Resolving Coordination Frictions in Green Labor Transitions

Minimizing Unemployment, Fiscal Costs, and Welfare Distortions

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Context: Green Energy & Labor Transition

- **Green transition**: Economy-wide shift from fossil fuels to low-carbon to achieve net-zero target by 2050 [International Energy Agency, 2021].
- Requires not just technology, but also workforce for a successful transition.
- Unlike gradual changes, demands **rapid** worker reallocation that could be **costly**.
  $\implies$ Bottlenecks and coordination failures.
- **Policy needed to meet the target and avoid undesirable consequences.**

Motivation: Key Policy Concerns

- **Unemployment Risk**
  - Rapid green-job reallocation may increase transitional unemployment.
- **Fiscal Sustainability**
  - Large-scale reallocation requires substantial subsidies, raising funding concerns.
- **Aggregate Welfare**
  - Policies must preserve overall economic welfare and avoid unintended distortions.

Unemployment concerns

Unemployment concerns amidst the fossil-fuel workers

The Energy Transition Is Underway. Fossil Fuel Workers Could Be Left Behind.

The Biden administration is trying to increase renewable energy investments in distressed regions, but some are skeptical those measures would be enough to make up for job losses.

The New York Times

Labour's net zero quest will cost jobs, unions fear

11 September 2024

BBC

Biden Faces More Pressure From Environmentalists to Block Steel Merger

Climate change joins national security and concern about jobs in a mounting pressure campaign to prevent Nippon Steel from buying U.S. Steel.

The New York Times

CLIMATE CHANGE

Fossil-Fuel Industry Workers Say Green Economy Could Leave Them in Dust

Many environmental and labor leaders pitch New York's clean energy transition as a way to employ young and marginalized people — little consolation to workers in fossil-fuel industries worried about job loss.

Fiscal/Funding concerns

Financial costs concerns of green policies

Future of UN climate dialogue threatened by budget shortfall

By Kate Abnett

October 25, 2024 2:05 PM EDT · Updated October 25, 2024

SEPTEMBER 5, 2023 6:47AM

The Inflation Reduction Act's Energy Subsidies Are More Expensive Than You Think

Around the world, backlash against expensive climate change policies

By H. Sterling Burnett — May 18, 2019 4:00 am

ENERGY, ENVIRONMENT, FEDERAL GOVERNMENT

Coalition urges Congress to end costly green subsidies, citing economic harm

Who can afford to go green? Hard-pressed consumers are pushing back

Analysis by Hanna Ziady, CNN

8 minute read · Published 6:17 AM EST, Tue November 28, 2023

nature > nature communications > articles > article

Article | Open access | Published: 30 June 2021

Higher cost of finance exacerbates a climate investment trap in developing economies

Motivation: Labor Market Friction & Policy Gaps

Going deeper into the root causes of green-labor transition bottlenecks

- **Labor Market Friction:**
  - Brown-sector workers fear unemployment [Bluedorn et al., 2023].
  - Green industries face talent shortages [LinkedIn, 2024] Gap.
  - Only 0.7% of displaced "dirty" workers transition to green roles [Curtis et al., 2023].

- **Policy Gap:**
  - Emphasis on firm subsidies [Bistline et al., 2023], while workers shoulder retraining costs [ILO, 2019].
  - Misalignment of costs and benefits [IRA, 2023].

- **Implications:**
  - Intensified matching frictions.
  - Slower green-labor reallocation.
  - Need for better policy design.

Research Questions

- **Main Question:** Which mix of labor-market and firm-side policies most effectively scales green employment from 2% to 14% [WorkingNation, 2024] by 2030?
- **Success Metrics:**
  - *Employment Impact:* Minimize transitional unemployment
  - *Fiscal Efficiency:* Minimizes fiscal costs required to fund the policies
  - *Welfare Safeguards:* Maximizes aggregate economic welfare
- **Methodology:** Develop an analytical framework (extended Diamond–Mortensen–Pissarides (DMP) model) to simulate and compare policy packages under U.S. calibration.

