* is the mean share of an origin occupation's essential skills classified as green in ESCO.

Table S4. Per-worker income change at the first reachable job option, by program and country

Flow	Program	Base	€	%	€ change by country (k€)									
		(k€)	(k€)	change	FR	NO	CH	DK	IE	SE	FI	SK	PT	EL
Outward	Tailored	32.9	-8.3	-21.5	-7.7	-23.4	-18.3	-12.5	-14.3	-8.4	-4.0	-2.6	-3.9	-0.5
	Transferable	33.2	+2.0	+16.1	+1.6	-6.7	+5.8	+3.4	+1.2	+1.9	+7.3	+0.4	+6.4	+3.1
Inward	Tailored	26.6	+18.5	+81.7	+19.5	+27.3	+36.4	+21.1	+10.3	+15.8	+13.4	+5.7	+16.9	+6.5
	Transferable	28.5	+16.7	+68.0	+17.0	+29.3	+34.8	+19.4	+13.2	+12.5	+13.0	+2.9	+15.0	+7.2

Notes: Income changes are reported for workers who switch occupations, evaluated at the skill count at which the median switching worker first unlocks a reachable job option. For tailored reskilling, this occurs at step 4 in the outward journey and step 27 in the inward journey; for transferable reskilling, it occurs at steps 13 and 16, respectively. *Base* is the mean annual income of these switching workers before reskilling, and country columns report their mean income change in €. Green and digital programs are omitted because the median worker does not reach a transition under either flow.

Table S5. Country-level income losses of the at-risk workforce under no and tailored reskilling

	FR	NO	CH	DK	IE	SE	FI	SK	PT	EL	EU
Total, without reskilling (€ m)	-248	-53	-48	-23	-26	-43	-25	-10	-9	-10	-494
Total, with reskilling (€ m)	-110	-28	-26	-17	-19	-18	-8	-5	-5	-5	-240
Reduction (%)	56	46	46	27	26	58	70	54	48	48	52

Notes: Figures report the total annual change in income across all at-risk workers in each country, including workers who do not switch occupations. *Reduction* is the share of the income loss observed without reskilling that is removed under tailored reskilling. The EU total aggregates the ten countries for which earnings data are reported.

Table S6. Indicative total cost of reskilling by stylized program

Reskilling program	Participant cost (€)	Total workers with a new job option		Total program cost (€bn)	
		Outward	Inward	Outward	Inward
Transferable ^a	500–2,800	2.26M (99.7%)	1.86M (99.6%)	1.1–6.3	0.9–5.2
Tailored ^d	2,000–15,000	2.26M (100%)	1.85M (99%)	4.5–34	3.7–28
Green ^b	3,000–17,000	1.23M (55%)	0.43M (23%)	3.7–21	1.3–7.3
Digital ^c	2,000–15,000	0.48M (21%)	0 (0%)	1.0–7.2	—

Notes: Workers with a new job option unlock at least one option by journey's end (20 skills outward, 30 inward), applied to pools of 2.26M at-risk (outward) and 1.87M low-carbon-eligible (inward) workers, share-weighted from the EU-LFS. Total cost multiplies this by the per-participant band and is an order-of-magnitude range, not a point estimate. Bands follow the example programs in Table 1: ^aFrance's CPF [1] and Singapore's SkillsFuture [2]; ^bEU RES-SKILL [3]; ^cUK Skills Bootcamps [4] and EU coding bootcamps [5]; ^dGermany's education vouchers [6] and France's CPF de transition [7].

Table S7. Excluding optional-skill overlap, by reskilling program.

Program	Outward		Inward	
	Workers reaching a job option	Skills to 1st option	Workers reaching a job option	Skills to 1st option
Tailored	100.0% → 99.7%	4.0 → 8.2	99.0% → 90.9%	25.9 → 27.8
Transferable	99.7% → 80.9%	9.7 → 16.1	99.6% → 88.6%	17.1 → 26.2
Green	54.5% → 0.1%	10.8 → –	22.8% → 0.0%	19.0 → –
Digital	21.3% → 0.1%	0.1 → –	0.0% → 0.0%	– → –

Notes: Each cell reports the value with optional skills counted at $w=0.5$, followed by the value when optional skills are excluded ($w=0$), holding the viability threshold fixed. *Final reach* is the share of workers with at least one new job option by the end of the simulated reskilling journey (20 in the outward and 30 in the inward flow). *Skills to 1st option* is the mean number of skills acquired before a worker reaches a first new job option. An em dash denotes an undefined mean because reach is effectively zero. Excluding optional-skill overlap lowers reach across all programs but preserves the ordering: tailored and transferable programs continue to reach most workers, whereas green and digital programs do not.

Table S8. EU-LFS 2023

Country	Sample (%)	Median annual income (€)	Unique ISCO-3	Unique NUTS-2	Cross-border (%)
IT	15.6	—	122	22	0
NL	8.8	—	157	0	0
DE	8.7	20464	128	39	1
HU	7.5	8377	126	0	0
AT	7.5	31443	126	10	2
RO	7.2	—	126	8	0
PL	6.8	—	134	17	0
SE	5.4	30402	122	9	0
CH	3.2	55957	140	8	3
SK	3.0	9214	156	4	0
DK	2.9	30483	122	6	0
ES	2.9	23987	123	20	0
FR	2.2	27006	144	27	1
LT	2.1	—	128	2	0
SI	2.0	—	89	2	1
CY	1.5	—	122	0	0
BE	1.5	28997	126	12	1
CZ	1.4	15306	124	9	1
HR	1.2	—	125	4	0
BG	1.2	—	46	7	0
EE	1.1	17574	125	0	0
IE	0.9	30689	113	0	0
NO	0.9	41814	120	7	0
FI	0.8	30309	124	5	1
PT	0.8	11824	123	5	0
EL	0.8	8765	121	1	0
LU	0.7	47636	123	0	10
IS	0.7	—	115	0	0
MT	0.4	18940	22	0	0
LV	0.4	—	124	0	0