Resolving Coordination Frictions in Green Labor Transitions: Minimizing Unemployment, Costs, and Welfare Distortions

Adhikari, Shisham

University of California, Davis

20 January 2025

Resolving Coordination Frictions in Green Labor Transitions:

Minimizing Unemployment, Costs, and Welfare Distortions

Shisham Adhikari
University of California - Davis

ABSTRACT

Achieving global carbon neutrality by 2050 requires not only technological advancements but also a rapid reallocation of the workforce. Existing policies, such as the Inflation Reduction Act (IRA), focus on firm subsidies while overlooking critical labor market coordination frictions. Workers face high entry costs and uncertainty about green job opportunities, while firms hesitate to invest without a reliable labor supply. This creates a coordination problem: workers are reluctant to enter the green sector without job guarantees, and firms delay expansion without sufficient workers.

This paper extends the Diamond-Mortensen-Pissarides (DMP) model to incorporate these coordination frictions, calibrating it to U.S. labor market data. By evaluating subsidies targeted at firms, workers, and a combined strategy, the analysis shows that while individual subsidies can achieve the green employment target of 14% by 2030, a combined approach is far more efficient. It aligns incentives, reduces unemployment, and minimizes fiscal costs, highlighting the necessity of addressing coordination frictions to ensure a cost-effective and equitable green transition.

This Version: September, 2024

1 Introduction

The global push towards carbon neutrality by 2050 is increasingly threatened by critical labor market coordination challenges. Headlines highlight two pressing issues: polluting sector workers face uncertainty about their future in the green economy, and green sector employers struggle to attract a sufficient workforce. Workers in polluting industries fear being left behind during the transition, while firms aiming to "go green" grapple with the difficulty of finding employees to meet their expansion needs. Unemployment concerns among fossil fuel workers lie at the heart of the green transition (Bluedorn, Hansen, Noureldin, Shibata, and Tavares, 2023), but recent reports also underscore a growing labor shortage in the green sector. For instance, LinkedIn's Global Climate Talent Stocktake 2024 reveals that while demand for green jobs grew by 22.4% between 2022 and 2023, the green workforce increased by only 12.3% during the same period (LinkedIn, 2024). Similarly, studies by the International Labour Organization (ILO) and Boston Consulting Group (BCG) project that labor shortages in the green sector could reach 7 million by 2030, creating a significant bottleneck for global decarbonization efforts (ILO, 2019; BCG, 2023).

Despite major policies like the Inflation Reduction Act (IRA) (IRA, 2023), which focus heavily on subsidizing firms, the green labor market continues to be hampered by a classic coordination problem that current policies fail to address. Subsidies incentivize firms to transition to greener operations, but they do not reduce the critical barriers faced by workers, such as high entry costs and the lack of guarantees of stable employment, which deter them from participating in the green economy. This creates a coordination game where firms hesitate to invest in green production unless they expect a sufficient pool of workers, while workers are unwilling to pay the costs of transitioning without the assurance of adequate job opportunities. Subsidizing only firms is insufficient because it ignores the interdependence of decisions: firms and workers must act in concert for the green transition to succeed. Without addressing both sides of the market, the labor supply needed to support green expansion will remain inadequate, leading to suboptimal outcomes—underinvestment by firms and underparticipation by workers—that jeopardize the effectiveness of current climate policies and the broader decarbonization effort.

This paper develops an extended Diamond-Mortensen-Pissarides (DMP) model, calibrated to U.S. data, to analyze how different policy approaches can resolve the coordination challenges in the green labor market. We evaluate three policy interventions: subsidies to firms, subsidies to workers, and a combined strategy. Each intervention is assessed based on its ability to achieve the current target of increasing green employment from 2% to 14% by 2030. The results indicate that while subsidies targeted solely at firms or workers can meet the employment target, a combined strategy is far more efficient–maximizing welfare, minimizing unemployment, and reducing funding requirements. By addressing both sides of the coordination game, the combined approach ensures that firms and workers act in concert, aligning incentives and breaking the stalemate that has hindered the green transition.

The contributions of this paper are twofold. First, it provides a quantitative framework to analyze the coordination friction that impedes the growth of the green labor market. By explicitly modeling the game-theoretical interaction between firms and workers, this paper demonstrates how beliefs about each other's actions can either facilitate or obstruct the transition. Second, it offers actionable policy insights, highlighting the importance of a coordinated intervention to achieve optimal outcomes for green employment. Achieving global climate goals requires policies that address both labor supply and demand simultaneously. A combined approach is not just more efficient—it is essential to overcoming the current bottlenecks and ensuring a successful, sustainable transition to a greener economy.

2 Relevant Literature

The transition to a low-carbon economy has spurred extensive research on labor market dynamics, with a focus on the employment effects of environmental policies. Early studies using computable general equilibrium (CGE) models provide insights into sectoral job reallocation but typically assume full employment and overlook critical labor market frictions such as unemployment, search costs, and skill mismatches (Patuelli, Nijkamp, and Pels, 2005; Sancho, 2010; Böhringer, Rivers, and Rutherford, 2013; Freire-González, 2018). While models that integrate labor frictions partially address these limitations, they predominantly focus on aggregate outcomes like net job losses or sectoral shifts, without addressing the interdependence of decisions between firms and workers (Hafstead and Williams III, 2018; Hafstead, Williams III, and Chen, 2022).

Search and matching models offer a more nuanced framework for studying labor market frictions, particularly in capturing unemployment dynamics and labor market bottlenecks. Recent contributions, such as Gibson and Heutel (2023) and Lankhuizen, Rojas-Romagosa, and van Ewijk (2022), provide valuable insights into these dynamics but often fail to examine how coordination frictions between firms and workers influence outcomes. Specifically, these models do not fully address how firms hesitate to invest in green production without a reliable labor supply, and how workers are reluctant to transition without assurance of stable green jobs. Despite the growing recognition of the central role of unemployment and worker transitions in the political economy of the green transition (Bluedorn et al., 2023), coordination challenges remain underexplored.

This paper addresses this gap by explicitly analyzing the coordination frictions that hinder the green labor market transition. Using an extended search and matching framework, it evaluates three policy interventions—subsidies to firms, subsidies to workers, and a combined strategy—while focusing on their ability to resolve coordination failures. The key contribution is to demonstrate that small, targeted interventions aimed at aligning firm and worker incentives, such as reducing worker entry costs while incentivizing firm investments, are the most efficient. By quantitatively assessing these policies in terms of welfare, unemployment, and fiscal efficiency, this paper highlights the necessity of coordinated policy design for resolving labor market frictions and ensuring a successful and sustainable green transition.

3 Model

3.1 Physical Environment

We develop a discrete-time version of the Diamond–Mortensen–Pissarides (DMP) model (Pissarides, 2000), extended to include two sectors: green and non-green. Agents discount future payoffs at rate β, and the labor force is normalized to 1. The labor market is segmented into the green and non-green sectors, denoted by subscripts g and n, respectively. A continuum of unemployed workers receive an unemployment benefit z, and both workers and firms decide optimally which market to enter.

Firms that enter either sector incur a flow recruiting cost c, and existing jobs are destroyed at rate λ. Green firms receive a production subsidy τ_g, while non-green firms face a tax τ_n, which funds the subsidies.[1] On the worker side, entry into the green sector requires paying a flow cost κ_g, which is partially offset by a subsidy policy parameter s_g. The effective cost of entry for workers in the green sector becomes $(1 - s_g)\kappa_g$, where $s_g \in [0, 1]$ represents the fraction of κ_g subsidized. In contrast, entry into the non-green sector involves no cost.

The matching function in each sector $j \in \{g, n\}$ is:

$$f(u_j, v_j) = \delta_j \left(\frac{u_j v_j}{u_j + v_j} \right)^{1-\psi} (u_j v_j)^{\psi}, \quad \psi \in [0, 1],$$

where u_j and v_j are the number of unemployed workers and vacancies, respectively, and δ_j is a sector-specific matching efficiency parameter. For simplicity, we assume constant returns to scale ($\psi = 0$)[2]. The matching probabilities are given by:

$$\alpha_{wj} = \frac{v_j}{u_j + v_j}, \quad \alpha_{fj} = \frac{u_j}{u_j + v_j}, \quad j \in \{g, n\}.$$

---

[1] We have also solved a version of the model where all sectors are taxed to fund green subsidies. However, including both taxation and subsidies for green firms adds complexity without altering the main results. For clarity, we focus on the version where only non-green sectors are taxed.

