Labor Market Disruptions and Gendered Reservation Wages

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Abstract

This study analyzes labor supply dynamics and the vulnerabilities of social reproduction in Puerto Rico following exogenous economic shocks. It extends the concept of reservation wages by incorporating compelling and coercive forces that shape workers' opportunity sets and decisions. A two sector model of labor reproduction that reflects gendered labor market segmentation is developed, drawing on Setterfield (2024), Charpe et al. (2014), and Greiner et al. (2004). Empirically, a Markov Switching dynamic regression model is used to estimate transition probabilities and regime shifts across employment states in the post disaster context. The results indicate marked gender asymmetries. Women experience longer unemployment durations with an average of 2.48 months compared to 1.93 months for men, and they spend more time in turbulent regimes where exits from unemployment are less likely. Stationary distributions confirm a higher long run probability of women remaining unemployed, while men transition more frequently into self employment or alternative work. Expansionary episodes for women appear as short lived states that collapse quickly into contraction, which reflects the fragility of their labor market dynamics. The evidence shows that climate related shocks reinforce pre existing gender inequalities by altering reservation wages through both compelling and coercive forces. These mechanisms link structural barriers in social reproduction to persistent vulnerabilities in labor market recovery.

Keywords: Reservation wages, Disruptions, Social reproduction, Markov Switching Models, Gender segmentation, Puerto Rico
JEL classification, C32, J22, E12, Q54

1. Introduction

Hurricane María struck Puerto Rico on September 20, 2017, as a Category 4 storm, causing catastrophic damage, an island-wide power outage, and a humanitarian crisis. The storm arrived less than two weeks after Hurricane Irma, compounding the devastation. These hurricanes disrupted daily life and sharply reduced employment opportunities.

This study examines how workers respond to large economic shocks, focusing on how socially constructed opportunity sets shape their labor market decisions. Drawing on Stiglitz's (2024) notion of freedom, I analyze the compelling and coercive forces that influence reservation wages. This framing highlights how an individual's opportunity set is constrained by structural pressures, especially during periods of disruption, limiting the range of feasible choices.

⋆All errors are my own.

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In labor economics, the reservation wage is defined as the minimum wage an individual is willing to accept before entering employment. Prior work shows that this threshold depends not only on market wages but also on the value of time spent outside paid work, sometimes referred to as the value of home time (Ferber & Green, 1985; Sharpe & Abdel-Ghany, 1997). For women, unpaid domestic and care work raises this opportunity cost, leading to higher reservation wages relative to market offers (Duncan, 1992). These dynamics contribute to persistent gender gaps in labor force participation, which may widen after shocks when caregiving demands intensify.

Workers with limited bargaining power often enter non-standard arrangements, such as gig or temporary jobs. These positions typically offer flexibility but lack benefits such as health coverage or retirement plans. Workers in these arrangements are more likely to accept lower reservation wages, reflecting coercion rather than voluntary entry.

This study builds on these insights by investigating how shocks alter the relationship between reservation wages, employment outcomes, and gender disparities. A central hypothesis is that heightened economic need reduces reservation wages and raises labor force participation. The findings, however, suggest a more complex reality. While some groups do enter at lower thresholds, women remain unemployed longer and are more likely to cycle through unstable labor market states. This persistence points to structural and social constraints that keep women's reservation wages relatively high despite adverse conditions.

The analysis challenges standard labor supply models that treat job acceptance as a voluntary and utility-maximizing choice. Preferences are instead understood as endogenous, shaped by care obligations, institutional norms, and social roles. What appears to be individual choice may reflect deeper structural barriers. To address this, I extend reservation wage theory with the concepts of compelling and coercive forces, which capture the external pressures that push workers into or keep them out of employment.

Coercion can expand access to labor market participation, particularly for marginalized groups, but the resulting jobs are not always stable or socially optimal. This perspective helps explain why shocks produce gender-differentiated impacts and why labor market hierarchies persist. By acknowledging the endogeneity of preferences, the analysis reconsiders standard labor supply models and raises questions about the distributional consequences of labor market adjustment.

The theoretical model developed in this study builds on three main frameworks to construct a two-sector model of labor reproduction with disruptions and segmentation. Setterfield (2024) incorporates care work and social reproduction into macroeconomic theory, highlighting gender as a structural source of stratification. Charpe et al. (2014) provide a framework for modeling labor flows in segmented labor markets with heterogeneous agents. Greiner et al. (2004) contribute an approach with two types of workers and differentiated wage structures to capture wage inequality and segmentation. Together, these frameworks provide the foundation for a model in which gendered labor segmentation interacts with output, investment, and demand.

Empirically, I use a Markov Switching dynamic regression model to estimate transition probabilities between employment states—employment, unemployment, and out of the labor

force—in the post-disaster context. The results show marked gender asymmetries. Women experience longer unemployment durations, averaging 2.48 months compared to 1.93 months for men. They are also more likely to remain in turbulent regimes where exits from unemployment are less frequent. Stationary distributions confirm a higher long-run probability of women remaining unemployed, while men transition more often into self-employment or alternative work. Expansionary episodes for women appear as short-lived states that collapse quickly into contraction, underscoring the fragility of their employment dynamics.

Two measures further highlight these differences. Expected durations capture how long groups remain in a given state, while the stationary distribution reflects long-run tendencies. Both indicate that women face greater persistence in unemployment and more volatile outcomes after shocks. These findings show that climate-related shocks interact with structural inequalities, reinforcing gender-specific vulnerabilities in labor market recovery.

The remainder of the study is structured as follows. Section 2 develops the concept of compelling and coercive forces within reservation wage theory. Section 3 introduces the macro model with gendered labor segmentation. Section 4 illustrates the two-sector model using a Lotka–Volterra system. Section 5 presents the empirical analysis with the Markov Switching framework.

2. Puerto Rican Labor Market

Understanding labor supply decisions in Puerto Rico requires a deeper look into the economic challenges that have shaped employment patterns across decades. Since the mid-twentieth century, Puerto Rico's economy has undergone significant structural shifts. Operation Bootstrap in the 1950s spurred industrialization through tax incentives and manufacturing expansion, prompting massive rural-to-urban migration. However, in the 1970s, deindustrialization reversed many of these gains, as global competition and rising labor costs triggered a decline in manufacturing (Dietz, 1986).

Policymakers promoted fertility reduction efforts. By the late 1960s, more than one-third of Puerto Rican women of childbearing age had been sterilized, one of the highest rates globally (Presser, 1969). Access to contraceptives, including early birth control pill trials, was further expanded (Briggs, 2002). While population policies successfully curbed natural growth, overall population size became increasingly determined by migratory flows rather than birth rates (Santiago, 1992). Today, Puerto Rico's fertility rate ranks among the lowest worldwide, accelerating demographic aging and reshaping labor force composition (World Bank, 2023).

Large-scale migration to the mainland United States, particularly among younger and more educated workers, also deeply impacted the labor market (Rivera-Batiz and Santiago, 1996). Puerto Rico's close political and economic relationship with the United States offers migration as an alternative labor market strategy. The opportunity to earn significantly higher wages outside the island establishes a wage floor locally, Migration serves both as a safety valve and as a comparison benchmark, encouraging individuals to hold out for higher-paying jobs (Freeman

& Encahuntegui, (2005). More recently, fiscal austerity measures under the PROMESA Act of 2016 exacerbated economic hardship through public sector cuts and layoffs, further straining employment opportunities on Puerto Rico.

2.1. Gender Patterns

Gender dynamics in Puerto Rico's labor market have shifted over the past two decades. Female labor force participation increased from 37.9% in 1990 to a peak of 45.2% in 2005, while male participation declined from 68.5% to 59.8% over the same period (U.S. Bureau of Labor Statistics, 2023).

Yet, despite these gradual gains, significant gender disparities remain. Women not only participate at lower rates than men but also face a persistent earnings gap, even after accounting for educational attainment.

Figure 1 shows average earnings by gender and education level, demonstrating that across all groups, women consistently earn less than men. This disparity reflects structural inequalities that influence labor market outcomes beyond participation decisions. It suggests that barriers to equitable employment are rooted both in access to the labor market and in the conditions within it.

Given the high levels of female educational attainment, these persistent wage gaps are especially important for understanding how structural coercion shapes labor market choices, particularly in post-disaster contexts where economic opportunities are limited.

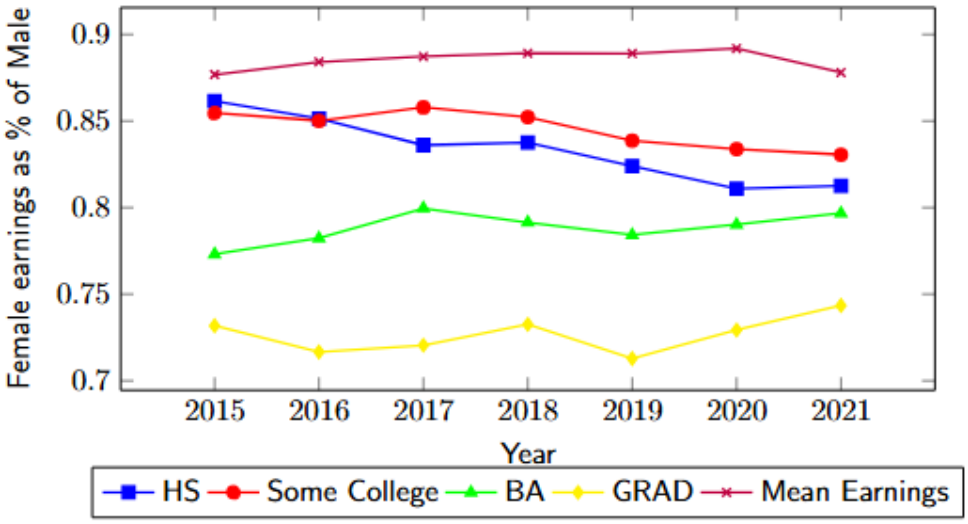

Figure 1: Female Earnings as Percentage of Males' Earnings by Education (2015-2021) in Puerto Rico (Sources: U.S. Census, Puerto Rico Community Survey)

Figure 2 shows unemployment rates by gender between 2013 and 2021. Both male and female unemployment rates have trended downward over the period, though differences persist.

A central debate on Puerto Rico's low labor force participation centers on reservation wages and the role of public assistance. Studies suggest that income transfers, such as U.S. federal

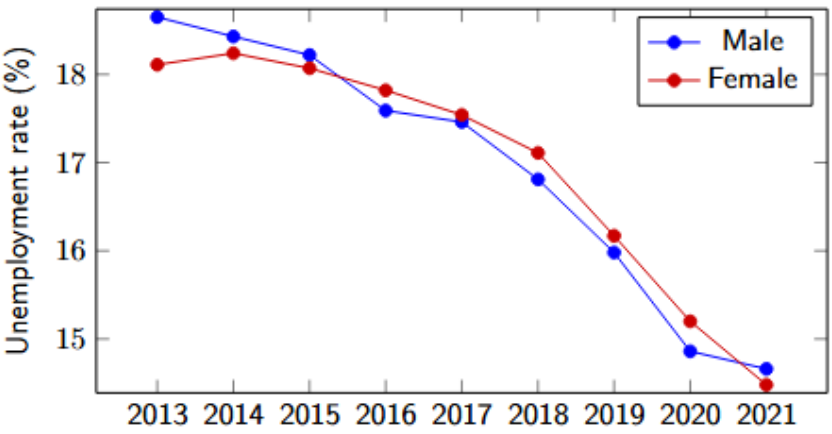

Figure 2: Unemployment Rate by Gender (2013–2021)

programs including unemployment insurance and welfare, raise reservation-wage thresholds, discouraging job search and labor supply, particularly among low-skilled men. Field evidence from San Juan's Caño Martín Peña, for example, reported an average reservation wage of $7 per hour, above the prevailing minimum wage at the time, supporting the view that non-labor income reduces the urgency to accept low-wage employment (Enchautegui & Freeman, 2006). This interpretation is consistent with micro-evidence showing that reservation wages begin high and decline gradually over unemployment spells (Krueger & Mueller, 2016), as well as with research on unemployment insurance highlighting liquidity effects on search duration (Chetty, 2008).