Answers

- Extends Diamond–Mortensen–Pissarides (DMP) search-match model[2] with:
  - Green firms receive production subsidies.
  - Workers need to pay entry cost to green sector.
  - Policies:
    - Subsidize green production.
    - Subsidize worker entry costs.
    - Subsidize both simultaneously.

- Key message:
  - All policies meet the employment target.
  - Jointly lowering κ_g (entry) and increasing τ_g (subsidy) is optimal:
    - **Higher Welfare**: $+0.09\%$ vs. κ_g, $+1.10\%$ vs. τ_g.
    - **Lower Funding**: -7.48% vs. κ_g, -24.03% vs. τ_g.
    - **Lower Unemployment**: -15.78% vs. κ_g, -18.73% vs. τ_g.
  - *Policy:* Achieving green-job targets cost-effectively and equitably requires aligned incentives for both workers and firms.

[2]The DMP model endogenously determines unemployment, vacancies, and wages from costly search and matching between workers and firms.

One Shot Model Set-up

Extend the standard one-shot Diamond Mortessen Pissarides (DMP) model to allow firms and workers **endogeneously** decide to enter green or non-green sectors[3]

- *Workers:* Need to pay for entry cost to enter the green sector

$$\text{Green: } -\kappa_g + \alpha_{wg} w_g + (1-\alpha_{wg})z \quad \text{and} \quad \text{Brown: } \alpha_{wn} w_n + (1-\alpha_{wn})z.$$

- *Firms:* Gets the green production subsidy in the green sector

$$\text{Green: } -c + \alpha_{fg}(y + \tau_g - w_g) \quad \text{and} \quad \text{Brown: } -c + \alpha_{fn}(y - \tau_n - w_n).$$

- *Government:* Funds the subsidy τ_g to all matched and producing green firms by imposing a tax τ_n on all matched and producing brown firms:

$$\tau_n = \frac{\tau_g \alpha_{fg} v_g}{\alpha_{fn} v_n} = \tau_g \cdot \frac{\frac{\pi}{(\pi + v_g)} \cdot v_g}{\frac{(1-\pi)}{(1-\pi+v_n)} \cdot v_n}$$

[3]Following Curtis and Marinescu [2022], we define green jobs as renewable-energy occupations (solar, wind, EVs) for clear calibration and policy relevance; these roles account for roughly 80% of U.S. energy-related emissions [World Nuclear Association, 2024].

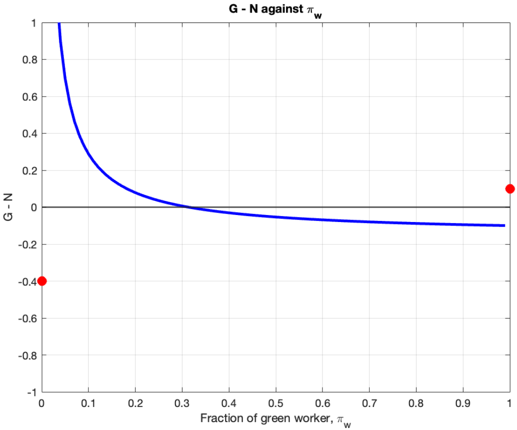

Figure: Multiplicity of Equilibria (CRS)