[2] We also analyzed the model with increasing returns to scale (IRS), but it added complexity without providing additional insights, so we omitted it from the main analysis.

After matches are formed, wages are determined through Nash bargaining, where workers have bargaining power η. Other parameters, including the unemployment benefit z, job destruction rate λ, and matching efficiency δ, are identical across sectors, ensuring that results are driven by policy-specific variables τ_g, τ_n, and s_g.

This framework captures a critical coordination problem inherent to the green labor market. Firms benefit from subsidies (τ_g), which encourage their entry into the green sector, while workers bear the effective entry cost $(1 - s_g)\kappa_g$. This misalignment of incentives creates interdependence in decision-making: firms are reluctant to enter the green sector unless they anticipate a sufficient pool of workers, while workers hesitate to transition without confidence in job availability. These dynamics reflect a coordination game, where the entry decisions of firms and workers depend on their beliefs about the actions of the other. For instance, firms expecting insufficient worker entry may reduce vacancies, further discouraging workers from entering the green sector. Conversely, strong expectations of mutual participation can lead to successful sector growth. The one-shot version of this coordination game, fully characterized in Appendix A, highlights the potential for multiple equilibria depending on these beliefs.[3]

By incorporating this coordination friction, the model enables analysis of how different targeted subsidies (τ_g, s_g) can align firm and worker incentives to resolve these frictions and achieve green employment targets effectively.

3.2 Discussion of Modeling Choices and Empirical Relevance

3.2.1 Definition of Green Jobs

Defining green jobs is essential for capturing their dynamics in the labor market. Broad definitions, such as those provided by the International Labour Organization (ILO), describe green jobs as "decent jobs that contribute to preserving or restoring the environment" (International Labor Organization, 2024). Task-specific classifications based on databases like O*NET refine this further by focusing on job-specific contributions to the green transition (Vona, Marin, Consoli, and Popp, 2018; Vona, Marin, and Consoli, 2019; Consoli, Marin, Marzucchi, and Vona, 2018). However, these approaches often fail to include emerging occupations like "solar panel installer" relevant to the green economy. This paper adopts the definition from Curtis and Marinescu (2022), which encompasses all employment in renewable energy sectors, including solar, wind, and electric vehicles. This definition aligns well with both empirical and policy contexts, as energy-related

---

[3] The one-shot game produces multiple equilibria, driven by differing expectations about firm and worker participation. See Appendix A for the full characterization.

activities account for 70% of U.S. anthropogenic emissions (World Nuclear Association, 2024), and recent policies such as the Inflation Reduction Act (IRA) focus heavily on renewable energy and EV sectors (Bushnell and Smith, 2024).

3.2.2 Entry Costs for Workers: κ_g

Worker entry costs in the green sector (κ_g) represent the structural barriers faced by workers transitioning to green jobs. These costs are modeled broadly to reflect various frictions:

- **Training Costs.** Green jobs often demand new technical and managerial skills, requiring reskilling even in related occupations (Vona et al., 2018; Consoli et al., 2018).
- **Relocation Costs.** Green jobs are geographically dispersed, necessitating relocation from fossil fuel hubs to regions rich in renewable resources (Brookings Institute, 2022; Johnson and Schulhofer-Wohl, 2019; Lim et al., 2023).
- **Unionization and Benefits.** Fossil fuel jobs typically offer stronger union representation and better benefits compared to green jobs, deterring workers from transitioning (Emden and Murphy, 2019; Pollin, Garrett-Peltier, et al., 2020).
- **Uncertainty and Behavioral Barriers.** Perceived instability in green jobs and behavioral factors such as risk aversion or sunk costs further impede transitions (Villas-Boas, 2021; Dixit and Rob, 1994).

Although the model remains agnostic about the exact composition of κ_g, its inclusion reflects the real-world barriers to green labor market flexibility and the economics of the model goes through any of those assumptions.

3.2.3 Subsidy to Firms: τ_g

The Inflation Reduction Act (IRA) provides substantial production and investment tax credits (τ_g) to incentivize renewable energy deployment, with credits ranging from \$5/MWh to \$32/MWh based on criteria such as labor conditions and domestic content (Bistline et al., 2023). These subsidies have accelerated green technology adoption but have largely overlooked workforce development (Walsh, 2023). By modeling τ_g, the framework captures the financial incentives driving renewable energy expansion while highlighting the gap in policies targeting the labor market.

3.2.4 Why Policy-Driven Solutions?

The green transition relies heavily on government policy, unlike past structural changes such as globalization or automation, which were primarily market-driven. While gradual technological change allows labor markets to adapt naturally (Pissarides, 2000), the clean energy transition demands the rapid reallocation of millions of workers by 2050 to meet decarbonization targets. This accelerated timeline creates bottlenecks and coordination challenges, as polluting job losses may outpace the creation of green jobs. Historical transitions, such as the Soviet Union's economic restructuring, illustrate the risks of unmanaged labor shifts (Oei et al., 2020). Policy interventions, including subsidies and training programs, are therefore critical to aligning labor supply and demand, resolving coordination frictions, and ensuring a smooth and equitable transition.

3.3 Analysis of the Model

We now analyze the model by deriving the equilibrium conditions in the labor market. We examine how green production subsidies and worker entry costs affect equilibrium outcomes, focusing on the Beveridge curves, value functions, and wage determination. This allows us to derive policy implications for achieving optimal green sector employment.

3.3.1 Beveridge Curves

We start with the derivation of the Beveridge curves, which describe the relationship between unemployment and job vacancies in both the green and non-green sectors. Figure 1 helps illustrate the worker flows between the various states in the economy.

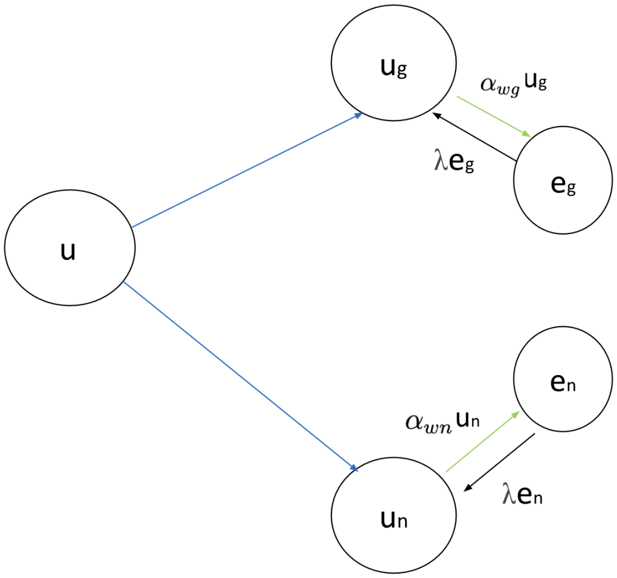

Figure 1. Worker flows between unemployment and employment in both sectors.

As shown in the diagram, unemployed workers (u) can choose to enter either the green (u_g) or non-green (u_n) sector, where they may find a job and transition to employment (e_g and e_n, respectively). Similarly, employed workers in both sectors face the possibility of job destruction at rate λ, which returns them to unemployment. Equating the flows in and out of each state gives us the following relationships in steady state:

- For the green sector:
$$\alpha_{wg} u_g = \lambda e_g \tag{1}$$
- For the non-green sector:
$$\alpha_{wn} u_n = \lambda e_n \tag{2}$$
- The total labor force is normalized to 1:
$$u_g + u_n + e_g + e_n = 1 \tag{3}$$

These Beveridge curves will play a critical role in understanding the dynamics of the labor market under different climate policies, as the green and non-green sectors respond differently to government interventions such as subsidies and taxes.

3.3.2 Firms' Value Functions and Free Entry

Firms choose between entering the green or non-green sectors based on expected profits, which is analogous to free entry in both sectors. Let V represent the value of a vacant firm, and $V_g(J_g)$ and $V_n(J_n)$ be the values of vacant (filled) jobs in the green and non-green sectors, respectively.

- **Vacant Firms**: A firm posts a vacancy in either sector, choosing the one with higher expected returns:

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

  The value of a vacancy in the green sector is:

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

  and in the non-green sector:

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

  where c is the recruiting cost, and α_{fg} and α_{fn} are the probabilities of filling vacancies in the green and non-green sectors, respectively.