Building on this perspective, Enchautegui (1997) examined how social programs and economic insecurity shaped women's labor force participation. For women, reservation-wage dynamics were determined by caregiving responsibilities, the availability of part-time work, and family structure (Enchautegui, 1997; Krueger & Mueller, 2016). Cordero-Guzmán (2016) extended the analysis by emphasizing structural factors, including weak labor demand, educational mismatches, and the fragmentation of formal employment, which all elevate effective reservation wages beyond what income effects alone would predict.

2.2. Disruptions and Workers

Hurricane María in September 2017 severely disrupted Puerto Rico's labor market. The island lost about 40,000 jobs in the month following the storm, with total employment dropping to roughly 925,000, the lowest level since the late 1980s (Figure 3). Although some jobs were later restored, employment remained tens of thousands below pre-storm levels a year after María.

The shock also accelerated changes in employment arrangements. Workers can be grouped into three broad categories: salaried employees, the self-employed, and those in alternative work such as contract firm placements, temporary agency jobs, and gig employment. Self-employment rebounded most strongly during the recovery, suggesting that many turned to freelance or own-account work. By Fiscal Year 2021, Puerto Rico's self-employed workforce had reached about

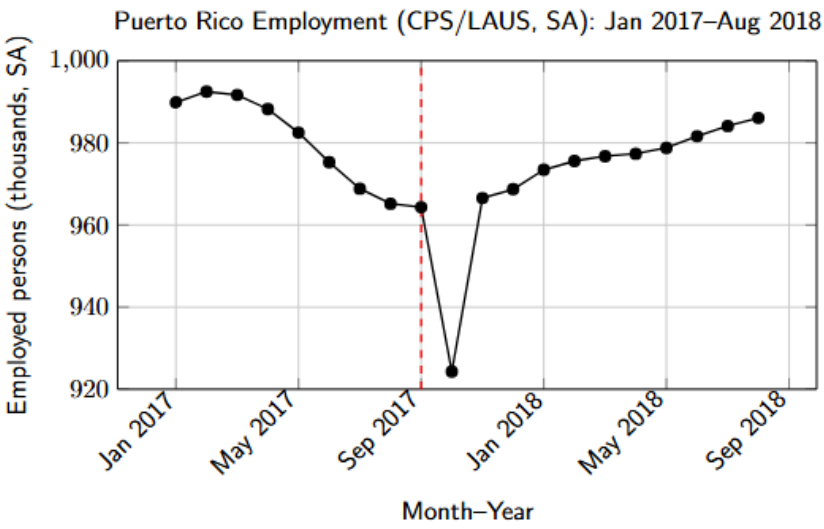

Figure 3: Employed individuals (Jan 2017 – September 2018)

173,000, the highest level in more than a decade.[1]. For comparison, self-employment stood at about 159,000 in 2011 and declined to around 149,000 by 2014, before rising again after 2017. This increase helped offset some of the losses in formal jobs. Men in particular shifted into self-employment after the hurricane, and by 2021, the number of women in salaried positions slightly exceeded that of men. This reversal of earlier patterns occurred partly because many male workers moved into independent work **?**.

Earnings among the self-employed are highly uneven. A small group may earn relatively high incomes, but median earnings are typically lower than those of salaried employees, since many self-employed operate small-scale businesses. For example, one report by the Labor Department of Puerto Rico found that when all income sources (wages plus self-employment) were included, Puerto Rico's median earnings at one point were higher for women. However, when only salaried wages were considered, men continued to earn more [2].

This evidence suggests that including self-employment income, where men are overrepresented and incomes are more dispersed, raises men's overall earnings. At the same time, a typical self-employed worker likely earns less than a salaried employee in a stable job, especially once benefits are considered. In addition, Puerto Rico's minimum wage and labor protections often do not extend to independent contractors, leaving many gig workers with relatively low hourly pay. Recent tax data show that both salaries and self-employment earnings have been rising. Average salaries increased by about five percent in 2023, and the growth of professional-services income points to robust demand for independent work.[3]

[1]See the Puerto Rico Economic Analysis Report 2020-2021.dol.gov
[2]See Labor Department of Puerto Rico repost 2023 (trabajo.pr.gov)
[3]See Puerto Rico Fiscal Agency and Financial Advisory Authority Report 2023 (aafaf.pr.gov)

2.3. *Gender Disparities and Work Arrangements*

Gender differences in work arrangements remain pronounced in Puerto Rico. Men are more likely to be self-employed or engaged in independent contracting, while women are concentrated in wage-and-salary employment, particularly in education, health, and public services. Official statistics from the Labor Department of Puerto Rico indicate that men account for the majority of the self-employed, while women remain underrepresented in management and higher-paying occupations [4].

Although Puerto Rico has at times exhibited a narrower gender pay gap than the mainland United States, recent data show widening disparities. Men's wages have grown more rapidly in post-disaster reconstruction and other sectors dominated by male workers, while women's earnings have risen more slowly in service-oriented and part-time jobs. As a result, women's median pay in 2023 was substantially below that of men when focusing on formal sector wages.[5].

The informal sector, estimated to account for more than one-fifth of Puerto Rico's economy, is also significant for understanding gender disparities. Women are disproportionately represented in informal or household-based work, where earnings are lower and benefits are absent. These activities are generally not captured by payroll records or official surveys, which suggests that the measured wage gap likely understates the true extent of gender inequality in earnings.

Alternative work arrangements such as gig jobs, on-call work, and short-term contracting have also expanded in Puerto Rico following economic shocks, including Hurricane María and the COVID-19 pandemic. While reliable estimates are limited, self-employment rates remain considerably higher than in the mainland United States, and survey evidence points to growth in independent and non-employer businesses (Golden, 2001).[6] These forms of work typically lack employer-provided benefits, leaving workers—many of them women—without health coverage, paid leave, or retirement plans.

2.4. *Vulnerabilities and Social Reproduction of Labor in Puerto Rico*

The concept of social reproduction implies that daily activities, such as caregiving, household maintenance, and raising the next generation of workers, are crucial for sustaining the economy, yet they often remain undervalued. As Katz (2001) notes, "the notion of social reproduction has multiple meanings and is part and parcel of several foundational debates in feminist scholarship." For Katz, social reproduction is the "daily and long-term reproduction of the mode of production and the labor power that makes it work." Braunstein (2018) extends this view, defining social reproduction as "the time and money it takes to produce, maintain and invest in the labor force." In other words, social reproduction encompasses all the work—paid and unpaid, as well as the institutions and cultural practices that regenerate society across generations. Katz further reminds us that this labor does not end "at the factory door," but continues in the home and community,

[4]See Departamento del Trabajo y Recursos Humanos. (2024)
[5]See Puerto Rico Treasury yearly W-2 Report 2023
[6]See Puerto Rico Economic Analysis Report 2020-2021.dol.gov

effectively subsidizing capital by lowering the cost of labor. Struggles over who bears these costs, whether capital, the state, or households, remain central to capitalist development, particularly as neoliberal reforms have shifted more responsibilities onto families. In Puerto Rico, extended family networks and informal caregiving economies have historically absorbed a disproportionate share of this burden, especially under conditions of economic restructuring.

Safa (1984) examines Puerto Rican women during the island's industrialization under Operation Bootstrap and illustrates how these caregiving structures were both relied upon and strained. One of the main findings was that young, single women were preferred as factory workers for their perceived docility and fewer household burdens. In contrast, older and married women often have dual responsibilities of wage labor and family support. Factory closures made many women face challenging migration patterns, reshaping household reproduction and gender roles in Puerto Rico.

The relationship between vulnerability and social reproduction became even more evident during major disasters. Segarra Alméstica (2019) documents how Hurricane Maria exposed preexisting vulnerabilities in Puerto Rican society, such as poverty, housing, and limited infrastructure. Vulnerable populations—including women, the elderly, disabled individuals, and rural residents—faced the brunt of these structural weaknesses. Segarra Alméstica proposes a vulnerability index, identifying key dimensions such as socioeconomic status, household composition, minority status, and housing conditions.

In addition to economic and structural vulnerabilities, Segarra Alméstica also highlights the critical role of social capital in disaster resilience. Drawing on scholars like Putnam (1994) and Aldrich (2010), she argues that communities with stronger social networks, norms of trust, and mutual aid can better prepare for, withstand, and recover from natural disasters. Evidence from events such as the 2004 tsunami in Sri Lanka and Hurricane Katrina shows that local social ties often determine the speed and equity of recovery. In Puerto Rico, strong community ties became vital after Hurricane Maria, facilitating recovery efforts and promoting collective action where government support was insufficient.

The table 1 provides a snapshot of vulnerable groups as of 2017–2018. Out of a total population of approximately 3.2 million, significant shares faced structural barriers to workforce participation.[7] About 46.7% lived below the poverty line, and 38.3% received SNAP benefits, reflecting widespread economic hardship. Other barriers included high rates of disability (23%), older age (21%), and low English proficiency (20%). Additional challenges, such as single parenthood, low literacy, veteran status, youth disconnection from work and education, racial minority status, criminal records, and homelessness, further complicate labor market entry for smaller groups. Importantly, individuals may belong to multiple categories, and figures are not additive.

Braunstein, Seguino, and Altringer (2018) connect the organization of social reproduction to

[7]Note: One individual can be counted in several groups. Numbers cannot be added. (*) Teens aged 16–19 not in school and not working (Source: National Kids Count Data).

Populations	Persons	%	Source
Total population (2018)	3,195,153		US Census Bureau
Persons below poverty level	1,492,925	46.7%	ACS 2017 - 5 yrs estimate
SNAP recipients	1,222,606	38.3%	ACS 2017 - 5 yrs estimate
Individuals with disabilities	734,789	23.0%	ACS 2017 - 5 yrs estimate
Older Individuals (65+)	661,215	20.7%	US Census Bureau
English language learners	659,195	20.6%	ACS 2017 - 5 yrs estimate
Single parents	371,328	11.6%	ACS 2017 - 5 yrs estimate
Individuals with low levels of literacy	255,612	8.0%	PR Literacy Survey - 2010
Veterans	83,641	2.6%	ACS 2017 - 5 yrs estimate
Disconnected youth*	22,000	0.7%	National Kids Count Data
American Indians and other races	10,985	0.3%	ACS 2017 - 5 yrs estimate
Ex-offenders	7,663	0.2%	PRDCR
Homeless	3,501	0.1%	HUD

Table 1: Population with Barriers to Employment in Puerto Rico (Sources: ACS 2013-2017 5-Year Estimates and others)

macroeconomic performance. Using a Kaleckian model and empirical analysis, they show that whether social reproduction is organized through the household, market, or public sector has significant implications for growth. Societies that undervalue or underinvest in care infrastructure tend to experience slower and more volatile economic growth, highlighting the importance of social reproduction for macroeconomic stability.