One Shot CRS Equilibria Comparative Statics

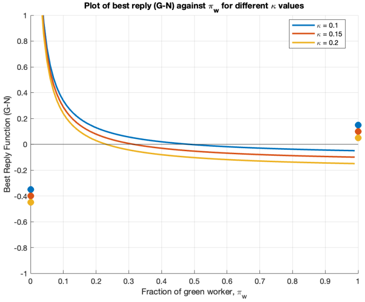

Figure: Increasing training cost decreases equilibrium entry to green sector

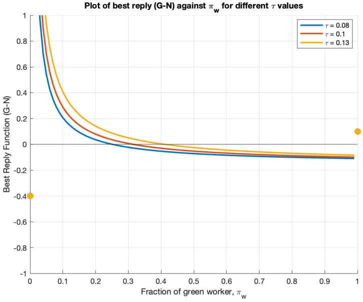

Figure: Increasing green subsidy increases equilibrium entry to green sector

Dynamic Model Set Up

- Discrete time, infinite horizon; discrete rate β.
- *Similar to the one-shot version Green Policies (incentives/costs) in this setting*
  - Workers decide whether to enter green labor marker or traditional one.[4]
  - Matching technology is same as before.

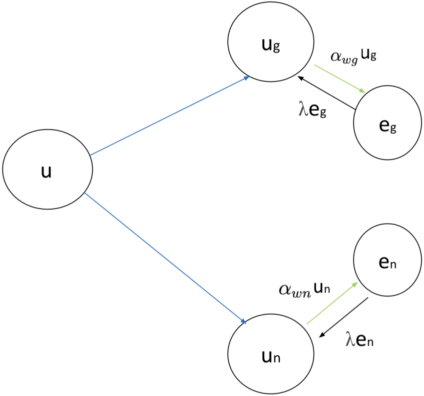

Figure: Worker flows in and out of the various states

[4] Labor market segmentation, though might seem an extreme assumption, Curtis et al. [2023] show that in 2021, only 0.7 percent of workers who transitioned out of a dirty job transitioned into a green job.

As per WorkingNation [2024], in the US, green jobs are expected to expand to nearly 24 million, comprising 14% of total US jobs by 2030.

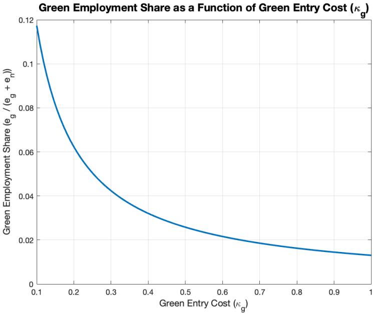

Figure: Decreasing green sector entry cost increases equilibrium green employment share.

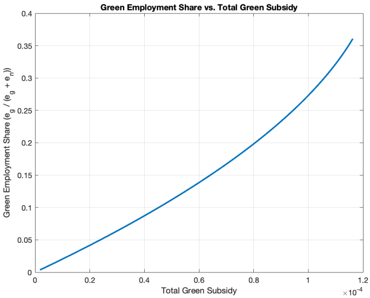

Figure: Increasing green subsidy increases equilibrium green employment share.

Achieving labor market transition goal ctd

How to achieve the target of green employment to move from current 2% to 14% of total US jobs by 2030?

Table: Comparison of Different Approaches to Achieve Green Employment Target

Equilibrium	**Per worker entry cost**	**Per worker cost subsidy**	**Per firm green subsidy**	**Total green firm subsidy**	**Green emp. share**
Reduce workers' cost increase firm subsidy	**-0.1649**	**0.889514**	**0.256501**	**0.000645**	**14%**
Fix per firm subsidy reduce workers' cost	-0.1810	0.905630	0.0272	6.8000e-05	14%
Fix total firm subsidy reduce workers' cost	-0.1756	0.900243	0.0036	8.9074e-06	14%
Fix workers' cost increase per firm subsidy	0.7246	0	2.52733	0.0063	14%
Baseline	0.7246	0	0.0272	8.9074e-06	2%

$\Longrightarrow$ Both reducing green entry/training cost κ_g and increasing green production subsidy τ_g achieves the employment target.