- **Filled Firms**: Once matched, a firm produces output p. Green firms also receive a subsidy τ_g, while non-green firms pay a tax τ_n:

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

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

  where w_g and w_n are wages, and λ is the job destruction rate.

In equilibrium, firms enter the sector where expected profits are highest, balancing wages, subsidies, and taxes. 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. Free entry in both sectors implies that in equilibrium $V_g = V_n = V = 0$, therefore, we can state the free entry conditions as:

$$c = \beta\alpha_{fg} J_g \tag{4}$$

$$c = \beta\alpha_{fn} J_n \tag{5}$$

Imposing free entry to the value functions for filled firms also gives:

$$J_g = (1+\tau_g)p - w_g + \beta(1-\lambda)J_g \tag{6}$$

$$J_n = p - w_n - \tau_n + \beta(1-\lambda)J_n \tag{7}$$

3.3.3 Workers' Value Functions and Optimal Sector Choice

Now, let's examine the value functions of workers in different states. In our model, workers make an endogenous decision to enter either the green or non-green sector, optimizing their choice based on expected utility. This decision forms part of the equilibrium, where the expected utilities for both sectors must equalize. Let U represent the value of an unemployed worker, with $U_g(W_g)$ and $U_n(W_n)$ denoting the values of unemployed (employed) workers in the green and non-green sectors, respectively.

- **Unemployed Workers**: An unemployed worker chooses the sector that maximizes their expected utility. The overall value of being unemployed is given by:

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

  The value of being unemployed in the green sector is:

  $$U_g = z - (1-s_g)\kappa_g + \beta\left[\alpha_{wg}W_g + (1-\alpha_{wg})U_g\right], \tag{8}$$

  and in the non-green sector:

  $$U_n = z + \beta\left[\alpha_{wn}W_n + (1-\alpha_{wn})U_n\right], \tag{9}$$

  where z is the unemployment benefit, $(1-s_g)\kappa_g$is the effective entry cost, and α_{wg} and α_{wn} are the probabilities of finding a job in the green and non-green sectors, respectively.

- **Employed Workers**: Once employed, a worker earns wage w_j in their respective sector. If a job is destroyed at rate λ, the worker returns to unemployment. The value of being employed in the green sector is:

  $$W_g = w_g + \beta\left[(1-\lambda)W_g + \lambda U\right], \tag{10}$$

  and in the non-green sector:

  $$W_n = w_n + \beta\left[(1-\lambda)W_n + \lambda U\right], \tag{11}$$

  where w_g and w_n are the wages in the green and non-green sectors, respectively, and

λ is the job destruction rate.

- **Workers' Optimal Entry**: Workers choose which sector to enter based on the expected utility in each sector. Combining the value functions for unemployed and employed workers in each sector, we get:

  $$U_g = \frac{[1-\beta(1-\lambda)](z-(1-s_g)\kappa_g) + \beta\alpha_{wg}w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))} \text{ and } U_n = \frac{[1-\beta(1-\lambda)]z + \beta\alpha_{wn}w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}.$$

  In equilibrium, workers are indifferent between entering the green and non-green sectors, so the following condition must hold:

  $$U_g = U_n,$$

  $$\implies \frac{[1-\beta(1-\lambda)](z-(1-s_g)\kappa_g) + \beta\alpha_{wg}w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))} = \frac{[1-\beta(1-\lambda)]z + \beta\alpha_{wn}w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}. \tag{12}$$

  This condition ensures that workers optimally choose their sector based on expected payoffs.

With the value functions of all economic agents fully detailed, we now turn our attention to analyzing the bargaining challenges across various meeting scenarios.

3.3.4 Bargaining Problems

Non-green sector: Let us start by describing the terms of trade in a meeting between a firm and an unemployed in the non-green sector. Solving the standard Nash bargaining problem leads to the following condition that must be satisfied:

$$(1-\eta)(W_n - U_n) = \eta J_n, \tag{13}$$

This condition indicates that each party receives a share of the total surplus from the match, proportional to their bargaining power. (Recall that η represents the worker's bargaining power.) Substituting the value functions J_n, U_n, and W_n from above equations (7), (9), and (11) respectively, we can express the wage in the non-green sector as follows:

$$w_n = \frac{(1-\eta)z[1-\beta(1-\lambda)] + \eta(p-\tau_n)[1-\beta(1-\lambda-\alpha_{wn})]}{1-\beta(1-\lambda-\eta\alpha_{wn})}. \tag{14}$$

See Appendix B.1 for the derivation. This establishes a relationship between the wage of workers in non-green sector and their job arrival rate α_{wn}, which depends on firm entry and market tightness. A key insight here is that w_n decreases as the tax imposed on non-green firms τ_n increases, introducing a new dynamic into the wage determination for non-green workers.

Green sector: Next, consider the bargaining problem between a firm and a worker in the green sector, where workers incur real costs to enter the sector, while firms receive government subsidies when they match with workers and produce. Again, we have:

$$(1-\eta)(W_g - U_g) = \eta J_g. \tag{15}$$

Similar to before, we can substitute the value functions J_g, U_g, and W_g from above equations (6), (8), and (10) respectively to derive the wage in the green sector to be:

$$w_g = \frac{(1-\eta)(z-(1-s_g)\kappa_g)[1-\beta(1-\lambda)] + \eta p(1+\tau_g)[1-\beta(1-\lambda-\alpha_{wg})]}{1-\beta(1-\lambda-\eta\alpha_{wg})}. \tag{16}$$

See Appendix B.2 for the derivation. Again, we derive a relationship between the wage for green sector workers and their job arrival rate α_{wg}, which is influenced by firm entry and market conditions. Here, τ_g represents the green production subsidy to firms, κ_g is the entry cost for workers in the green sector, and s_g is the entry cost subsidy to workers in the green sector. Notice that an increase in τ_g and s_g leads to an increase in w_g, while a rise in κ_g causes w_g to decrease.

3.3.5 Government's Budget Constraint

The government's budget constraint ensures that tax revenues collected from the non-green sector fully fund the subsidies provided to the green sector. In other words, the tax paid by all producing firms in the non-green sector balance the subsidies received by all producing firms in the green sector, which results in the following condition:

$$\tau_n = \tau_g \cdot \frac{\alpha_{fg} \cdot v_g}{\alpha_{fn} \cdot v_n}, \tag{17}$$

where τ_n represents the tax on non-green firms, τ_g is the subsidy for green firms, α_{fg} and α_{fn} are the firm matching rates in the green and non-green sectors, respectively, and v_g and v_n are the vacancies in the green and non-green sectors.

3.3.6 Definition of Steady State Equilibrium

A steady state equilibrium in our model consists of wages (w_g, w_n) for workers in the green and non-green sectors, a green production subsidy τ_g, a flat tax τ_n paid by non-green firms, measures of vacancies in both sectors (v_g, v_n), and measures of employed and unemployed workers in the various states (u_g, u_n, e_g, e_n). The subsidy and tax satisfy the government budget constraint (17). The remaining equilibrium variables satisfy the free entry condition (4, 5), the wage curve (16, 14), three Beveridge curves (1, 2, 3), and optimal entry condition (12), after one replaces the various α's with the respective matching probabilities given in (3.1).

4 Calibration

We calibrate the benchmark model to the U.S. economy in 2022, with a focus on the green transition in the labor market. A period in the model corresponds to one month in calendar time. Several parameters that have direct empirical counterparts are set exogenously. The discount factor β is set to 0.9959, consistent with an annual interest rate of 5%. Worker productivity p is normalized to 1, and the matching function exhibits constant returns to scale (CRS) with $\psi = 0$. In line with Shimer (2005), the worker's bargaining power η is set to 0.72, and the non-employment benefit z is set to 40% of average productivity.