2.5. Reservation wages after María: who held out, and why?

Reservation wages in Puerto Rico were highly heterogeneous after Hurricane María. Some groups required substantially higher pay to reenter employment, while others accepted low-paid or informal work quickly. Three mechanisms help explain these differences.

First, caregiving burdens raised reservation wages, especially for women. School closures, elder care, and housing repairs increased the opportunity cost of market work, so acceptable wages had to compensate for foregone household production and the costs of substitutes (Krueger & Mueller, 2016; Departamento del Trabajo y Recursos Humanos [DTRH], 2024).

Second, skilled and in-demand workers, particularly in construction and selected professional services, benefited from increased bargaining power during the reconstruction surge. Evidence shows that hurricanes generate short-run employment contractions alongside industry reallocation toward rebuilding, which raises outside options and reservation wages in capacity-constrained trades (Barattieri, Farah-Yacoub, & Kempa, 2023).

Third, households with liquidity, through insurance, remittances, or disaster assistance, could afford to wait for better matches. This dynamic aligns with unemployment insurance research emphasizing that liquidity extends job search and raises effective reservation wages (Chetty, 2008; Krueger & Mueller, 2016).

By contrast, workers with fewer resources or weaker outside options transitioned rapidly into gig, contingent, or informal jobs. These arrangements, such as independent contracting and

temporary agency work, typically lack benefits and differ sharply from payroll employment in earnings profiles (Barattieri et al., 2023; DTRH, 2024; U.S. Bureau of Labor Statistics, 2024).

Because Puerto Rico is excluded from the Current Population Survey, detailed distributions of reservation wages by class of worker are limited. Researchers, therefore, rely on administrative payroll and tax records, combined with the broader empirical literature on self-employment and benefit coverage, to infer patterns (Government Accountability Office, 2018).

From this, two implications follow: (i) groups with higher home-production burdens or superior outside options should exhibit slower re-entry and higher accepted wages; (ii) transitions into alternative arrangements should be concentrated among lower-reservation-wage workers.

2.6. Centering Social Constraints in Reservation Wage Theory

The classic labor economics question *to work or not to work?* frames the decision-making process behind labor force participation. As Borjas (2016) describes in his widely cited textbook, the decision to work ultimately depends on whether the "terms of trade" between leisure and consumption are attractive enough to induce a person to enter the labor market. In this framework, the reservation wage captures the critical threshold: the minimum wage offer makes participation preferable to continued leisure.

However, this binary framing, whether to work or not, limits the dimensionality of the reservation wage concept. It implicitly assumes that the decision hinges purely on individual tastes for work versus leisure, as mediated by wage offers. Yet in many cases, especially for marginalized groups, the choice is not strictly voluntary. Structural pressures, caregiving obligations, and constrained opportunity sets complicate the simple trade-off between leisure and consumption.

Borjas (2016) further notes that cross-country differences in women's reservation wages are influenced not only by economic variables but also by cultural factors and institutional settings. This observation points out that broader social and economic structures shape labor market participation beyond individual preferences alone. It suggests that models must move beyond treating external constraints as mere background conditions to fully understand labor supply behavior, especially in crisis contexts.

The reservation wage is traditionally defined as the lowest wage an individual is willing to work for. It plays a central role in labor supply models, job search, and market participation. Labor supply theory reflects the marginal rate of substitution between leisure and consumption, commonly illustrated through indifference curves. In contrast, job search theory captures the decision between accepting a job offer now or waiting for a potentially better one. This is often illustrated using a kinked labor supply curve, where no labor is supplied for wage levels below the reservation wage (w^*), and labor enters the market only when the offered wage meets or exceeds this threshold, as shown in Figure 4.

Surveys such as the Current Population Survey (CPS) and the Current Employment Statistics (CES), often collect information by asking "What is the lowest wage you would be willing to work for?" (Kesternich et al. 2022). Yet, responses to this question vary with the size of an individual's

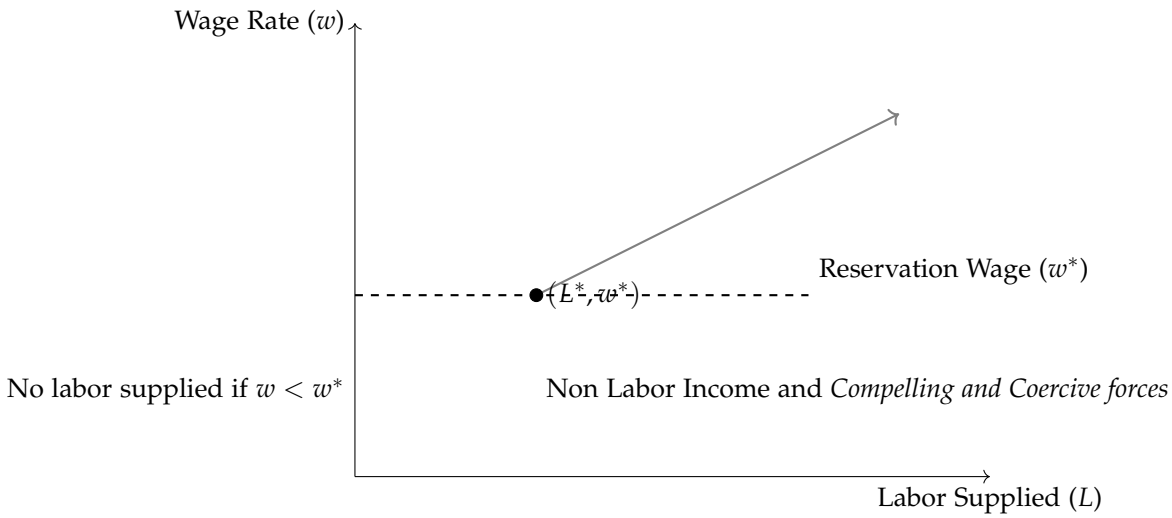

Figure 4: Definition of Reservation wage

opportunity set, which is often shaped by factors like class, caregiving burdens, or local job markets.

While the reservation wage framework is theoretically flexible enough to absorb external factors, such as caregiving burdens, non-labor income, and structural constraints, through shifts in preferences and utility slopes, in empirical practice, these factors are often left implicit or modeled incompletely. For example, caregiving obligations, particularly for women, can steepen the marginal rate of substitution between leisure and income, effectively raising the reservation wage. Yet during disaster recovery or crisis contexts, the actual modeling of such burdens tends to remain in the background and is not explicitly accounted for.

This research adds to the current concept of reservation wages by considering the idea of compelling and coercive forces. Rather than assuming that preferences silently incorporate all social and structural pressures, this framework explicitly brings these forces to the foreground. It applies social coercion, limited alternatives, and economic necessity as measurable influences on labor supply behavior. Especially after disasters, when opportunity sets shrink and external pressures intensify, compelling and coercive forces approach provide a more direct lens to study labor market participation. In this sense, the concept extends rather than replaces the traditional reservation wage model by making hidden constraints visible and central. The compelling and coercive forces approach does not reflect a purely voluntary threshold, but rather describes a wage level at which the worker is compelled to accept a job due to constrained opportunity sets and can also be illustrated in the area below the reservation wage line in figure 4.

Figure 5 depicts two interacting circles representing two social groups, where Group B, shown as the larger circle, possesses a bigger opportunity set than Group A. This visual metaphor captures Stiglitz's (2024) concept of freedom, highlighting that an individual's opportunity set is not purely self-determined but socially constructed and constrained. The relative size of the circles reflects a structural hierarchy in which Group A's limited access to opportunities is shaped

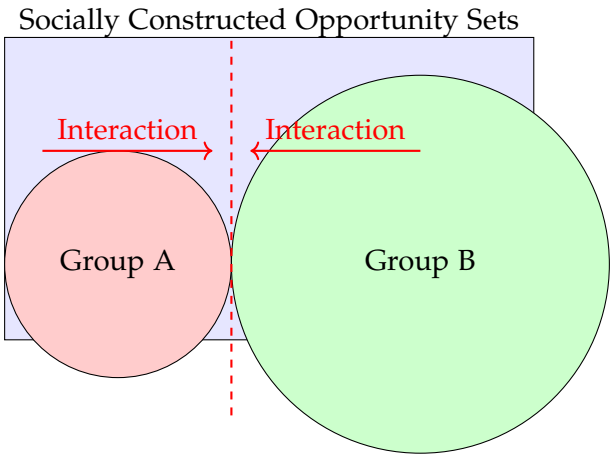

Figure 5: Socially Constructed Opportunity Sets

by social norms and economic conditions. In a disaster, coercion, rather than exploitation, may act as a mechanism to expand the "common opportunity" available to Group A, particularly by reducing barriers to labor market participation, highlighting the gender-differentiated impacts of economic shocks, where historically disadvantaged groups face more constrained post-disaster recovery paths.

In the context of risky jobs, the reservation price is defined as the wage premium necessary to induce a worker to accept additional risk. It represents the financial compensation required to make the worker indifferent between a safe and a risky occupation. This framework highlights an important insight: individuals must sometimes be "bribed" or compensated to accept conditions they would otherwise reject. The greater the disutility associated with the adverse condition (e.g., risk), the higher the required reservation price.

In this view, the notion of a *compelling and coercive forces* proposed in this study builds on a similar logic. Still, it applies to structural constraints workers face, particularly following disasters. Rather than compensating for physical risk, compelling and coercive forces emerge when individuals are economically or socially pressured into labor market participation under constrained opportunity sets.

Again, the reservation wage reflects the minimum wage at which a worker, facing caregiving burdens, limited alternatives, or economic necessity, feels forced to accept employment, even if the job conditions or pay are far from ideal. Just as the reservation price quantifies the cost of accepting risk, the reservation wage quantifies the cost of enduring structural coercion. Thus, the compelling and coercive forces concept completes the traditional reservation wage by making explicit the external forces that shift labor supply behavior, especially in post-disaster or highly unequal settings where "choice" is heavily constrained by necessity. This recognition is important because it reframes the interpretation of labor market behavior, particularly among marginalized groups.

3. Two Sector Model of Labor Reproduction with Disruptions and Segmentation NEW

This section presents the model's equations and highlights key features from Greiner et al. (2004), Braunstein et al. (2011), Flaschel et al. (2014), and Setterfield (2024) that contribute to the objectives of this research. The two-sector demand-led model of labor reproduction developed in this section links reservation wages, labor market segmentation, and macroeconomic dynamics under conditions of disruption. The model distinguishes between a high-wage primary segment and a low-wage secondary segment, reflecting the persistent gendered division of labor. It emphasizes how compelling and coercive forces shape reservation wages and thereby influence sectoral mobility, wage outcomes, investment, and growth.

The model is organized around several interconnected mechanisms. First, reservation wages rise or fall depending on care burdens, disaster shocks, discrimination, bargaining power, and the extent of state support. These shifts in turn influence labor market dynamics, shaping the flows of workers between sectors and putting particular downward pressure on wages in the secondary segment. Social reproduction enters as a further constraint: the amount of unpaid care provided feeds back into effective labor productivity, linking household responsibilities to market outcomes. On the demand side, output is driven by consumption, investment, and government spending, with capacity utilization serving as the measure of slack in the system. Finally, investment is modeled as a function not only of profitability and utilization but also of gender equality, so that greater inclusion strengthens the economy's growth potential. Together, these channels capture how social and institutional pressures reinforce labor market stratification and affect long-run stability.