Key Results: Welfare, Funding Requirement, and Agg. Unemployment

Equilibrium	Welfare	Funding Req.	Agg. Unemployment
Reduce workers' cost, increase firm subsidy	**0.9617**	**0.004786**	**0.044858**
Fix per firm subsidy, decrease workers' cost	0.9598	0.005173	0.047638
Fix total green subsidy, decrease workers' cost	0.9597	0.005190	0.047842
Fix workers' cost, increase firm subsidy	0.9554	0.00630	0.053251
Baseline	0.9675	8.9074e-06	0.035000

- **Welfare improvement**: Optimal strategy improves welfare by:
  - 0.09% vs. fixed subsidy, reduced κ_g.
  - 1.10% vs. fixed κ_g, increased τ_g.
- **Tax efficiency**: Reduces funding requirement by:
  - 7.48% vs. fixed subsidy, reduced κ_g.
  - 24.03% vs. fixed κ_g, increased τ_g.
- **Unemployment reduction**: Lowers total unemployment by:
  - 15.78% vs. fixed subsidy, reduced κ_g.
  - 18.73% vs. fixed κ_g, increased τ_g.

Conclusion: Reducing κ_g and increasing τ_g is the most effective strategy for welfare, tax savings, and unemployment reduction.

Adding Green Production Externality to Welfare

Welfare in the DMP Model:

- *Without externality:*

$$W_0 = p \cdot (e_g + e_n) + (z - \kappa_g)u_g + z \cdot u_n - c \cdot (v_n + v_g)$$

- *With positive externality from green employment:*

$$W_\alpha = p \cdot (e_g + e_n) + (z - \kappa_g)u_g + z \cdot u_n - c \cdot (v_n + v_g) + \alpha \cdot e_g$$

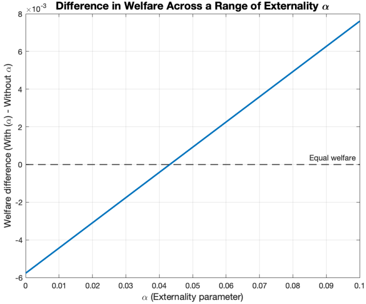

Figure: Welfare Gain/Loss as a Function of Externality Parameter α

The welfare gain/loss depends on α; welfare equalizes at $\alpha = 0.0432$.

Productivity Equivalence of the Externality Threshold

Steps:

1. Compute W_0 and $W_{\alpha=0.0432}$.
2. Find productivity p' such that $W_0(p') = W_{\alpha=0.0432}$.
3. Calculate percentage change in p.

$\alpha \ = \ 0.0432$ is equivalent to a ∼0.6% productivity increase.

$\Longrightarrow$

Subsidizing the green sector is welfare-improving if the externality exceeds 0.6%.

Increasing Returns to Scale in Matching

- Even mild IRS ($\psi > 0$)[5] amplifies our transition channels: reduces unemployment further, raises welfare slightly, and cuts total subsidies needed.

Table: Impacts of IRS on Unemployment, Welfare, and Subsidy

$\psi_n = \psi_g$	Total Unemployment ↓	Welfare ↑	Total Subsidy ↓
0.000	0.044954	0.9617	0.004801
0.001	0.042896	0.9628	0.004337
0.010	0.040815	0.9641	0.003678
0.020	0.040924	0.9644	0.003628

IRS means each extra worker or vacancy makes the next match even easier, fueling self-reinforcing market momentum.

[5] Constant returns to scale is the standard assumption in search–match models, but Martellini and Menzio [2020] explores non-constant returns to scale in labor matching.

Economic Insight

Key Insight:
Simultaneously subsidizing workers and firms is the most efficient way to achieve 14% green employment.

Why is it optimal?

- **Workers:** Entry cost subsidies boost the supply of skilled workers.
- **Firms:** Production subsidies increase labor demand.
- **Combined:** Aligns labor supply and demand, improving matching efficiency.
  $\Rightarrow$ Achieves target with smaller interventions, lower unemployment, and higher welfare.

Conclusion and Policy Recommendation

- **Model**: DMP with:
  - Green subsidies for firms.
  - Worker entry costs.

- **Result**: Achieving 14% green jobs by 2030 requires:
  - Lower worker costs (κ_g) and higher firm subsidies (τ_g).
  - A combined policy maximizes welfare, reduces unemployment, and minimizes costs.