We use several key data targets to guide our calibration. First, the wage premium for green sector workers relative to non-green sector workers is targeted at 2%, based on estimates from the Fund (2022)[4]. Additionally, the green employment share is set at 2% of the total U.S. workforce, consistent with 2022 estimates from the Energy Information Administration (EIA) ((EIA), 2024) and calculation of employment share in the renewable sector[5]. The hiring likelihood ratio, which compares the probability of workers with green skills being hired relative to those without such skills, is calibrated to 29%, as reported by LinkedIn (2023). Labor market tightness, measured as the ratio of job vacancies to unemployed workers, is set at 1.868 based on data from FRED Blog (2024). Finally, the unemployment rate is targeted at 3.5%, consistent with Bureau of Labor Statistics (BLS) data from 2023 (of Labor Statistics (BLS), 2023). In addition, we account for the green tax subsidy, which ranges from 0.1% of U.S. GDP, based on estimates from the Inflation Reduction Act (IRA) of 2022.[6]

---

[4] This estimate is on the lower end compared to other studies, which find the green wage premium to be around 4% in VoxEU (2023) and approximately 20% in Curtis and Marinescu (2022).

[5] In 2022, there were 3.3 million renewable energy jobs ((E2), 2023) and 212.4 million total jobs ((REA), 2024), resulting in $e_g/e \approx 2\%$.

[6] This estimate is based on the range of production tax credits for renewable energy generation, which vary from \$5/MWh to \$32/MWh depending on eligibility factors (Bushnell and Smith, 2024). With 0.91 billion MWh of renewable electricity generated in 2022 (of Energy, 2023) and a U.S. GDP of 25.44 trillion USD (Bank, 2022), the green production credits range from approximately 0.01788% to 0.11445% of total

The model's performance in matching these calibration targets is summarized in the table below:

Data Moments	**Model Values**	**Target Values**
Wage Premium (Green/Non-green)	1.018	1.02
Employment Share (Green)	0.0195	0.0195
Hiring Likelihood Ratio (Green/Non-green)	1.29	1.29
Labor Market Tightness	1.868	1.868
Unemployment Rate	3.5%	3.5%

Table 1: Model performance in matching the calibration targets.

The internally calibrated parameters that allow the model to replicate green and non-green labor market dynamics are given in the table 2.

Parameter	**Description**	**Calibrated Value**
c	Vacancy creation cost	0.1640
λ	Separation rate	0.0188
δ_g	Matching efficiency in green sector	0.8826
δ_n	Matching efficiency in non-green sector	0.7961
κ_g	Green entry barrier cost	0.7246

Table 2: Internally calibrated parameters.

The calibrated baseline model captures the essential dynamics of the U.S. labor market in the context of the green transition in 2022. With these parameters, we are now equipped to tackle the key question of this paper: *How can the U.S. increase green employment from 2% to 14% of total U.S. jobs by 2030?* As projected by WorkingNation (2024), green jobs are expected to grow to nearly 24 million by 2030, comprising 14% of the U.S. workforce. This calibration enables us to analyze the necessary policy interventions to reach this ambitious target and assess the best policy in terms of welfare, unemployment outcomes, and funding requirement.

5 Quantitative Analysis

The U.S. aims to increase green employment from 2% to 14% of total U.S. jobs by 2030, as per (WorkingNation, 2024), where green jobs are projected to expand to nearly 24 million. This quantitative analysis uses the calibrated model to explore the channels through

---

GDP.

which we can achieve this ambitious goal. We focus on two key policy levers: reducing the green sector entry cost for workers and increasing green production subsidies for firms.

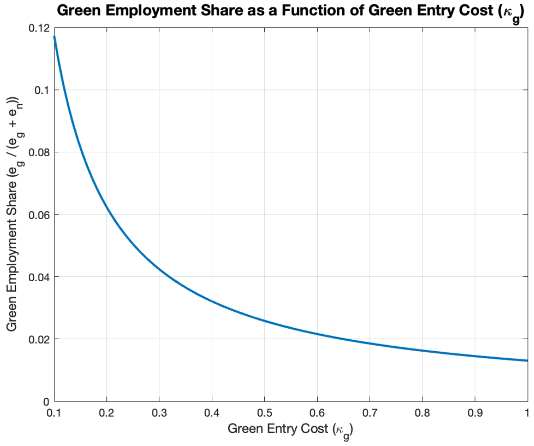

Figure 2. Decreasing green sector entry cost increases green employment share.

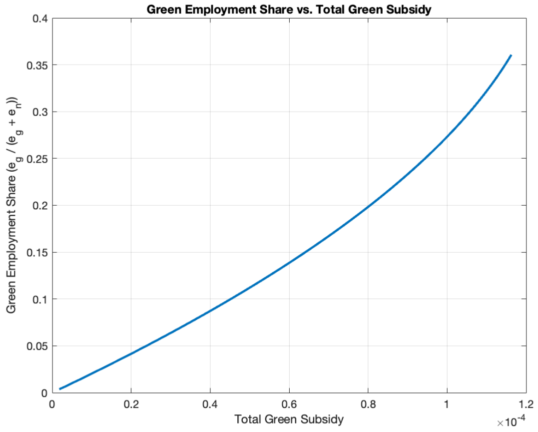

Figure 3. Increasing green subsidy increases green employment share.

The figure above shows how reducing worker entry costs, κ_g (using the worker subsidy s_g) increases the green employment share, while raising production subsidies to firms, τ_g, similarly boosts the equilibrium green employment share. Both policies are effective independently (see Appendix A.6), but their combined impact, as demonstrated in the comparative statics of the one-shot model, is even more substantial.

5.1 Achieving the Green Employment Target

Table 3 compares the effectiveness of various policy strategies in achieving the green employment target. The policies analyzed include: (i) maintaining a fixed per-firm green subsidy while subsidizing worker entry costs through taxes collected from non-green firms, (ii) fixing the total green subsidy across all green firms and reducing worker entry costs, recognizing the distinction between per-firm subsidies and aggregate subsidies, (iii) holding worker entry costs constant while increasing the green firm subsidy, and (iv) simultaneously reducing worker entry costs and increasing firm subsidies.

The baseline scenario reveals that only 2% of U.S. jobs are currently in the green sector. All other rows demonstrate how various combinations of subsidies targeting worker entry costs and green firm production can achieve the target of 14% green employment. This exercise highlights the effectiveness of individual subsidies as well as a combined approach in reaching the desired green employment target. The next section evaluates these

Table 3: Comparison of Different Approaches to Achieve Green Employment Target

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

policy mixes to identify the optimal strategy in terms of welfare, funding requirements, and unemployment outcomes.

5.2 Key Results: Welfare, Funding, and Unemployment

Table 4 presents the outcomes of each policy combination, comparing their effects on welfare, funding requirements, and aggregate unemployment. The combined strategy of reducing worker entry costs while increasing green subsidies emerges as the most effective approach, delivering the highest welfare, the lowest funding requirement, and the largest reduction in unemployment.

Table 4: Welfare, Funding Requirement, and Aggregate 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	0.006300	0.053251
Baseline	0.9675	8.9074e-06	0.035000

The combined strategy offers a welfare gain of 0.20% compared to fixing per firm subsidies while reducing worker entry costs, and 0.21% compared to fixing total green subsidies with reduced worker entry costs. It achieves a 7.48% reduction in funding requirements relative to fixed per firm subsidies with reduced entry costs, and a 24.03% reduction compared to fixed worker entry costs with increased firm subsidies. Aggregate unemployment decreases by 5.84% compared to fixed per firm subsidies with reduced entry costs, and by 15.76% compared to fixed worker entry costs with higher subsidies.

In summary, reducing worker entry costs and increasing green subsidies is the most efficient policy combination, maximizing welfare, minimizing funding burdens, and significantly lowering unemployment.

5.3 Welfare Analysis with Green Production Externality

In the standard DMP framework, aggregate welfare is calculated without considering the positive externalities of green sector expansion. This omission explains why all policy interventions yield lower welfare compared to the baseline scenario, despite achieving the green employment target. To address this limitation, we extend the standard DMP welfare function to include a positive production externality from green employment. This addition allows us to quantify how large the externality needs to be for the green sector expansion to result in welfare improvements.

5.3.1 Welfare Function with Externality

The standard DMP welfare function is given by:

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

where e_g and e_n are employment levels in the green and non-green sectors, u_g and u_n are unemployed workers in the green and non-green sectors, κ_g is the worker entry cost in the green sector, and c is the recruiting cost for vacancies.

To incorporate the positive externality, we modify the welfare function as follows:

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

where α represents the externality parameter, capturing the environmental benefit generated by each unit of employment in the green sector.