Reservation wage and disruptions

The reservation wage captures the minimum compensation at which workers are compelled to accept employment. It is not purely a reflection of preferences but is shaped by external pressures such as unpaid care, disaster shocks, discrimination, bargaining strength, and state support. Formally,

$$\tilde{w} = \tilde{w}_0 + \theta_C C + \theta_D D - \lambda G_c + \delta(w_H - w_L) + \xi D_{\text{soc}} + \mu B^{-1}, \tag{3.1}$$

where $\tilde{w}_0$ is the baseline reservation wage. An increase in care burden C, disaster impact D, or social discrimination D_{soc} raises the reservation wage, while greater care infrastructure G_c lowers it. A wider wage gap $(w_H - w_L)$ and weaker bargaining power B both push the reservation wage upward.

Intuitively, the reservation wage summarizes how strongly workers are pressured into the market: higher values reflect constrained agency and weaker outside options.

Segmentation and mobility

Following Charpe et al. (2013), the model incorporates two segmented labor supply functions that describe the flows that account for upward and downward mobility between sectors based on employment conditions. $\dot{L}_1$ and $\dot{L}_2$ are two types of labor supplies that refer to segmented

but interconnected labor markets. Workers are divided into the primary (high wage, L_1) and secondary (atypical) (low wage, L_2) segments. Labor mobility between them depends on economic conditions and structural pressures. These equations help us understand that when reservation wages rise, upward mobility slows and downward mobility accelerates. In other words, external pressures trap workers in the secondary segment, reinforcing labor market stratification. This mechanism reflects how disruptions exacerbate unequal opportunities for advancement.

The dynamic equations are:

$$\dot{L}_1 = -\gamma^d L_1 + \gamma^u L_2 + nL_1, \tag{3.2}$$

$$\dot{L}_2 = \gamma^d L_1 - \gamma^u L_2 + nL_2, \tag{3.3}$$

where n is demographic labor force growth.

Labor mobility between high- and low-skill sectors is modeled as a function of employment conditions and structural social pressure. The upward mobility rate γ^u and downward mobility rate γ^d are endogenized through exponential functions of the reservation wage $\tilde{w}$, such that:

$$\gamma^u = \bar{\gamma}^u e^{-\theta_u \tilde{w}}, \qquad \gamma^d = \bar{\gamma}^d e^{\theta_d \tilde{w}}. \tag{3.4}$$

As $\tilde{w}$ increases—signaling greater economic and social compulsion to accept work—the probability of upward movement into higher-skill employment declines, while the likelihood of downward mobility increases. This reflects how labor market stratification is reinforced under conditions of constrained agency. When individuals face stronger external pressures to participate in precarious employment, their chances of progressing within the labor market hierarchy diminish. This formulation captures the asymmetric effect of structural compulsion on opportunity flows and sectoral sorting, aligning with the stratification framework used by Braunstein (2011) and Setterfield (2024).

In this new labor supply function, labor mobility is described across high- and atypical workers (low-skill sectors) and are influenced by both employment dynamics and structural constraints. By endogenizing the upward (γ^u) and downward (γ^d) transition rates as exponential functions of the reservation wage $\tilde{w}$, which summarizes economic and social pressure to accept marginal employment. As $\tilde{w}$ rises, upward mobility becomes more difficult ($\gamma^u \downarrow$), while downward mobility becomes more likely ($\gamma^d \uparrow$). This formulation captures how constrained opportunities and involuntary labor participation reinforce labor market segmentation and reduce long-run equality of access.

Social reproduction and productivity

The supply side model follows the Braunstein et al. (2011) model by including unpaid caregiving in the household. Unpaid care provisioning H_c declines as reservation wages rise, reflecting the tradeoff between labor market participation and social reproduction. Setterfield

(2024) formalized the unpaid caregiving function as the social reproduction of labor. Following Setterfield (2024), labor productivity x_i is formulated as follows.

$$H_c = H_c(w_H, w_L), \qquad \frac{\partial H_c}{\partial w_H} < 0, \ \ \frac{\partial H_c}{\partial w_L} < 0. \tag{3.5}$$

Productivity in each segment x_i then depends on both wages and care provisioning.

$$x_i = x_i(w_H, w_L, H_c), \qquad \frac{\partial x_i}{\partial H_c} > 0. \tag{3.6}$$

Equations 5 and 6 show how the social reproduction provides the foundation for productive capacity. If care collapses, effective productivity falls, even if market wages rise.

Labor demand, wage setting, and consumption

The labor demand in each sector is derived from a Leontief production function. Similar to Flaschel et al. (2014), the labor demand by firms is determined by output Y and average labor productivity x, the rate of growth assumed to be a given magnitude but may depend positively on both the infrastructure/capital stock ratio and the labor share v, i.e.

On the demand side, labor demand is given by

$$L_i^d = \frac{Y_i}{x_i}, \qquad Y = Y_1 + Y_2. \tag{3.7}$$

Wages are linked to marginal productivity but are reduced when reservation wages are high. To capture this effect, realized wages are modeled as a multiplicative function of productivity and reservation wage pressure:

$$w_H = \mathrm{MPL}_H \cdot e^{-\theta_H \tilde{w}}, \tag{3.8}$$

$$w_L = \mathrm{MPL}_L \cdot e^{-\theta_L \tilde{w}}, \qquad \theta_L > \theta_H > 0. \tag{3.9}$$

Here MPL_i denotes the marginal product of labor in segment i, while the exponential terms reflect how compelling and coercive forces suppress realized wages below their productivity level. The sensitivity parameters θ_i determine how strongly wages respond to reservation wage pressures. Because $\theta_L > \theta_H$, wages in the secondary (low-skill, female-dominated) segment fall more steeply when $\tilde{w}$ rises, reinforcing labor market stratification and widening the wage premium between segments.

Aggregate wage income is $W = \sum_i w_i L_i^d$ and capital income is $R = \rho_K K$. Consumption is a function of after tax incomes:

$$C = c_w(1 - t_w)W + c_r(1 - t_r)R. \tag{3.10}$$

Demand, utilization, and investment

Output Y is demand-driven, composed of consumption C , investment I, and public spending G, including general G_S and care-specific G_c . Total demand determines output:

$$Y = C + I + G, \qquad G = G_s + G_c. \tag{3.11}$$

Capacity utilization measures slack relative to installed capital:

$$u = \frac{Y}{K}. \tag{3.12}$$

Investment has two components, Conventional investment and Care-related investment, and follows Setterfield (2024) interpretation of Braustein et al. (2011) by modeling investment spending on services that contribute to human capabilities H_C.

Conventional investment depends on profit share and utilization:

$$I_K = \iota_0 + \iota_\pi \pi + \iota_u u, \qquad \pi = 1 - \frac{W}{Y}. \tag{3.13}$$

Care related investment depends on profitability, utilization, and gender inclusion:

$$I_{H_c} = \kappa \pi^\alpha u^\beta \text{GEI}^\gamma, \quad \alpha, \beta, \gamma > 0, \tag{3.14}$$

Care-related investment depends on profit share π, capacity utilization u, and gender equality GEI. The elasticities α, β, and γ capture their relative effects, with κ as a scaling parameter. Thus, investment rises with greater profitability, higher capacity use, and gender inclusion.

Gender Equality Indicator

To link labor market stratification to macroeconomic dynamics, the model introduces a gender equality indicator GEI. Let L_F denote female employment and L_M male employment. The index is defined as

$$\text{GEI} = \frac{L_F}{L_F + L_M}. \tag{3.15}$$

The GEI captures the share of women in total employment. Higher values indicate greater gender inclusion, while lower values reflect stronger exclusion. For reference, an alternative measure is the gender gap index (GGI), defined as $1 - \text{GEI}$, which emphasizes the shortfall in women's participation.

This indicator enters the investment function by amplifying spending on care and human capacity. When GEI is higher, investment in I_{H_c} is stronger, reflecting the positive feedback between gender equality, social reproduction, and long-run growth. In this way, the model embeds gender inequality not just as a distributional outcome but as a structural determinant of macroeconomic performance.

Growth

Finally, output growth is defined as

$$\dot{Y} = f(u, \omega), \qquad \omega = \frac{W}{Y}. \tag{3.16}$$

Depending on parameters, the system can produce wage-led or profit-led growth regimes.

3.1. Simulation

This section aims to simulate the dynamic interaction between gendered employment and output using a Lotka-Volterra system with four employment categories: low-skill female $L_{LF}(t)$, low-skill male $L_{LM}(t)$, high-skill female $L_{HF}(t)$, and high-skill male $L_{HM}(t)$. Output $Y(t)$ evolves endogenously based on labor contributions from each sector and is penalized by a Gender Gap Index GGI, which reflects structural inefficiencies arising from gendered labor segmentation.

A disaster shock is introduced at $t = 5$, disproportionately reducing female employment, particularly in the low-skill sector. To model government response, the model incorporates a time-dependent policy function $\theta_i(t)$ directly into the employment equations, where $i \in \{LF, LM, HF, HM\}$. This policy activates at time $t = 15$ and continues until $t = 30$, representing targeted reemployment incentives such as care infrastructure spending, wage subsidies, or direct public hiring.

Each equation follows a Lotka-Volterra-type differential equation $\frac{dL_i}{dt} = L_i\left(\eta_i Y - \lambda_i w_i + \theta_i(t)\right)$.

$$\begin{aligned}
\frac{dL_{LF}}{dt} &= L_{LF}\left(\eta_1 Y - \eta_2 \tilde{w}_F + \theta_{LF}(t)\right) \\
\frac{dL_{LM}}{dt} &= L_{LM}\left(\eta_3 Y - \eta_4 \bar{w}_M + \theta_{LM}(t)\right) \\
\frac{dL_{HF}}{dt} &= L_{HF}\left(\eta_5 Y - \eta_6 \tilde{w}_F + \theta_{HF}(t)\right) \\
\frac{dL_{HM}}{dt} &= L_{HM}\left(\eta_7 Y - \eta_8 \bar{w}_M + \theta_{HM}(t)\right) \\
\frac{dY}{dt} &= Y\left(\eta_9 L_{LF} + \eta_{10} L_{LM} + \eta_{11} L_{HF} + \eta_{12} L_{HM} - \eta_{13}\mathrm{GGI}\right)
\end{aligned}$$

where w_i represents the reservation or market wage for each group, and $\theta_i(t)$ is defined as:

$$\theta_i(t) = \begin{cases} 0, & \text{if } t < 15 \\ \theta_0(t-15), & \text{if } 15 \le t \le 30 \\ \theta_0(30-15), & \text{if } t > 30 \end{cases}$$

with $\theta_0 > 0$ only for $i = LF, HF$, targeting female employment. The simulation illustrates that while female sectors experience sharper employment losses after the shock, they also exhibit stronger recovery due to the policy stimulus, contributing to output growth and reducing the gender employment gap over time.