- **Policy**: Subsidizing both firms and workers is optimal to meet green employment target in a fiscally and socially efficient manner.

Workers shortage amidst green jobs

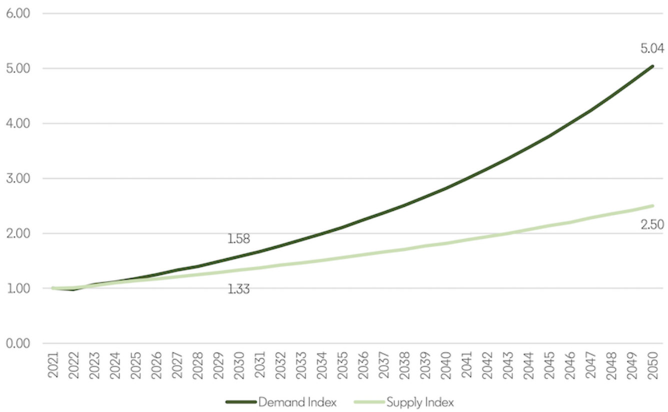

Figure: Source: LinkedIn Economic Graph 2024

Model Choice: Entry Costs (κ_g)

What could κ_g be?

Reskilling Needs: Green jobs require new skills, increasing transition costs for workers [Vona et al., 2018, Lim et al., 2023].

Geographic Frictions: Green jobs are regionally mismatched with fossil fuel hubs [Brookings Institute, 2022, Lim et al., 2023].

Non-Wage Benefits: Lower union protections and fewer benefits in green jobs [Emden and Murphy, 2019].

Job Uncertainty: Green jobs often involve intermittent or short-term work [Villas-Boas, 2021].

Takeaway: Despite wage premium and high matching likelihood in green sector, there is green workers shortage, so κ_g represents the broad costs workers face when shifting to green jobs.

Model Choice: Green Subsidies (τ_g)

IRA Subsidies: The Inflation Reduction Act focuses on firm subsidies but lacks reskilling programs [Bistline et al., 2023]; It provides tax credits for renewable energy, ranging from $5/MWh to $32/MWh based on eligibility [Bushnell and Smith, 2024].

Key Issue: Current policy misaligns costs and benefits; A policy-driven transition can help address market frictions [Oei et al., 2020].

One Shot Model ctd.

- *Matching technology:* The matching technology for market j is:

$$f_j(u,v) = \delta_j \left(\frac{uv}{u+v}\right)^{1-\psi} (uv)^{\psi}, \quad j \in \{n,g\}, \quad \psi \in [0,1]$$

  where u and v are the measures of unemployed workers and vacant jobs.
- For CRS ($\psi = 0$), the matching probabilities are:

$$\alpha_{wg} = \frac{v_g}{\pi + v_g}, \quad \alpha_{wn} = \frac{v_n}{1-\pi+v_n}$$

$$\alpha_{fg} = \frac{\pi}{\pi + v_g}, \quad \alpha_{fn} = \frac{1-\pi}{1-\pi+v_n}$$

One Shot Model Equilibrium

Endogeneous variables: $\pi, v_g, v_n, w_g, w_n, \tau_n$
Equilibrium conditions:

$$c = \frac{\pi}{\pi + v_g}(y + \tau_g - w_g) \tag{1}$$

$$c = \frac{1-\pi}{1-\pi+v_n}(y - \tau_n - w_n) \tag{2}$$

$$w_g = \theta(y + \tau_g) + (1-\theta)z \tag{3}$$

$$w_n = \theta(y - \tau_n) + (1-\theta)z \tag{4}$$

$$\tau_n = \tau_g \cdot \frac{\frac{\pi}{(\pi+v_g)} \cdot v_g}{\frac{(1-\pi)}{(1-\pi+v_n)} \cdot v_n} \tag{5}$$

$$\pi = \begin{cases} 0 & \text{if } G < N, \\ \in (0,1) & \text{if G = N}, \\ 1 & \text{if } G > N. \end{cases} \tag{6}$$

$$G = -\kappa_g + \frac{v_g}{\pi + v_g} w_g + \left(1 - \frac{v_g}{\pi + v_g}\right) z \quad \text{and} \quad N = \frac{v_n}{1-\pi+v_n} w_n + \left(1 - \frac{v_n}{1-\pi+v_n}\right)$$