5.3.2 Results and Threshold Analysis

The welfare gain or loss from policy interventions depends critically on the value of α. Figure 4 illustrates the relationship between welfare and the externality parameter α. The analysis shows that welfare under the combined policy intervention (W_α) equals baseline welfare (W_0) when $\alpha = 0.0432$. This implies that the positive externality parameter needs to be bigger than $\alpha = 0.0432$ for green sector expansion to improve welfare relative to the baseline.

5.3.3 Productivity Equivalence of the Externality Threshold

To contextualize the threshold $\alpha = 0.0432$, we compute its productivity equivalence. This involves finding the percentage increase in productivity (p) required to achieve the same

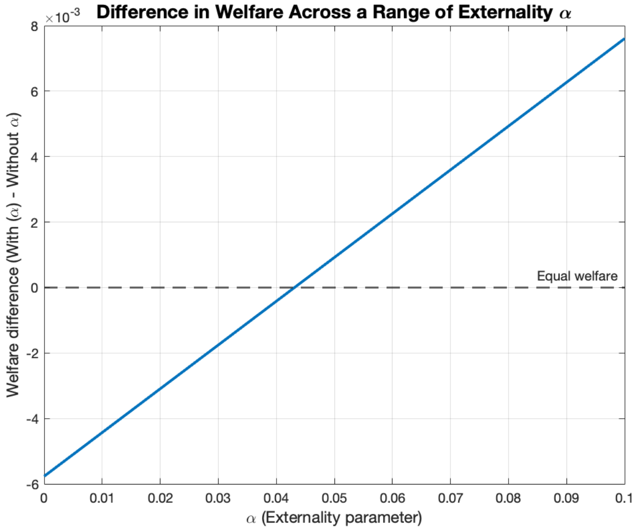

Figure 4. Welfare Gain/Loss as a Function of Externality Parameter α

welfare gain as the externality. The results indicate that $\alpha = 0.0432$ corresponds to a 0.5957% increase in productivity. Thus, subsidizing the green sector becomes welfare-improving if the environmental externality is equivalent to a 0.6% boost in productivity. This provides a novel approach for quantifying environmental externalities and integrating them into labor market models like DMP.

In summary, the results highlight the importance of explicitly accounting for environmental externalities in welfare analysis. This adjustment not only enriches the standard DMP framework but also help quantify the aggregate welfare benefits of green sector expansion.

6 Economic Insights

This analysis shows that the most effective strategy to achieve the green employment target of 14% by 2030 is a combined approach of subsidizing worker entry costs and increasing firm production subsidies in the green sector. At the heart of this strategy is the resolution of a critical coordination friction: workers hesitate to transition into the green sector without job assurances, while firms delay creating green vacancies without a sufficient supply of workers. The combined policy aligns these interdependent decisions, fostering a cycle where firms expand green jobs in response to worker entry, and workers are further encouraged to transition as job opportunities grow.

By reducing worker entry costs, the policy alleviates supply-side barriers, while firm subsidies reduce hiring costs and boost labor demand. Together, these interventions create a self-reinforcing dynamic that improves matching efficiency, minimizes funding requirements, and maximizes welfare. Isolated policies fail to address this coordination, requiring far larger interventions to achieve comparable outcomes, making them less efficient and fiscally burdensome.

The combined approach directly tackles the root cause of labor market frictions, aligning the incentives of workers and firms to unlock the potential of the green economy. It offers the most cost-effective and impactful path to achieving green employment.

7 Conclusion

This paper highlights the pivotal role of resolving coordination frictions between workers and firms to achieve ambitious green employment targets. Using an extended Diamond–Mortensen–Pissarides framework calibrated to the U.S. labor market, we show that a combined policy approach—subsidizing worker entry costs and increasing firm production subsidies—is the most effective strategy for fostering a successful green transition. By addressing the interdependence of decisions—where workers hesitate to enter the green sector without job assurances, and firms delay expansion without a reliable labor supply—the combined approach ensures that workers and firms act in concert, breaking the stalemate that undermines current climate policies.

The findings demonstrate that targeting both worker and firm incentives is significantly more efficient than isolated policies, which fail to address the root coordination problem. The combined strategy aligns labor supply and demand, creating a self-reinforcing dynamic that raises green employment from 2% to 14% of U.S. jobs by 2030 while minimizing fiscal costs, reducing unemployment, and improving aggregate welfare.

Additionally, this paper also provides a framework for incorporating environmental externalities into welfare analysis within the DMP model. This side contribution provides additional tools for evaluating the societal benefits of green employment policies. Together, these insights offer a practical and impactful roadmap for resolving labor market frictions during structural transitions and advancing toward long-term decarbonization goals.

During the preparation of this work, the author used ChatGPT solely to format the LaTeX code and to edit the final content for clarity and presentation. After utilizing this tool, the author thoroughly reviewed and modified the content as necessary and takes full responsibility for the accuracy and integrity of the publication.

References

Bank, W. (2022). Gdp (current us$) - united states. Accessed: 2024-10-18.

BCG, B. C. G. (2023). To reach sustainability goals, organizations must address critical sustainability skills gap. BCG Henderson Institute.

Bistline, J. E. et al. (2023). Economic impacts of the inflation reduction act on u.s. energy and climate policy. *Energy Economics*.

Bluedorn, J., N.-J. Hansen, D. Noureldin, I. Shibata, and M. M. Tavares (2023). Transitioning to a greener labor market: Cross-country evidence from microdata. *Energy Economics 126*, 106836.

Brookings Institute (2022). How renewable energy jobs can uplift fossil fuel communities and remake climate politics.

Bushnell, J. B. and A. Smith (2024). Modeling uncertainty in climate policy: An application to the us ira. Technical report, National Bureau of Economic Research.

Böhringer, C., N. Rivers, and T. F. Rutherford (2013). Climate policy and inequality: An assessment of the social impact of climate policy on income distribution. *Journal of Environmental Economics and Management 66*(2), 211–228.

Consoli, D., G. Marin, A. Marzucchi, and F. Vona (2018). Green skills. *Journal of Environmental Innovation and Societal Transitions 10*, 86–101.

Curtis, E. M. and I. Marinescu (2022). Green energy jobs in the us: What are they, and where are they? Technical report, National Bureau of Economic Research.

Dixit, A. and R. Rob (1994). Switching costs and sectoral shifts: Evidence from microdata. *Quarterly Journal of Economics 109*(4), 1387–1412.

(E2), E. E. (2023). Clean jobs america 2023. Accessed: 2024-10-18.

(EIA), U. E. I. A. (2024). Annual energy outlook. Accessed: 2024-10-18.

Emden, J. and L. Murphy (2019). Power struggle: Fossil fuel jobs, green jobs, and the energy transition. IPPR Environmental Research Report.

FRED Blog, F. R. B. o. S. L. (2024). The job openings to unemployment ratio: Labor markets are in better balance. Accessed: 2024-10-18.

Freire-González, J. (2018). Environmental taxation and the double dividend hypothesis in cge models: A critical review. *Journal of Policy Modeling 40*(1), 194–223.

Fund, I. M. (2022). How the green transition will impact u.s. jobs. Accessed: 2024-10-18.

Geromichalos, A., L. Herrenbrueck, and S. Lee (2023). The strategic determination of the supply of liquid assets. *Review of Economic Dynamics 49*, 1–36.

Gibson, M. and G. Heutel (2023). Environmental policy and business cycles with labor market frictions. *Journal of Environmental Economics and Management 107*, 102–118.

Hafstead, M. A. C. and R. C. Williams III (2018). Environmental policy, full-employment models, and employment: The role of labor market frictions. *Journal of the Association of Environmental and Resource Economists 5*(3), 673–709.

Hafstead, M. A. C., R. C. Williams III, and Y. Chen (2022). Labor market frictions, green jobs, and the energy transition. *Resource and Energy Economics 70*, 101–132.

ILO, I. L. O. (2019). *Skills for a Greener Future: A Global View*. Geneva: International Labour Organization.

International Labor Organization (2024). What is a green job?

IRA, U. C. (2023). Inflation reduction act of 2023. `https://www.congress.gov/bill/117th-congress/house-bill/5376`. Public Law No: 117-169.

Johnson, J. and S. Schulhofer-Wohl (2019). Uneven job growth and geographic mobility. *Journal of Labor Economics 37*(1), 105–133.

Lankhuizen, M., H. Rojas-Romagosa, and C. van Ewijk (2022). Matching jobs with skills during the energy transition: Labor market bottlenecks in the netherlands. *Energy Economics 106*, 104705.