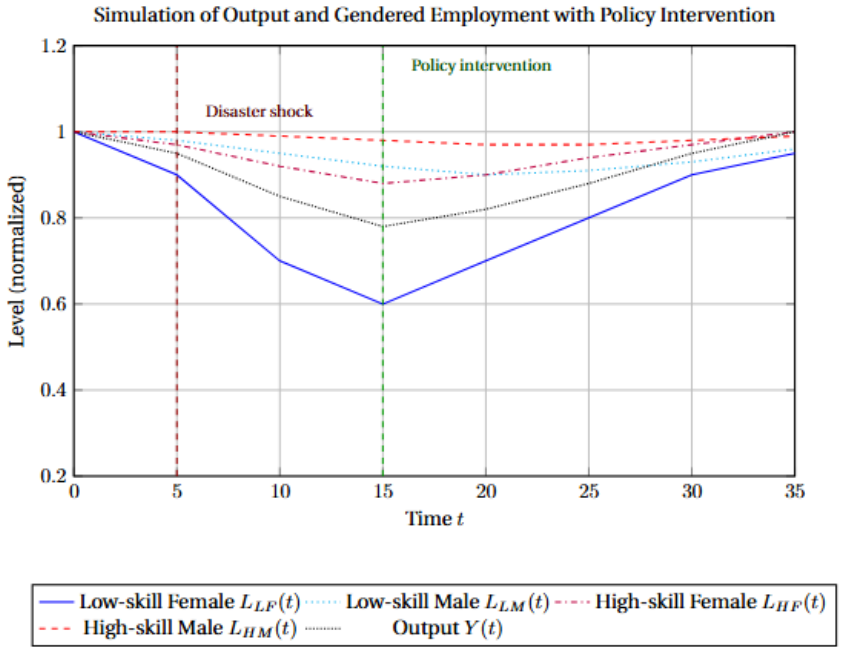

Figure 6: Lotka-Volterra simulation with a disaster shock at $t = 5$ followed by a targeted policy response from $t = 15$, accelerating female employment recovery and stimulating output.

4. Markov Chain and Labor Market Dynamics

The econometric approach of this study relies on a Markov-Switching Dynamic Regression (MSDR) model to analyze labor market behavior under different economic regimes. The model assumes a first-order Markov process, allowing for the identification of transition probabilities between employment states and the estimation of regime-dependent dynamics, such as periods of high unemployment or labor market stability. This approach helps analyze resilience, understood as the system's ability to absorb shocks and return to stability. By incorporating disruptions into the analysis, the model can capture how interactions between variables amplify or dampen responses to external shocks. Additionally, stationary distribution parameters are estimated to assess the long-run probabilities of the labor market remaining in each state. These parameters provide insight into the stability or persistence of each regime, helping to evaluate how different groups of workers recover, or not, after a crisis.

By definition, a Markov Chain model can be described as follows. Let $X_0, X_1, X_2, ...$ be a Markov chain with state space S, where S has size N (possibly infinite). The transition probabilities of the Markov chain are the following.

$$p_{ij} = \mathbb{P}(X_{t+1} = j | X_t = i) \text{ for } i, j \in S, t = 0, 1, 2... \tag{4.1}$$

The transition matrix of the Markov chain is $P = (p_{ij})$.

The t step transition probabilities can be defined as:

$$(P)_{ij} = p_{ij} = \mathbb{P}(X_1 = j | X_0 = i) = \mathbb{P}(X_{n+1} = j | X_n = i) \text{ for any } n. \tag{4.2}$$

p_{ij} - is the probability of making a transition from state i to state j in a single step.

To model the transitions between labor market states using a Markov chain approach and allow for stratification (gender) and segmentation (two distinct time regimes: pre- and post-disaster), the labor market states are defined as employed E, unemployed U, and not in the labor force N. Each individual belongs to one of two gender groups: male M or female F. The disaster refers to an exogenous economic shock.

The model is defined over discrete time t, with transitions divided by gender- and time-specific probabilities. Let $g \in \{M, F\}$ and $t \in \{\text{Pre}, \text{Post}\}$. Then, the probability that an individual in state $i \in \{E, U, N\}$ at time t transitions to state $j \in \{E, U, N\}$ in the next period is denoted by:

$$p_{ij}^{g}(t) = \Pr(S_{t+1} = j \mid S_t = i, G = g)$$

4.1. Gender Labor Market Estimations

The empirical analysis begins with the construction of labor market shares from monthly data on employment, unemployment, and individuals out of the labor force for Puerto Rico, covering the period 2014–2021. Each group was expressed as a share of the working-age population, allowing for a consistent decomposition into employment, unemployment, and out of the labor force. To reduce dimensionality and capture the joint dynamics, a principal component analysis (PCA) was conducted separately for men and women. For both genders, the first principal component explained the majority of the variance, with positive loadings on unemployment and negative loadings on employment, effectively producing a single index of labor market conditions. This index increases when employment rises and unemployment falls, and decreases in the opposite scenario.[8]

Variable	Male PC1	Female PC1
Employment share	-0.7087	-0.6431
Unemployment share	0.5346	0.5038
Out-of-labor-force share	0.4604	0.5767

Table 2: Principal Component Analysis of Labor Market Shares by Gender (Employment, Unemployment, Out of Labor Force)

Note: Coefficients are the PC1 scoring coefficients used to construct each gender's composite index. Larger magnitude implies greater weight in the index (sign indicates direction).

Table 2 shows the first principal component (PC1) shares by gender. The PC1 for the male index places a larger negative weight on employment (–0.7087) and positive weights on unemployment

[8]See Appendix for details

(0.5346) and non-participation (0.4604). For the female index, the signs are identical, but the weights differ slightly. Employment enters less negatively (–0.6431), while non-participation receives a higher positive weight (0.5767). In both cases, PC1 summarizes labor market stress; the index rises when unemployment and exits from the labor force increase relative to employment, and falls when employment dominates. The differing magnitudes suggest that the male index is somewhat more sensitive to movements on the employment margin, whereas the female index loads relatively more on participation changes, consistent with a larger role for non-participation in women's labor market fluctuations.

The resulting first principal component (pc1) for male was then modeled using a two-state Markov-switching dynamic regression. For the female index (pc1f), a three-state Markov-switching dynamic regression since the procedure identified three distinct regimes in the labor market dynamics. The specification allowed for an autoregressive component common across regimes, while intercepts and variances were permitted to vary by state. The estimation was conducted in Stata using maximum likelihood via the expectation–maximization algorithm.

Following estimation, smoothed probabilities of regime membership were derived and plotted against time. These probabilities identified the timing and intensity of shifts between stable and turbulent labor market conditions. In addition, fitted values of the principal component were compared with the binary regime classification to illustrate how shocks such as Hurricane Maria in 2017 coincide with regime switches.

Complementing this analysis, log differences of the out of labor force share were calculated to assess participation shocks separately from employment and unemployment. This transformation provided growth rates in non-participation and allowed for a gender comparison of entry and exit dynamics relative to the labor market. The results indicated more frequent sharp decreases in male non-participation, consistent with stronger re-entry, and more persistent levels of female non-participation, consistent with slower returns to the labor market.

Figure 7 shows the month-to-month log-differences of the out-of-labor-force share by gender. Negative spikes represent sudden re-entries into the labor force, while positive spikes indicate rising non-participation. The results reveal a clear gender contrast, with the male index displaying more frequent and stronger negative spikes, signaling that they rejoined the labor market more aggressively following shocks. The female index, by contrast, exhibits fewer large negative swings and more persistent fluctuations around zero or above, consistent with a slower and more fragile recovery of participation. This pattern suggests that when faced with disasters such as Hurricane Maria and the COVID-19 pandemic, women were more likely to remain outside the labor force.

4.2. Male Labor Market Analysis

Table 3 presents the coefficient estimates for the male labor market. The autoregressive parameter is 0.92, indicating that shocks to labor market conditions are highly persistent and propagate over multiple months. Beyond this common persistence, the two estimated states differ in both their mean behavior and their volatility.

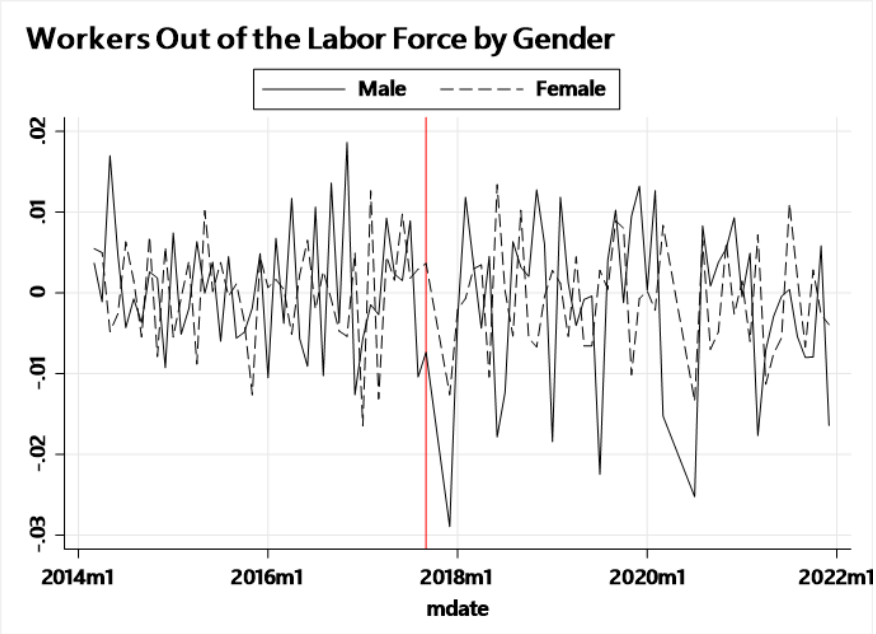

Figure 7: Out of the Labor Force Share by Gender (log-differences

	Coefficient	Std. Error	95% CI	p-value
Autoregressive term	0.916	0.050	[0.819, 1.013]	<0.001
State 1 (baseline)				
Constant	-0.803	0.197	[-1.188, -0.417]	<0.001
Variance (σ_1^2)	0.350	0.105	[0.194, 0.628]	–
State 2 (turbulent)				
Constant	0.227	0.129	[-0.027, 0.481]	0.079
Variance (σ_2^2)	0.442	0.081	[0.309, 0.632]	–
Fit statistics				
Log-likelihood		-87.12		
AIC		1.98		
HQIC		2.06		
SBIC		2.17		

Table 3: Markov-switching regression estimates, male labor market (pc1)
9

The first state is characterized by a negative intercept and relatively low variance. This regime corresponds to periods of stagnation or gradual decline in male employment conditions, where changes occur steadily and volatility remains limited. In other words, even when the labor market weakens, adjustments are relatively smooth and do not involve large short-term swings.

The second state is instead characterized by a higher intercept and substantially greater variance. This regime captures episodes of instability in which the male labor market index exhibits more abrupt month-to-month fluctuations. Transitions into this state coincide with major

shocks, such as Hurricane Maria in 2017. Taken together, the estimates indicate that the male labor market is predominantly situated in the first, baseline state, with the turbulent state emerging only during periods of acute disruption.