Theoretical Model

1. Workers
   - Unemployed

$$U = \max\{U_g, U_n\}$$

$$\begin{aligned} U_g &= z - \kappa_g + \beta\left[\alpha_{wg} W_g + (1-\alpha_{wg}) U_g\right] \\ U_n &= z + \beta\left[\alpha_{wn} W_n + (1-\alpha_{wn}) U_n\right] \end{aligned}$$

2. Employed

$$\begin{aligned} W_g &= w_g + \beta\left[(1-\lambda) W_g + \lambda U\right] \\ W_n &= w_n + \beta\left[(1-\lambda) W_n + \lambda U\right] \end{aligned}$$

3. Firms[6]
   - Vacant

$$V = \max\{V_g, V_n\}$$

$$V_g = -c + \beta\left[\alpha_{fg} J_g + (1-\alpha_{fg}) V\right]$$
$$V_n = -c + \beta\left[\alpha_{fn} J_n + (1-\alpha_{fn}) V\right]$$

   - Filled

$$J_g = (1+\tau_g)p - w_g + \beta\left[\lambda V + (1-\lambda) J_g\right]$$
$$J_n = p - w_n - \tau_n + \beta\left[(1-\lambda) J_n + \lambda V\right]$$

[6]In this framework, allowing firms to choose between green and brown sector is analogous to allowing for free entry in both sector which is what I do hereon.

Solving the model

- Bargaining and wage curves
  1. Non-green jobs: $(1-\eta)(W_n - U_n) = \eta J_n$

$$\implies w_n = \frac{(1-\eta)z[1-\beta(1-\lambda)] + \eta(p-\tau_n)[1-\beta(1-\lambda-\alpha_{wn})]}{[1-\beta(1-\lambda-\eta\alpha_{wn})]}$$

     i.e. $\tau_n \uparrow \implies w_n \downarrow$

  2. Green jobs: $(1-\eta)(W_g - U_g) = \eta J_g$

$$\implies w_g = \frac{(1-\eta)(z-\kappa_g)[1-\beta(1-\lambda)] + \eta p(1+\tau_g)[1-\beta(1-\lambda-\alpha_{wg})]}{[1-\beta(1-\lambda-\eta\alpha_{wg})]}$$

     i.e. $\tau_g \uparrow \implies w_g \uparrow$ and $\kappa_g \uparrow \implies w_g \downarrow$.

- Optimal Choices for agents

$$U_g = \frac{[1-\beta(1-\lambda)][z-\kappa_g] + \beta\alpha_{wg}w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}$$

$$U_n = \frac{[1-\beta(1-\lambda)]z + \beta\alpha_{wn}w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}$$

$$U_g^* = U_n^*$$

Equilibrium Definitions

A steady state equilibrium comprises of wages (w_g, w_n), measure of green and traditional vacant firms (v_g, v_n), measure of green and traditional unemployed and employed workers (u_g, u_n, e_g, e_n), fraction of unemployed workers who choose to be green (π), and a green production subsidy τ_g given a flat tax τ_n that satisfy the beveridge curves, wage curves, job creation curves, agents' optimal choices, and government budget constraint.