Lim, S. et al. (2023). Spatial mismatch, relocation costs, and employment in transitioning labor markets. *American Economic Journal: Applied Economics*.

LinkedIn (2023). Global green skills report 2023. LinkedIn2023.

LinkedIn (2024). Global climate talent stocktake. Accessed: 2024-10-14.

Oei, P.-Y. et al. (2020). Lessons learned from the coal phase-out in germany: Policies and transition pathways for a sustainable future. *Energy Policy 146*, 1111–1120.

of Energy, U. D. (2023). Fotw #1291, may 22, 2023: Net generation of electricity from renewable sources exceeded coal for the first time in 2022. Accessed: 2024-10-18.

of Labor Statistics (BLS), U. B. (2023). Current population survey (cps). Accessed: 2024-10-18.

Patuelli, R., P. Nijkamp, and E. Pels (2005). Environmental externalities in regional economic models: Concepts, issues and methods. *Environment and Planning A 37*(5), 845–863.

Pissarides, C. A. (2000). *Equilibrium Unemployment Theory*. MIT Press.

Pollin, R., H. Garrett-Peltier, et al. (2020). Green recovery: Assessing the employment impacts of green energy investments for the u.s. *Political Economy Research Institute Report*.

(REA), R. E. A. P. (2024). Total employment comparative trends analysis. Accessed: 2024-10-18.

Sancho, F. (2010). Green tax reforms and double dividend in decentralized economies. *Journal of Environmental Economics and Management 59*(1), 42–53.

Shimer, R. (2005). The cyclical behavior of equilibrium unemployment and vacancies. *American economic review*, 25–49.

Villas-Boas, S. B. (2021). Uncertainty in green job transitions: A labor market analysis.

Vona, F., G. Marin, and D. Consoli (2019). Measures, drivers, and effects of green employment: Evidence from us local labor markets, 2006–2014. *Journal of Economic Geography 19*(5), 1021–1048.

Vona, F., G. Marin, D. Consoli, and D. Popp (2018). Environmental regulation and the greening of jobs: An empirical analysis of the labour market transition. *Journal of the Association of Environmental and Resource Economists 5*(4), 865–891.

VoxEU (2023). Labour markets and the green economy. *VoxEU*. Accessed: 2024-10-18.

Walsh, J. (2023). Bluegreen alliance statement on ira's training and skills gaps.

WorkingNation (2024). Green jobs now: Opportunities for a clean energy future. Accessed: October 2, 2024.

World Nuclear Association (2024). Energy and emissions in the us.

A One-shot DMP Model

In this section, we present a simplified one-shot version of the dynamic model to provide intuition on the interactions between the green and non-green sectors, and how subsidies and entry costs affect equilibrium outcomes. The government's role remains consistent with the dynamic model, as outlined in Section 3.3.5, and the matching probabilities follow the same structure as described in Section 3.1. All the notations are same as the dynamic case except $\pi \in [0,1]$ denote the fractions of unemployed workers who enter the green sector.

A.1 Workers

Unemployed workers must decide whether to enter the green or non-green sector. While the unemployment benefit z is the same in both sectors, entering the green sector requires paying a one-time training cost κ^g. The expected surplus for workers in each sector is:

$$\begin{aligned}&\text{Green: } -\kappa^g + \alpha_w^g w^g + (1-\alpha_w^g)z,\\ &\text{Non-Green: } \alpha_w^n w^n + (1-\alpha_w^n)z.\end{aligned}$$

In equilibrium, workers must be indifferent between entering the green and non-green sectors, implying:

$$-\kappa^g + \frac{v_g}{\pi+v_g}w^g + \left(1-\frac{v_g}{\pi+v_g}\right)z = \frac{v_n}{1-\pi+v_n}w^n + \left(1-\frac{v_n}{1-\pi+v_n}\right)z.$$

This condition ensures that workers' entry into the two sectors is balanced.

A.2 Firms

Firms also face an entry decision between the green and non-green sectors. Productivity y is the same for both, but green firms receive a subsidy τ^g, while non-green firms pay a tax τ. Firms post vacancies until the free entry condition holds. The free entry conditions for both sectors are:

$$
\begin{aligned}
&\text{Green: } c = \alpha_f^g (y + \tau^g - w^g),\\
&\text{Non-Green: } c = \alpha_f^n (y - \tau - w^n).
\end{aligned}
$$

These conditions ensure that firms will continue to post vacancies until the expected profits from hiring a worker equal the cost of posting a vacancy, c.

A.3 Bargaining

Green Sector: In the green sector, wages are determined through Nash bargaining between workers and firms. The solution to the bargaining problem is:

$$
\begin{aligned}
&\max_{w^g} (w^g - z)^\theta (y + \tau^g - w^g)^{1-\theta},\\
&\implies \frac{\theta}{w^g - z} = \frac{1-\theta}{y + \tau^g - w^g},\\
&\therefore w^g = \theta(y + \tau^g) + (1-\theta) z.
\end{aligned}
$$

The wage in the green sector depends positively on the firm's productivity y and the green subsidy τ^g, while the worker's outside option is captured by z.

Non-Green Sector: In the non-green sector, the wage bargaining process is analogous, except for the presence of the tax τ imposed on firms. The resulting wage is:

$$
\begin{aligned}
&\max_{w^n} (w^n - z)^\theta (y - \tau - w^n)^{1-\theta},\\
&\implies \frac{\theta}{w^n - z} = \frac{1-\theta}{y - \tau - w^n},\\
&\therefore w^n = \theta(y - \tau) + (1-\theta) z.
\end{aligned}
$$

Here, the wage in the non-green sector is lower due to the tax burden τ on firms.

A.4 Interior Equilibrium with Both Sectors Operating

In equilibrium, firms and workers optimally choose their sectors. The endogenous variables are π, v_g, v_n, w_g, w_n, and τ. The system of equilibrium conditions is:

$$
\begin{aligned}
c &= \frac{\pi}{\pi + v_g}(y + \tau^g - w^g), \\
c &= \frac{1-\pi}{1-\pi+v_n}(y - \tau - w^n), \\
w^g &= \theta(y + \tau^g) + (1-\theta)z, \\
w^n &= \theta(y - \tau) + (1-\theta)z, \\
\tau &= \tau^g \cdot \frac{\frac{\pi}{(\pi+v^g)} \cdot v^g}{\frac{(1-\pi)}{(1-\pi+v^n)} \cdot v^n}, \\
\pi &= \begin{cases} 0 & \text{if } G < N, \\ \in (0,1) & \text{if G = N}, \\ 1 & \text{if } G > N. \end{cases}
\end{aligned}
$$

$$
G = -\kappa^g + \frac{v_g}{\pi + v_g} w^g + \left(1 - \frac{v_g}{\pi + v_g}\right) z \quad \text{and} \quad N = \frac{v_n}{1-\pi+v_n} w^n + \left(1 - \frac{v_n}{1-\pi+v_n}\right) z.
$$

A.5 Corner Equilibria

The model also allows for corner equilibria where only one sector operates.

A.5.1 Corner Equilibrium: $\pi = 0$, $v_g = 0$

It must be the case that $v_g = 0$ iff $\pi = 0$. In this case, only non-green labor market operates with $v_n > 0$ and the matching probabilities become:$\alpha_{wg} = \alpha_{fg} = 0, \alpha_{wn} = \frac{v_n}{1+v_n}$, and $\alpha_{fn} = \frac{1}{1+v_n}$. The equilibrium conditions are:

$$
\begin{aligned}
&v_g = 0, \\
&c = \frac{1}{1+v_n}(y - \tau - w^n), \\
&w^g = \theta(y + \tau^g) + (1-\theta)z, \\
&w^n = \theta(y - \tau) + (1-\theta)z, \\
&\tau = \tau_g = 0, \\
&\pi = 0, \text{with } G < N,
\end{aligned}
$$

where G and N are the expected utilities in the green and non-green sectors, respectively:

$$G = -\kappa^g + z, \quad N = \frac{v_n}{1+v_n} w^n + \left(1 - \frac{v_n}{1+v_n}\right) z, \quad \text{and} \quad G - N = -(1-s_g)\kappa_g - \frac{v_n}{1+v_n}(w^n - z) < 0.$$