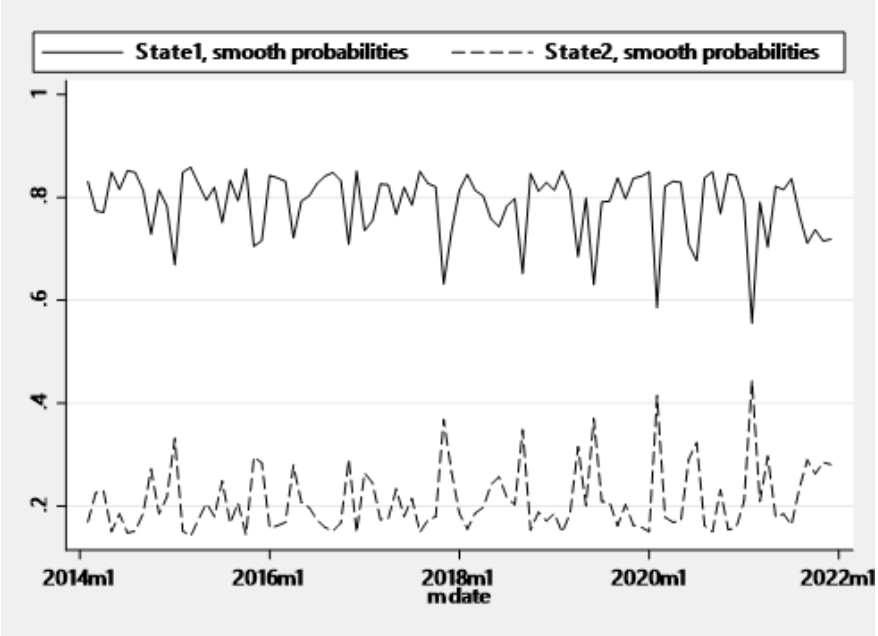

Figure 8: Regime Switching probabilities on Male

Figures 8 plots the smoothed probabilities and Figure 9 shows the pc1 index with regime overlays. The baseline regime dominates most of the sample, but State 2 emerges during major disruptions. In particular, the probability of State 2 spikes in September 2017, coinciding with Hurricane Maria, and again in 2020 with the COVID-19 pandemic. These events temporarily shifted the labor market into a high-volatility regime. Because of the strong persistence, their effects extended far beyond the month of the initial shock.

In figure 8, the transition probabilities show that the economy does not remain in the turbulent state for long but tends to revert to the baseline regime. State 1 remains well above 0.5, showing that the baseline regime dominates for most of the period. State 2 is a minority regime that only appears briefly after the disruptions of Hurricane Mario in September 2017, causing a temporary rise in State 2 probability, but it quickly reverts to State 1. Hurricane Maria was strong enough to increase the volatility but not enough to flip the labor market fully into the shock regime for long.

The interpolation overlay on the male labor market index (pc1) shown by Figure 9 confirms that the series evolves smoothly over the sample period, with no abrupt discontinuities introduced by data preparation. The overlayed line closely follows the observed pc1 values, suggesting that the interpolation method preserved the underlying cyclical pattern of employment and unemployment dynamics.

Two features stand out. First, the index remains mostly above zero before 2017, consistent with relatively favorable labor market conditions. Second, sharp declines are visible around the major

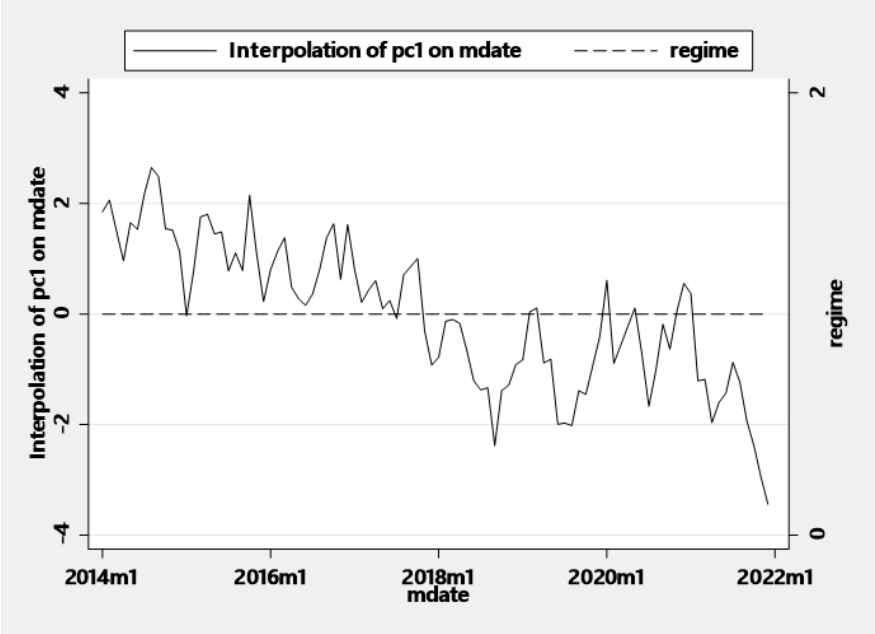

Figure 9: Interpolation overlay on Male

shocks of Hurricane Maria (late 2017), after which the series does not fully return to its earlier positive values. The interpolation line highlights these shifts clearly, showing that the downturns are not isolated data issues but represent persistent structural changes in the male labor market.

4.3. Female Labor Market Analysis

We allow the number of regimes to differ by gender. Model selection is based on information criteria, regime interpretability, and transition dynamics. The Markov-swithcing regression for male allowed a two-state specification parsimoniously captures a stable baseline and a turbulent regime and a three-state alternative does not improve fit and yields a rarely occupied expansion state. For the Markov-swithcing regression for female, the two-state model collapses into a dominant regime with a transitory state (near-zero persistence), whereas the three-state model delivers economically interpretable crisis, baseline, and expansion regimes with non-degenerate transition probabilities. We therefore estimate a two-state model for men and a three-state model for women. Results are robust to alternative lag structures and to specifications without variance switching.

For the female labor market, the first principal component of employment and unemployment shares exhibits strong persistence (AR = 0.878). The better fit was shown to be a three regime markov switching regression model. The model identifies three regimes: State 1, with a negative mean and lower variance, corresponding to short-lived downturns; and State 2, with near-zero mean but substantially higher variance, corresponding to volatile conditions. The transition probabilities indicate that the female labor market rarely stays in the downturn regime, instead spending most of the time in the turbulent regime. This suggests that women's employment and unemployment dynamics are more unstable and shock-sensitive than the overall labor force.

Table 4 reports the coefficient estimates for the female labor market. The autoregressive parameter is 0.88, confirming that shocks are highly persistent and extend across multiple months. In contrast to the male labor market, however, the distinction between states is less about a stable baseline versus a turbulent episode, and more about a rare downturn state relative to a dominant volatile state.

	Coefficient	Std. Err.	p-value	[95% CI]
AR term	0.8992	0.0533	0.000	[0.7946, 1.0038]
State 1 (Negative regime)				
Constant	-0.5056	0.1860	0.007	[-0.8702, -0.1410]
Variance (σ^2)	0.5498	0.0888		[0.4007, 0.7545]
State 2 (Moderate regime)				
Constant	0.2406	0.0859	0.005	[0.0721, 0.4090]
Variance (σ^2)	0.2839	0.0694		[0.1758, 0.4584]
State 3 (Expansionary regime)				
Constant	1.1607	0.1879	0.000	[0.7924, 1.5291]
Variance (σ^2)	0.3095	0.1133		[0.1511, 0.6341]
Transition Probabilities				
p_{11}	0.5972	0.1631		[0.2812, 0.8485]
p_{12}	0.3097	0.1571		[0.0961, 0.6545]
p_{21}	0.2956	0.1272		[0.1125, 0.5815]
p_{22}	0.5831	0.1375		[0.3158, 0.8899]
p_{31}	0.8597	0.4081		[0.0091, 0.9998]
p_{32}	0.1403	0.4081		[0.0002, 0.9999]

Table 4: Markov-Switching Regression Results (Female, 3 Regimes)

The three-regime specification reveals a richer set of dynamics in the female labor market. State 1 is defined by a negative constant and relatively high variance, corresponding to contractionary phases where employment weakens relative to both unemployment and non-participation. These downturns, although not persistent, represent marked declines when they occur. State 2 displays a modestly positive constant with lower variance, capturing intermediate conditions in which the labor market stabilizes around small gains and moderate volatility. This state can be interpreted as a "neutral" regime where fluctuations are contained and the system avoids sharp swings. Finally, State 3 is characterized by a large positive constant, significantly higher than the other two, and moderate variance. This regime reflects expansionary episodes in which women's labor market participation and employment improve markedly, often following recovery from shocks. Together, the three regimes illustrate how female labor market dynamics alternate between sharp contractions, moderate stabilization, and periods of pronounced growth, with transition probabilities indicating that persistence is strongest in the expansionary state.

The smoothed probabilities in Figure 10 illustrate the relative dominance and persistence of the three regimes over time. State 2 emerges as the baseline regime, with probabilities consistently

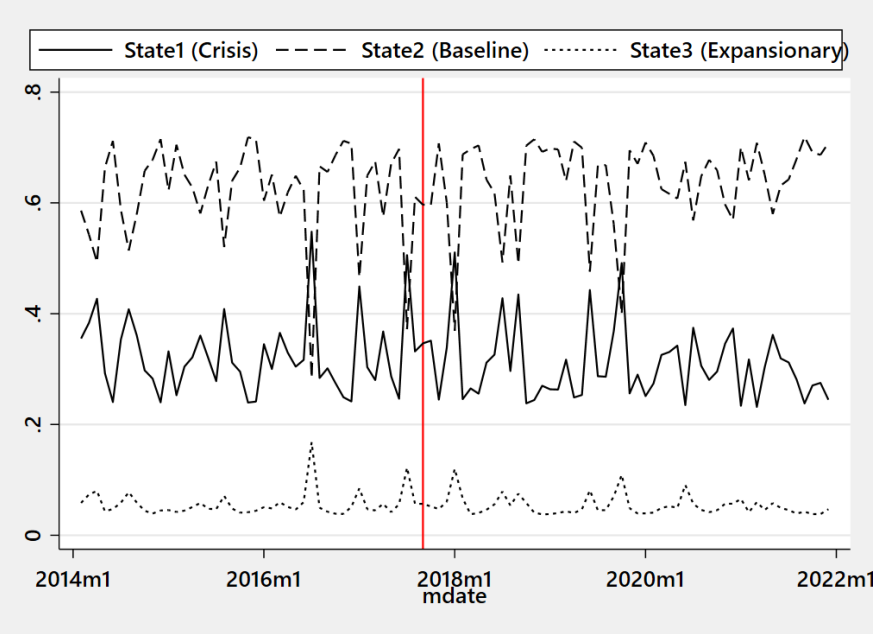

Figure 10: Smoothed Probabilities on Female

above 0.6 across most of the sample, reflecting that women's labor market dynamics are most often characterized by moderate gains and contained volatility. State 1 appears intermittently with probabilities around 0.3–0.4, corresponding to contractionary phases where downturns are present but not prolonged. By contrast, State 3 shows very low probabilities throughout, spiking only occasionally. This indicates that expansionary episodes in the female labor market, marked by systematic improvements in employment and participation, are rare and short-lived. The relative dominance of State 2 underscores that instability and moderate fluctuations, rather than persistent downturns or strong expansions, define the prevailing dynamics of women's labor market outcomes during this period.

Figure 11 shows the trajectory of the female labor market index composed of the interpolation of the principal component (pc1f). This index shows that women's employment and unemployment dynamics in Puerto Rico experienced a significant structural shift during the period under study. In the early years (2014–2016), the index remained positive, reflecting relatively stable labor market conditions with higher employment shares and lower unemployment shares. However, beginning in late 2017 with the shock of Hurricane Maria, the index crosses into negative territory and does not recover to pre-disaster levels. From 2018 onward, it has been mostly negative, signaling persistently weaker female labor market conditions.

The regime classification confirms this pattern. Before 2017, the female labor market was largely in the baseline regime, with stable though modest fluctuations. After Maria, the probability of being in the turbulent regime increased, and regime switches became more frequent. By 2020–2021, coinciding with the COVID-19 pandemic, women's labor market conditions not only declined further but also displayed heightened volatility.