Equilibrium Equations

1. *Beveridge Curves:*
   - $\alpha_{wg} u_g = \lambda e_g$
   - $\alpha_{wn} u_n = \lambda e_n$
   - $u_n + u_g + e_n + e_g = 1$
2. *Wage Curves*
   - $w_n = \frac{(1-\eta)z[1-\beta(1-\lambda)]+\eta(p-\tau_n)[1-\beta(1-\lambda-\alpha_{wn})]}{[1-\beta(1-\lambda-\eta\alpha_{wn})]}$
   - $w_g = \frac{(1-\eta)(z-\kappa_g)[1-\beta(1-\lambda)]+\eta p(1+\tau_g)[1-\beta(1-\lambda-\alpha_{wg})]}{[1-\beta(1-\lambda-\eta\alpha_{wg})]}$
3. *Job Creation Curves:*
   - $w_g = (1+\tau_g)p - \frac{c(1-\beta(1-\lambda))}{\beta\alpha_{fg}}$
   - $w_n = p - \tau_n - \frac{c(1-\beta(1-\lambda))}{\beta\alpha_{fn}}$
4. *Agents' Optimal Choices:*
   - $U_n^* = U_g^*$ i.e. $\frac{[1-\beta(1-\lambda)]z+\beta\alpha_{wn}w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))} = \frac{[1-\beta(1-\lambda)][z-\kappa_g]+\beta\alpha_{wg}w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}$
5. *Government's Budget Constraint*
   - $\tau_n = \tau_g \cdot \frac{\alpha_{fg}\cdot v_g}{\alpha_{fn}\cdot v_n}$

Remember:

- $\alpha_{wg} = \delta_g \left(\frac{v_g}{(u_g+v_g)^{1-\psi}}\right)$
- $\alpha_{wn} = \delta_n \left(\frac{v_n}{(u_n+v_n)^{1-\psi}}\right)$
- $\alpha_{fg} = \delta_g \left(\frac{u_g}{(u_g+v_g)^{1-\psi}}\right)$
- $\alpha_{fn} = \delta_n \left(\frac{u_n}{(u_n+v_n)^{1-\psi}}\right)$

Endogeneous variables: $\{v_g, v_n, u_g, u_n, e_g, e_n, w_g, w_n, \tau_g\}$

Parameters: $\{\beta, p, \psi, \eta, c, \lambda, z, \delta_g, \delta_n, \kappa, \tau_g\}$

Model Calibration

- Exogeneously set parameters
  - $\beta = 0.9959$ (discount rate)
  - $p = 1$ (worker productivity)
  - $\psi = 0$ (CRS case for the matching function)
  - $\eta = 0.72$ (worker's bargaining for CRS case)
  - $z = 40\%$ of average productivity

- Data Targets:
  - Wage Premium: 2% (IMF, 2022) [7].
  - Green (Renewable Sector) Employment Share: 2% of U.S. workforce (EIA, 2022).
  - Hiring Likelihood Ratio: Workers with green skills 29% more likely to be hired [LinkedIn, 2023].
  - Labor Market Tightness: 1.868 (FRED, 2024).
  - Unemployment Rate: 3.5% (BLS, 2023).
  - Green Tax Subsidy: 0.01788% - 0.11445% of U.S. GDP (IRA 2022, net renewables).

[7] Estimates up to 4% (CEPR, 2023).

Model Calibration

- Calibration

Data Moments	*Model Analogue*	*Model Values*	*Target Values*
Wage Premium	w_g/w_n	1.018	1.02
Employment Share	$e_g/(e_n + e_g)$	0.0195	0.0195
Hiring Likelihood Ratio	α_{wg}/α_{wn}	1.29	1.29
Labor market tightness	$(v_n + v_g)/(u_n + u_g)$	1.868	1.868
Unemployment Rate	$u_n + u_g$	3.5%	3.5%

Table: Matching the calibration targets.

- Calibrated parameters

Parameter	*Description*	*Value*
c	Vacancy cost	0.1640
λ	Separation rate	0.0188
δ_g	green matching efficiency	0.8826
δ_n	non-green matching efficiency	0.7961
κ_g	green entry barrier cost	0.7246

Table: Internally calibrated parameters

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