A.5.2 Corner Equilibrium: $\pi = 1$, $v_n = 0$

It must be the case that $v_n = 0$ iff $\pi = 1$. In this case, only green labor market operates with $v_g > 0$ and the matching probabilities become:$\alpha_{wn} = \alpha_{fn} = 0, \alpha_{wg} = \frac{v_g}{1+v_g}$, and $\alpha_{fn} = \frac{1}{1+v_g}$. The equilibrium conditions are:

$$\begin{aligned}
&v_n = 0, \\
&c = \frac{1}{1+v_g}(y + \tau^g - w^g), \\
&w^g = \theta(y + \tau^g) + (1-\theta)z, \\
&w^n = \theta(y - \tau) + (1-\theta)z, \\
&\tau = \tau_g = 0, \\
&\pi = 1, \text{with } G > N,
\end{aligned}$$

where G and N are the expected utilities in the green and non-green sectors, respectively:

$$G = -\kappa^g + \frac{v_g}{1+v_g} w^g + \left(1 - \frac{v_g}{1+v_g}\right) z, \quad N = z, \quad \text{and} \quad G - N = -(1-s_g)\kappa_g + \frac{v_g}{1+v_g}(w^g - z) > 0.$$

A.5.3 Equilibrium

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 and vacant firms respectively who choose to be green π, and a green production subsidy τ^g given a flat tax τ that satisfy the above listed equilibrium conditions.

Proposition 1. *There are multiple equilibria with following properties*[7]*:*

- *$\exists$ a corner equilibrium where $\pi = 0$ and there are no jobs/production in the economy is green.*

---

[7] In a different context centered on asset liquidity, (Geromichalos, Herrenbrueck, and Lee, 2023) investigates how agents select among various asset markets when faced with random liquidity demands, deriving a solution that mirrors the characterization presented here.

- *∃ a corner equilibrium where* $\pi = 1$ *and all jobs/production in the economy is green.*
- *For CRS case with* $\psi = 0$, $\lim_{\pi \to 0^+} G(\pi) > 0 > G(0)$ *and* $\lim_{\pi \to 1^-} G(\pi) < 0 < G(1)$, *i.e. the corner equilibria are not robust to small trembles, but ∃ at least one robust interior equilibrium.*

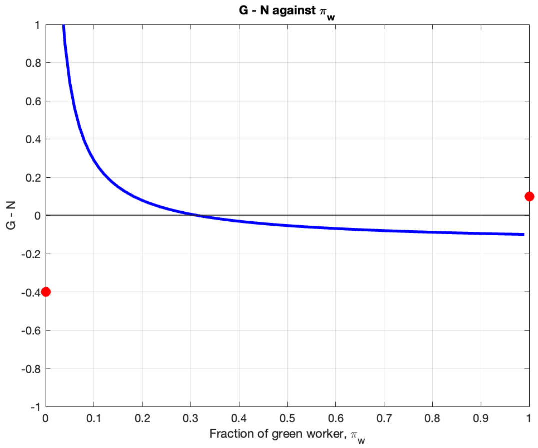

Figure 5. Multiplicity of equilibria (CRS) in the one-shot version

A.6 Comparative Statics

We can conduct comparative statics in the one-shot model to illustrate the main channel. As shown in Figure 6, decreasing workers' entry cost increases the equilibrium entry into the green sector, while Figure 7 shows that increasing firm subsidies similarly raises green sector entry.

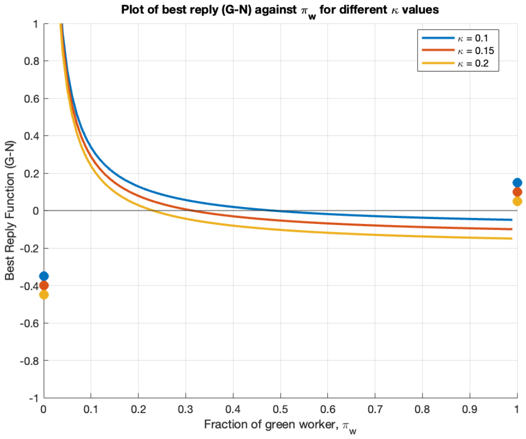

Figure 6. Increasing training cost decreases equilibrium entry into green sector

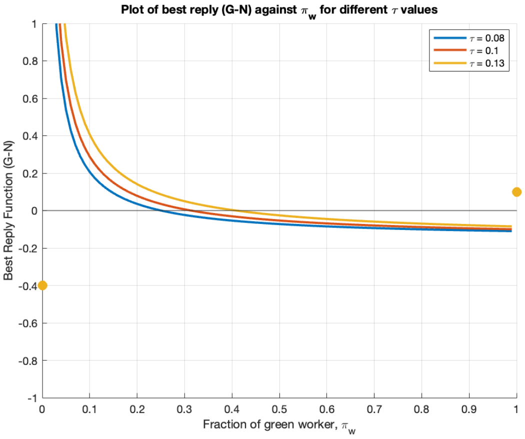

Figure 7. Increasing green subsidy increases equilibrium entry into green sector

B Bargaining Problem in the Dynamic Model

B.1 Bargaining Problem in non-green Jobs

Proof. The bargaining problem in non-green jobs is: $(1-\eta)(W_n - U_n) = \eta J_n$.

B.1.1 Derivation of the wage in the non-green sector w_n

Let's start with the value function of unemployed workers in the non-green sector U_n from equation (9):

$$U_n = z + \beta\left[\alpha_{wn} W_n + (1-\alpha_{wn})U_n\right] \implies U_n = \frac{z}{1-\beta(1-\alpha_{wn})} + \frac{\beta\alpha_{wn}W_n}{1-\beta(1-\alpha_{wn})} \tag{A.1}$$

Not, let's turn to the value function of employed workers in the non-green sector W_n from equation (11):

$$\begin{aligned}
&W_n = w_n + \beta\left[(1-\lambda)W_n + \lambda U_n\right] \\
&\implies \left[1-\beta(1-\lambda)\right]W_n = w_n + \beta\lambda U_n \\
&\implies \left[1-\beta(1-\lambda)\right]W_n = w_n + \beta\lambda\left[\frac{z}{1-\beta(1-\alpha_{wn})} + \frac{\beta\alpha_{wn}W_n}{1-\beta(1-\alpha_{wn})}\right] \\
&\implies W_n = \frac{w_n}{1-\beta(1-\lambda)} + \frac{\beta\lambda}{1-\beta(1-\lambda)}\left[\frac{z}{1-\beta(1-\alpha_{wn})} + \frac{\beta\alpha_{wn}W_n}{1-\beta(1-\alpha_{wn})}\right] \\
&\implies W_n\left[1 - \frac{\beta^2\lambda\alpha_{wn}}{(1-\beta(1-\lambda))(1-\beta(1-\alpha_{wn}))}\right] = \frac{w_n}{1-\beta(1-\lambda)} + \frac{\beta\lambda}{1-\beta(1-\lambda)}\left[\frac{z}{1-\beta(1-\alpha_{wn})}\right] \\
&\implies W_n\left[\frac{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}{(1-\beta(1-\lambda))(1-\beta(1-\alpha_{wn}))}\right] = \frac{w_n}{1-\beta(1-\lambda)} + \frac{\beta\lambda}{1-\beta(1-\lambda)}\left[\frac{z}{1-\beta(1-\alpha_{wn})}\right] \\
&\implies W_n = \frac{w_n(1-\beta(1-\alpha_{wn})) + \beta\lambda z}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}
\end{aligned}$$

Now, let's plug this back to the equation (A.1):

$$\begin{aligned}
U_n &= \frac{z}{1-\beta(1-\alpha_{wn})} + \frac{\beta\alpha_{wn}W_n}{1-\beta(1-\alpha_{wn})} \\
&= \frac{z}{1-\beta(1-\alpha_{wn})} + \frac{\beta\alpha_{wn}}{1-\beta(1-\alpha_{wn})}\left[\frac{w_n(1-\beta(1-\alpha_{wn}))+\beta\lambda z}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}\right] \\
&= \frac{z}{1-\beta(1-\alpha_{wn})} + \frac{\beta\alpha_{wn}w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))} \\
&+ \frac{\beta^2\lambda\alpha_{wn}z}{(1-\beta)(1-\beta(1-\alpha_{wn}))(1-\beta(1-\alpha_{wn}-\lambda))} \\
&= \frac{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))+\beta^2\lambda\alpha_{wn}}{(1-\beta)(1-\beta(1-\alpha_{wn}))(1-\beta(1-\alpha_{wn}-\lambda))}\cdot z + \frac{\beta\alpha_{wn}}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}\cdot w_n \\
&= \frac{(1-\beta(1-\lambda))(1-\beta(1-\alpha_{wn}))}{(1-\beta)(1-\beta(1-\alpha_{wn}))(1-\beta(1-\alpha_{wn}-\lambda))}\cdot z + \frac{\beta\alpha_{wn}}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}\cdot w_n \\
&\implies U_n = \frac{(1-\beta(1-\lambda))\cdot z+\beta\alpha_{wn}\cdot w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}
\end{aligned}$$