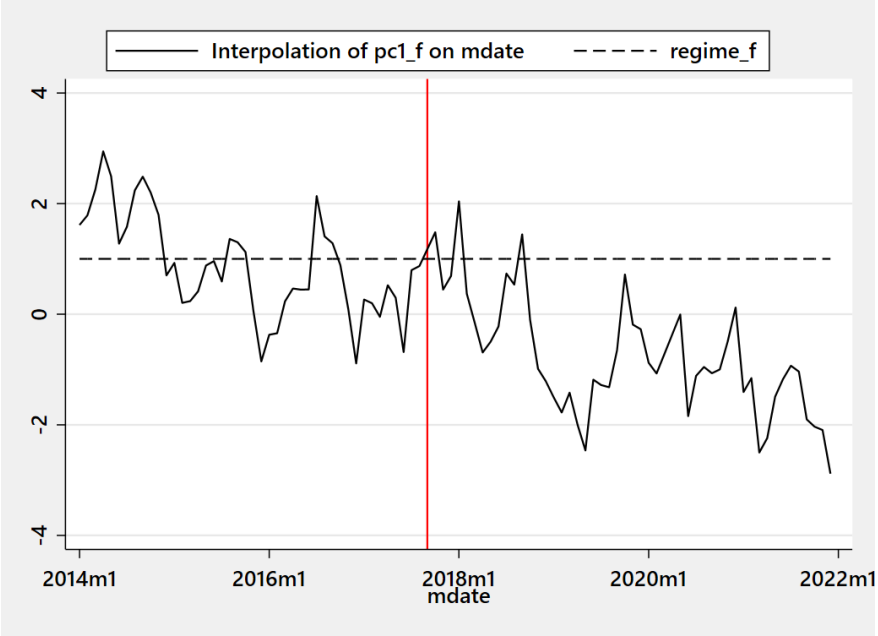

Figure 11: Female Markov Interpolation

A comparison of the male and female labor markets highlights important gender differences in how shocks were absorbed. For men and for the aggregate labor force, the baseline regime dominated the sample period, with the turbulent regime appearing only briefly during major events such as Hurricane Maria in 2017 and the COVID-19 pandemic in 2020. This suggests that while men experienced the shocks, their employment and unemployment dynamics quickly reverted to stable patterns.

By contrast, the female labor market shows a markedly different trajectory. The female labor market index not only declined sharply after 2017 but also remained in negative territory through 2021, reflecting a structural deterioration. Women's regime classification confirms this fragility: they entered the turbulent state more often and for longer durations than men. The volatility of female labor outcomes increased notably in both the aftermath of Maria and again during COVID, suggesting that women's employment conditions were more shock-sensitive and persistent in their downturns.

4.4. Transition Structures

In a Markov-switching framework, the dynamics of regime changes are governed by a transition probability matrix. This matrix summarizes the likelihood of remaining in the same regime or switching to an alternative regime from one period to the next. Formally, for a two-state model, the transition matrix is written as:

$$P = \begin{bmatrix} \mathbf{p}_{11} & \mathbf{p}_{21} \\ \mathbf{p}_{12} & \mathbf{p}_{22} \end{bmatrix}$$

The diagonal elements (p_{11}, p_{22}) measure state persistence, while the off-diagonals (p_{12}, p_{21}) capture the probability of switching between regimes from one month to the next.

In a Markov–switching framework with three regimes, the dynamics are governed by a 3×3 transition probability matrix,

$$P = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{bmatrix}, \qquad p_{ij} \equiv \Pr(S_{t+1} = j \mid S_t = i), \quad \sum_{j=1}^{3} p_{ij} = 1, \; p_{ij} \in [0, 1].$$

The diagonal elements (p_{11}, p_{22}, p_{33}) measure the persistence of each regime, while the off-diagonals capture the probability of switching from one regime to another between consecutive months.[10]

Figure 12 and 13 illustrate the respective Markov transition models representing labor market dynamics by gender. Individuals may occupy one of the two mutually exclusive states: State 1 or State 2. The model assumes that transitions across these states occur over discrete periods and follow a first-order Markov process. The probability of transitioning from a current state i to a future state j depends only on the current state and not on the sequence of prior states.

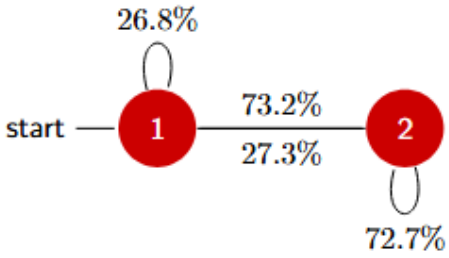

Figure 12: Male Transition Probabilities

In figure 12 shows self-loops and transitions for the Male labor market dynamics. The self-loops reflect persistence within the same state. State 1 corresponds to the baseline regime, and State 2 corresponds to the turbulent regime. The diagonal elements indicate the probability of remaining in the same state: 26.8 percent for State 1 and 72.7 percent for State 2. The off-diagonal elements capture the probability of switching between states: the probability of moving from State 1 to State 2 is 73.2 percent, while the probability of returning from State 2 to State 1 is 27.3 percent.[11]

This matrix setup implies that the baseline regime (State 1) is not highly persistent. When the system is in State 1, there is a much higher likelihood (73.2 percent) that it will transition to the turbulent regime in the following period rather than remain in the baseline. In contrast, once the labor market enters State 2, the turbulent regime, it tends to persist, with a probability of

[10] See Appendix for details on the Econometric framework

[11] Rows sum to one. "Stay" probabilities are $p_{11} = 0.268$ and $p_{22} = 0.727$ (computed as $1 - p_{21}$).

remaining in State 2 of 72.7 percent.

Therefore, after a disruption, the baseline regime is fragile and prone to switching into turbulence, while the turbulent regime, once entered, exhibits greater persistence.

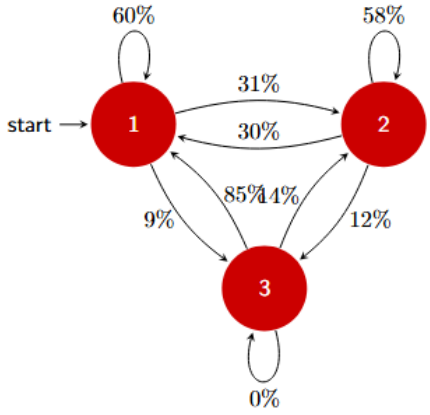

Figure 13: Female Transition Probabilities

Figure 13 shows the transition matrix for the Female Markov transition probabilities. The transition matrix provides insight into how the female labor market shifts across regimes over time. State 1 and State 2 represent the two more persistent regimes, with self-transition probabilities of 60% and 58%, respectively. This implies that once the system enters one of these states, it is expected to remain there for roughly two to three months before switching. Movement between these two regimes is relatively balanced: the probability of shifting from State 1 to State 2 is 31%, while the reverse transition from State 2 to State 1 is 30%. The pattern indicates frequent alternation between moderately different labor market conditions, with short cycles of stability and disruption. By contrast, State 3 behaves as a transitory regime. The probability of remaining in State 3 is essentially zero, meaning that whenever the system enters this regime, it exits immediately in the next period. The exits are highly asymmetric: with an 85% probability, State 3 is followed by State 1, while only 14% of cases transition into State 2. In substantive terms, expansionary bursts or atypical improvements in female labor market conditions are short-lived and overwhelmingly lead into contractionary episodes (State 1) rather than stabilizing outcomes (State 2).

4.5. Stability and Resilience

Figure **??** and **??** show how the Markov chain reaches a stationary distribution in which the proportion of the regimes is not changed under the transitions. Here, the stationary distribution consists of approximately 7.16% state 1 (employed), 20.15% state 2 (unemployed). Rather than predicting which state the series is in at a point in time, it is better to know the average time it spends in a given state. We can compute the expected duration of the process being in a given state. State 3, represented by the labor market dynamics, is yet to be included in the empirical analysis for stability and resilience.

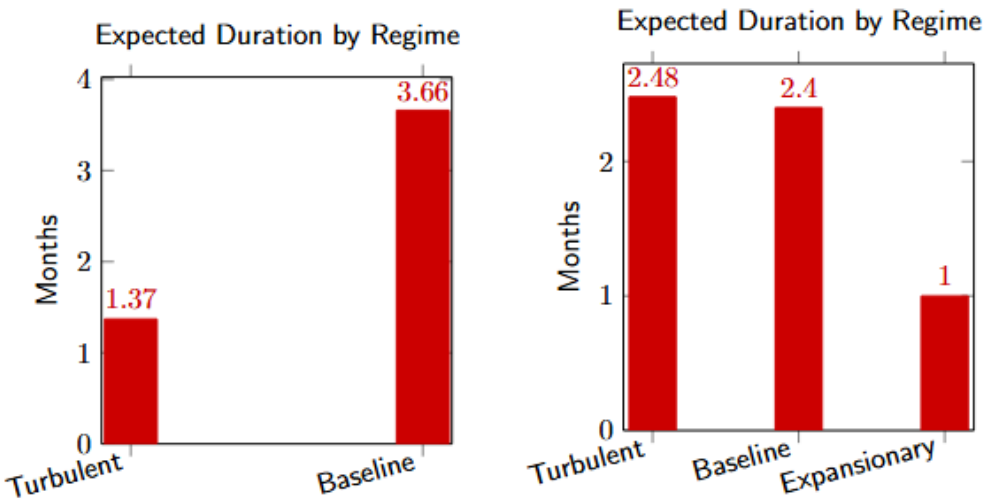

Figure 14: Expected duration

5. Conclusion

Hurricanes bring what Keynes described as fundamental uncertainty, situations where the future cannot be forecast or managed with probabilities. When uncertainty deepens, confidence weakens, discourages private activity, and destabilizes labor markets. These disruptions do not affect all workers equally. As the evidence in this paper shows, women experience longer unemployment spells and greater volatility after shocks, reflecting how reservation wages are shaped by compelling and coercive forces such as care responsibilities, social norms, and unequal access to stable jobs. In this context, the state becomes indispensable. Following Mazzucato (2013), recovery should not be limited to fixing market failures but should aim to reshape labor markets directly through investment, institution-building, and policies that lower the structural barriers for workers. For Puerto Rico, this means recovery after María cannot be reduced to restoring pre-storm conditions. Addressing uncertainty requires policies that integrate gendered dimensions of labor market disruption.

The Markov-switching results make this need clear. Women's labor market dynamics reveal a structural break after 2017, the female labor market index fell into negative territory and has not returned to pre-disaster levels. Regime classification shows that while men and the aggregate labor force remained mostly in the baseline regime, women cycled more frequently through turbulent states. Even when improvements occurred, they were short-lived and overwhelmingly gave way to contraction. Transition matrices further underscore this asymmetry, showing men's turbulence was persistent but temporary, while women alternated between fragile regimes, with expansionary bursts collapsing almost immediately. These patterns indicate that women's employment outcomes were weaker, more volatile, and less resilient.

These findings align with an interpretation of reservation wages shaped by compelling and coercive forces. Care responsibilities and social norms compel the female labor market to demand

higher thresholds for accepting jobs, slowing their reentry after shocks. At the same time, coercive pressures push many men quickly into self-employed work, which absorbs short-term dislocations but deepens labor market segmentation. The model shows that disruptions not only displace workers temporarily but also interact with gendered labor structures to generate unequal recovery paths.

The policy implications are direct. If reservation wages reflect structural constraints, then recovery must target those constraints. Public investment in childcare, paid leave, and flexible work would lower barriers for workers, especially for female workers, while broader support for stable job creation would prevent recovery from being directed disproportionately into other forms of work.

The evidence points to recovery paths that are shaped not only by uncertainty but also by pre-existing structural inequalities. Puerto Rico's post-María experience demonstrates how these forces interact, limiting labor market resilience.

6. References

[1] Aldrich, D. P. (2010). Fixing recovery: Social capital in post-crisis resilience. *Journal of Homeland Security, 6*(1), 1–10.

[2] Barattieri, A., Farah-Yacoub, R., & Kempa, B. (2023). Natural disasters and local labor markets. *Labour Economics, 81*, 102327. https://doi.org/10.1016/j.labeco.2023.102327

[3] Braunstein, E., & van Staveren, I. (2011). Embedding care and unpaid work in macroeconomic modeling: A structuralist approach. *Feminist Economics, 17*(4), 5–31. https://doi.org/10.1080/13545701.2011

[4] Charpe, M., Flaschel, P., Hartmann, F., & Proaño, C. (2013). *Stability and instability in the global economy*. Cambridge University Press.

[5] Chetty, R. (2008). Moral hazard versus liquidity and optimal unemployment insurance. *Journal of Political Economy, 116*(2), 173–234. https://doi.org/10.1086/588585

[6] Cordero-Guzmán, H. R. (2016). Poverty, employment, and the future of Puerto Rico. In S. M. Collins, B. P. Bosworth, & M. A. Soto-Class (Eds.), *The economy of Puerto Rico: Restoring growth* (pp. 263–302). Brookings Institution Press.

[7] Departamento del Trabajo y Recursos Humanos. (2024). *Informe anual sobre el mercado laboral en Puerto Rico*. Gobierno de Puerto Rico. Retrieved from https://www.trabajo.pr.gov

[8] Duncan, G. J. (1992). *The economic consequences of marriage and divorce*. Russell Sage Foundation.

[9] Enchautegui, M. E. (1997). The effects of public assistance on the Puerto Rican labor market. *Social Science Quarterly, 78*(3), 673–689.

[10] Enchautegui, M. E., & Freeman, R. B. (2006). Why don't more Puerto Rican men work? The rich uncle (Sam) hypothesis. *Boston Fed Public Policy Discussion Papers, 06–2*. Federal Reserve Bank of Boston.

[11] Ferber, M. A., & Green, C. A. (1985). Traditional economic models of the household and the economics of gender. *Journal of Economic Issues, 19*(1), 89–107. https://doi.org/10.1080/00213624.1985.11504418

[12] Flaschel, P., Greiner, A., & Semmler, W. (2014). *Quantitative macroeconomics: An introduction*. Springer.

[13] Golden, L. (2001). Flexible work schedules: Which workers get them? *Monthly Labor Review, 124*(3), 33–40.

[14] Government Accountability Office. (2018). *Contingent workforce: Size, characteristics, earnings, and benefits*. GAO-15-168R. Retrieved from https://www.gao.gov

[15] Greiner, A., Semmler, W., & Gong, G. (2004). *The forces of economic growth: A time series perspective*. Princeton University Press.

[16] Katz, C. (2001). Vagabond capitalism and the necessity of social reproduction. *Antipode, 33*(4), 709–728. https://doi.org/10.1111/1467-8330.00207

[17] Kesternich, I., Siflinger, B., Smith, J. P., & Winter, J. K. (2022). Individual behavior after natural disasters: Evidence from the 2013 flood in Germany. *Journal of Economic Behavior & Organization, 194*, 275–293. https://doi.org/10.1016/j.jebo.2021.12.032

[18] Krueger, A. B., & Mueller, A. (2016). A contribution to the empirics of reservation wages. *American Economic Journal: Economic Policy, 8*(1), 142–179. https://doi.org/10.1257/pol.20130374

[19] Oficina de Gerencia y Presupuesto de Puerto Rico / Autoridad de Asesoría Financiera y Agencia Fiscal (AAFAF). (2023). *Informe de recaudos y transferencias federales*. Gobierno de Puerto Rico. Retrieved from https://www.aafaf.pr.gov

[20] Putnam, R. D. (1994). *Making democracy work: Civic traditions in modern Italy*. Princeton University Press.

[21] Setterfield, M. (2024). *Stratification economics and macroeconomic performance*. Edward Elgar.

[22] Sharpe, D. L., & Abdel-Ghany, M. (1997). Determinants of the reservation wage of women. *Journal of Economic Issues, 31*(4), 1023–1041. https://doi.org/10.1080/00213624.1997.11505997

[23] Stiglitz, J. E. (2024). *The road to freedom: Economics and the good society*. W. W. Norton.

[24] U.S. Bureau of Labor Statistics. (2023). Local Area Unemployment Statistics: Puerto Rico labor force participation by sex, 1990–2023 [Data set]. U.S. Department of Labor. Retrieved from https://www.bls.gov/lau/

[25] U.S. Bureau of Labor Statistics. (2024). *Contingent and alternative employment arrangements*. U.S. Department of Labor. Retrieved from https://www.bls.gov

[26] U.S. Department of Labor. (2021). *Puerto Rico economic analysis report 2020–2021*. Retrieved from https://www.dol.gov

7. Appendix

7.1. Two proposed ways to define Compelling wages and the labor supply

7.2. Labor supply Non-linear threshold

The current formulation explains the gap between the market wage w_m and the compelling wage $\tilde{w}$ that determines the labor supply. As $\tilde{w}$ increases, the labor supply increases. indicating more pressure to work under structural constraints like unpaid care C and disasters D. This formulation reflects $\tilde{w}$ as a threshold: a level below which workers can enter the labor market.

$$\tilde{w} = \tilde{w}_0 + \theta_C C + \theta_D D - \lambda G_C$$

The Labor supply equation is

$$L^S = \phi_F(w_m - \tilde{w})$$

where w_m is the market wage and ϕ_F reflects the responsiveness to this gap. Another way is using a nonlinear structural constraint formulation.

$$L^S = \begin{cases} 0, & \text{if } w_m < \tilde{w} \\ \phi(w_m - \tilde{w}), & \text{if } w_m \geq \tilde{w} \end{cases} \tag{7.1}$$

This formulation reflects that labor supply only activates when the market wage exceeds the compelling wage threshold $\tilde{w}$, and increases linearly thereafter with responsiveness ϕ.

8. Appendix: Econometric Frameworks

This appendix documents the econometric methods used in the study. Two main approaches are applied: a Markov-switching dynamic regression model to analyze regime-dependent labor market dynamics, and a Principal Component Analysis (PCA) to construct composite indices of labor market conditions.

8.1. Markov-Switching Regression Models

8.2. Markov Chain Framework

A Markov chain is a stochastic process in which the probability of being in a particular state at time t depends only on the state at time $t-1$. In this study, regimes are interpreted as baseline, crisis, and turbulent labor market conditions. The process is governed by a transition probability matrix P of the form:

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1S} \\ p_{21} & p_{22} & \cdots & p_{2S} \\ \vdots & \vdots & \ddots & \vdots \\ p_{S1} & p_{S2} & \cdots & p_{SS} \end{bmatrix},$$

where p_{ij} is the probability of transitioning from regime i to regime j and each row sums to one.

8.3. Model Specification

The Markov-switching dynamic regression (MSDR) allows parameters to vary across regimes:

$$y_t = \alpha_{s_t} + \sum_{i=1}^{p} \phi_{i,s_t} y_{t-i} + X_t \beta_{s_t} + \epsilon_t,$$

where y_t is the labor market index, X_t includes exogenous covariates, $\epsilon_t \sim N(0, \sigma^2_{s_t})$, and the unobserved regime s_t evolves according to the Markov chain.

Autoregressive terms capture persistence in the data. The number of lags p is chosen based on the Akaike and Bayesian information criteria. For men, an AR(1) specification provides the best fit, while for women an AR(2) model captures short cycles of recovery and contraction. Similarly, regime selection criteria indicate two regimes for men (baseline and turbulent) and three regimes for women (two moderately persistent regimes and one transitory regime). These specifications reflect systematic model selection rather than ad hoc choices.

8.4. Smoothed Probabilities and Transition Matrices

Smoothed probabilities estimate the ex post likelihood that the system was in each regime at time t, conditional on the full sample. Figures **??** and **??** illustrate the smoothed probabilities, highlighting structural breaks after Hurricane María and during the COVID-19 pandemic.

Tables 5 and 6 present the estimated transition matrices. Expected durations are derived from self-transition probabilities, while stationary distributions summarize the long-run shares of time spent in each regime.

Table 5: Male Labor Market Transition Probabilities

	State 1 (Baseline)	State 2 (Turbulent)
State 1 (Baseline)	0.268	0.732
State 2 (Turbulent)	0.273	0.727

Table 6: Female Labor Market Transition Probabilities

	State 1	State 2	State 3 (Transitory)
State 1	0.60	0.31	0.09
State 2	0.30	0.58	0.12
State 3 (Transitory)	0.85	0.14	0.00

8.5. Principal Component Analysis (PCA)

To construct composite indices of labor market conditions, I use Principal Component Analysis (PCA). PCA reduces the dimensionality of correlated indicators, extracting a smaller set of orthogonal components that capture most of the variance.

Let Z denote the standardized variables, including employment, unemployment, labor force participation, and sectoral employment shares. PCA solves the eigenvalue decomposition of the covariance matrix:

$$\Sigma = V \Lambda V',$$

where V is the matrix of eigenvectors and Λ is the diagonal matrix of eigenvalues. The first principal component is used to construct the labor market index:

$$\text{Index}_t = v_1' Z_t,$$

where v_1 is the eigenvector associated with the largest eigenvalue.

For robustness, separate PCA indices are constructed for men and women. The first component explains 62 percent of the variance in the male series and 58 percent in the female series, confirming that the indices capture the dominant dynamics. Figures **??** and **??** plot the resulting indices over time.

- Iris Kesternich, Heiner Schumacher, Bettina Siflinger, Franziska Valder, Reservation wages and labor supply, Journal of Economic Behavior & Organization, Volume 194, 2022, Pages 583-607, ISSN 0167-2681, doi.org/10.1016/j.jebo.2021.12.031.
- Greiner, Alfred & Rubart, Jens & Semmler, Willi, 2004. "Economic growth, skill-biased technical change and wage inequality: A model and estimations for the US and Europe," Journal of Macroeconomics, Elsevier, vol. 26(4), pages 597-621, December.
- Elson, Diane, 1995. "Gender Awareness in Modeling Structural Adjustment," World Development, Elsevier, vol. 23(11), pages 1851-1868, November.
- Charpe, M., Flaschel, P., Krolzig, H. M., Proaño, C. R., Semmler, W., & Tavani, D. (2015). Credit-driven investment, heterogeneous labor markets and macroeconomic dynamics. Journal of Economic Interaction and Coordination, 10, 163-181.
- Nancy Folbre, 2006. "Measuring Care: Gender, Empowerment, and the Care Economy," Journal of Human Development and Capabilities, Taylor & Francis Journals, vol. 7(2), pages 183-199.
- Seguino, Stephanie, (2000), Gender Inequality and Economic Growth: A Cross-Country Analysis, World Development, 28, issue 7, p. 1211-1230, https://EconPapers.repec.org/RePEc:eee:wdevel:v:28:y:2 1230.
- Setterfield, M. (2024). The social reproduction of labour and macro theory: A compelling and fruitful conjunction. PSL Quarterly Review, 77(310), 237-246.
- Stiglitz, Joseph E. (2024). The Road to Freedom: Economics and the Good Society. New York, NY: Norton, 2024. 356 pages. (hardback).