Subtracting U_n from W_n above, we get:

$$\begin{aligned}
&\implies W_n - U_n = \left[\frac{w_n(1-\beta(1-\alpha_{wn}))+\beta\lambda z}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}\right] - \left[\frac{(1-\beta(1-\lambda))\cdot z+\beta\alpha_{wn}\cdot w_n}{(1-\beta)(1-\beta(1-\alpha_{wn}-\lambda))}\right] \\
&\therefore W_n - U_n = \left[\frac{w_n - z}{1-\beta(1-\alpha_{wn}-\lambda)}\right].
\end{aligned}$$

Going back to the bargaining problem,

$$(1-\eta)(W_n - U_n) = \eta J_n$$

Plugging in the equations from above and plugging the value of J_n from (7), we get:

$$\begin{aligned}
&(1-\eta)\left[\frac{w_n - z}{1-\beta(1-\alpha_{wn}-\lambda)}\right] = \eta\frac{p-\tau-w_n}{1-\beta(1-\lambda)} \\
&\implies w_n\left[\frac{1-\eta}{1-\beta(1-\alpha_{wn}-\lambda)} + \frac{\eta}{1-\beta(1-\lambda)}\right] = \frac{\eta(p-\tau)}{1-\beta(1-\lambda)} + \frac{(1-\eta)z}{1-\beta(1-\alpha_{wn}-\lambda)} \\
&\implies w^n = \frac{(1-\eta)z[1-\beta(1-\lambda)]+\eta(p-\tau)[1-\beta(1-\lambda-\alpha_{wn})]}{[1-\beta(1-\lambda-\eta\alpha_{wn})]}
\end{aligned}$$

i.e. $\tau\uparrow \implies w^n\downarrow$. □

B.2 Bargaining Problem in Green Jobs

Proof. The bargaining problem in green jobs is: $(1-\eta)(W^g - U^g) = \eta J^g$.

B.2.1 Derivation of the wage in the green sector w_g

Let's start with the value function of unemployed workers in the green sector U_g from equation (8):

$$U_g = z - (1-s_g)\kappa_g + \beta\left[\alpha_{wg} W_g + (1-\alpha_{wg})U_g\right] \implies U_g = \frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})} + \frac{\beta\alpha_{wg}W_g}{1-\beta(1-\alpha_{wg})} \tag{A.2}$$

Not, let's turn to the value function of employed workers in the green sector W_g from equation (10):

$$\begin{aligned}
&W_g = w_g + \beta\left[(1-\lambda)W_g + \lambda U_g\right] \\
&\implies \left[1-\beta(1-\lambda)\right] W_g = w_g + \beta\lambda U_g \\
&\implies \left[1-\beta(1-\lambda)\right] W_g = w_g + \beta\lambda\left[\frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})} + \frac{\beta\alpha_{wg}W_g}{1-\beta(1-\alpha_{wg})}\right] \\
&\implies W_g = \frac{w_g}{1-\beta(1-\lambda)} + \frac{\beta\lambda}{1-\beta(1-\lambda)}\left[\frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})} + \frac{\beta\alpha_{wg}W_g}{1-\beta(1-\alpha_{wg})}\right] \\
&\implies W_g\left[1 - \frac{\beta^2\lambda\alpha_{wg}}{(1-\beta(1-\lambda))(1-\beta(1-\alpha_{wg}))}\right] = \frac{w_g}{1-\beta(1-\lambda)} + \frac{\beta\lambda}{1-\beta(1-\lambda)}\left[\frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})}\right] \\
&\implies W_g\left[\frac{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}{(1-\beta(1-\lambda))(1-\beta(1-\alpha_{wg}))}\right] = \frac{w_g}{1-\beta(1-\lambda)} + \frac{\beta\lambda}{1-\beta(1-\lambda)}\left[\frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})}\right] \\
&\implies W_g = \frac{w_g(1-\beta(1-\alpha_{wg})) + \beta\lambda(z-(1-s_g)\kappa_g)}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}
\end{aligned}$$

Now, let's plug this back to the equation (A.2):

$$\begin{aligned}
&U_g = \frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})} + \frac{\beta\alpha_{wg}W_g}{1-\beta(1-\alpha_{wg})} \\
&= \frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})} + \frac{\beta\alpha_{wg}}{1-\beta(1-\alpha_{wg})}\left[\frac{w_g(1-\beta(1-\alpha_{wg})) + \beta\lambda(z-(1-s_g)\kappa_g)}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}\right] \\
&= \frac{z-(1-s_g)\kappa_g}{1-\beta(1-\alpha_{wg})} + \frac{\beta\alpha_{wg}w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))} \\
&+ \frac{\beta^2\lambda\alpha_{wg}(z-(1-s_g)\kappa_g)}{(1-\beta)(1-\beta(1-\alpha_{wg}))(1-\beta(1-\alpha_{wg}-\lambda))}
\end{aligned}$$

$$
\begin{aligned}
&= \frac{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))+\beta^2\lambda\alpha_{wg}}{(1-\beta)(1-\beta(1-\alpha_{wg}))(1-\beta(1-\alpha_{wg}-\lambda))}\cdot(z-(1-s_g)\kappa_g)\\
&+\frac{\beta\alpha_{wg}}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}\cdot w_g\\
&= \frac{(1-\beta(1-\lambda))(1-\beta(1-\alpha_{wg}))}{(1-\beta)(1-\beta(1-\alpha_{wg}))(1-\beta(1-\alpha_{wg}-\lambda))}\cdot(z-(1-s_g)\kappa_g)\\
&+\frac{\beta\alpha_{wg}}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}\cdot w_g\\
&\implies U_g = \frac{(1-\beta(1-\lambda))\cdot(z-(1-s_g)\kappa_g)+\beta\alpha_{wg}\cdot w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}
\end{aligned}
$$

Subtracting U_g from W_g, we get:

$$
\begin{aligned}
&\implies W_g-U_g = \left[\frac{w_g(1-\beta(1-\alpha_{wg}))+\beta\lambda(z-(1-s_g)\kappa_g)}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}\right]\\
&-\left[\frac{(1-\beta(1-\lambda))\cdot(z-(1-s_g)\kappa_g)+\beta\alpha_{wg}\cdot w_g}{(1-\beta)(1-\beta(1-\alpha_{wg}-\lambda))}\right]\\
&\therefore W_g-U_g = \left[\frac{w_g-(z-(1-s_g)\kappa_g)}{1-\beta(1-\alpha_{wg}-\lambda)}\right].
\end{aligned}
$$

Going back to the bargaining problem:

$$(1-\eta)(W_g-U_g)=\eta J_g.$$

Plugging in the equations from above and plugging the value of J_g from (6), we get:

$$
\begin{aligned}
&(1-\eta)\left[\frac{w_g-(z-(1-s_g)\kappa_g)}{1-\beta(1-\alpha_{wg}-\lambda)}\right]=\eta\frac{p+\tau_g-w_g}{1-\beta(1-\lambda)}\\
&\implies w_g\left[\frac{1-\eta}{1-\beta(1-\alpha_{wg}-\lambda)}+\frac{\eta}{1-\beta(1-\lambda)}\right]=\frac{\eta(p+\tau_g)}{1-\beta(1-\lambda)}+\frac{(1-\eta)(z-(1-s_g)\kappa_g)}{1-\beta(1-\alpha_{wg}-\lambda)}\\
&\implies w_g=\frac{(1-\eta)(z-(1-s_g)\kappa_g)[1-\beta(1-\lambda)]+\eta(p+\tau_g)[1-\beta(1-\lambda-\alpha_{wg})]}{[1-\beta(1-\lambda-\eta\alpha_{wg})]}.
\end{aligned}
$$

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