Education, Informality and the Pandemic: Explaining the Unequal Impacts of Covid-19 in the Mexican Labour Market Online Appendix

Aida Garcia-Lazaro* University of Bath
Chris Martin† University of Bath
Magdalyn Okolo‡ University of Bath

August 10, 2022

1 The Data

Table 1: Average values, 2018Q2 - 2019Q4 (Pre-pandemic)

Steady values	Full sample	Rolling sample
Total employment	**52,562,597**	**45,694,739**
Informal non-graduate	22,848,807	20,191,326
Informal graduate	7,430,722	6,110,004
Informal	**30,279,529**	**26,301,329**
Formal non-graduate	10,301,664	8,588,695
Formal graduate	11,981,404	10,804,715
Formal	**22,283,068**	**19,393,410**
Non-employed non-graduates	35,029,989	29,804,404
Non-employed graduates	10,114,538	8,126,297
TOTAL	97,707,124	83,625,441

Note: *Full sample* are the figures of employment reported by the National Institute of Statistics and Geography (INEGI) using the ENOE. *Rolling sample* contains 80-85% of the full sample as around 15-20% of the individuals get replaced every quarter.

We classify the different jobs of individuals in our data into either high- or low-skill occupations, using the International Standard Classification of Occupations of the International Labor Office. We classify Managerial, Professional and Technical occupations as high-skilled and the rest as low-skilled. As Figure 1) shows, the large majority of jobs in high-skill occupations are filled by graduates in both the formal and informal sectors, and the great majority of jobs in low-skill occupations, in either sector, are filled by non-graduates. This evidence shows that graduates and non-graduates largely do different jobs.

*ajgl21@bath.ac.uk; Institue for Policy Research, University of Bath, Bath BA2 7AY UK.
†cim21@bath.ac.uk; Department of Economics, University of Bath, Bath BA2 7AY. Corresponding author. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
‡muao20@bath.ac.uk; Department of Economics, University of Bath, Bath BA2 7AY UK.

Table 2: **Labour Market Transitions in Mexico, 2018Q2-2019Q4**

i) Graduate Transitions	Formal Jobs	Informal Jobs	Unemployment	Available	Non-available	Non-employment
Formal Jobs	8,259,136	1,162,680	177, 787	102, 243	494, 086	774, 115
Informal Jobs	1, 180, 608	3,446,500	165, 617	188, 704	759, 717	1, 114, 038
Unemployment	173, 359	179, 805	149, 041	59, 769	144, 150	352, 959
Available	98, 336	197, 146	57, 311	203, 864	573, 854	835, 028
Non-available	458, 614	768, 881	152, 126	585, 265	3, 894, 609	4, 632, 000
ii) Non-Graduate Transitions	Formal Jobs	Informal Jobs	Unemployment	Available	Non-available	
Formal Jobs	5, 842, 325	1, 671, 685	127, 999	111, 923	571, 390	811, 312
Informal Jobs	1, 737, 000	13, 831, 383	287, 927	658, 462	3, 185, 190	4, 131, 579
Unemployment	132, 130	310, 275	107, 488	62, 318	184, 479	354, 285
Available	109, 208	683, 504	69, 545	644, 894	2, 293, 485	3, 007, 924
Non-available	558, 216	3, 240, 967	192, 392	2, 348, 858	18, 091, 723	20, 632, 972

Notes: This table presents average data from the rolling sample, between 2018Q2-2019Q4 disaggregating unemployed into 'unemployment', 'available' and 'non-available' (in violet). Source: Authors' calculations using ENOE data.

Table 3: **Labour Market Transitions in Mexico, 2018Q2-2019Q4**

i) Graduate Transitions	Formal Jobs	Informal Jobs	Unemployment	Available	Non-available	Non-employment
Formal Jobs	0.810	0.114	0.017	0.010	0.048	0.076
Informal Jobs	0.206	0.600	0.029	0.033	0.132	0.194
Unemployment	0.246	0.255	0.211	0.085	0.204	0.500
Available	0.087	0.174	0.051	0.180	0.508	0.739
Non-available	0.078	0.131	0.026	0.100	0.665	0.791
ii) Non-Graduate Transitions	Formal Jobs	Informal Jobs	Unemployment	Available	Non-available	
Formal Jobs	0.702	0.201	0.015	0.013	0.069	0.097
Informal Jobs	0.088	0.702	0.015	0.033	0.162	0.210
Unemployment	0.166	0.389	0.135	0.078	0.232	0.445
Available	0.029	0.180	0.018	0.170	0.603	0.791
Non-available	0.023	0.133	0.008	0.096	0.740	0.845

Notes: This table documents transition rates between 2018Q2-2019Q4 disaggregating unemployed into 'unemployment', 'available' and 'non-available' (in violet). Source: Authors' calculations using ENOE data.

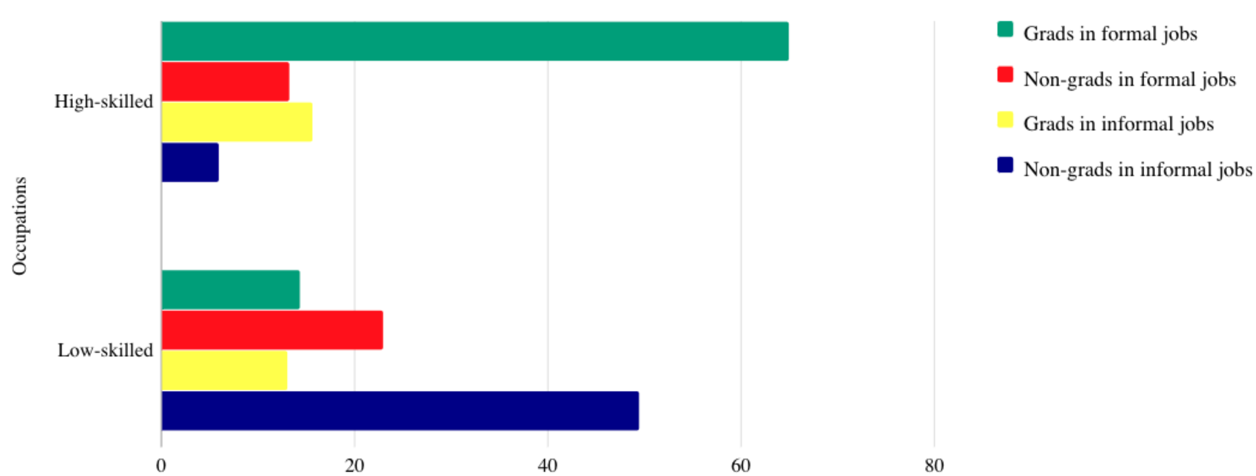

Figure 1: **Employment in Mexico by occupation, education and formality, 2018Q2-2019Q4**
Source: Authors' calculations using ENOE data.

2 The Labour Market

2.1 The Labour Market For Graduates in Formal Firms

Formal firms post $v_t^{g,F}$ vacancies for graduates. Search for these jobs comes from non-employed graduates and from graduates employed by informal firms, given by $s_t^{g,F} = \zeta^{g,\{NE,F\}} ne_t^g + \zeta^{g,\{I,F\}} n_t^{g,I}$, where $\zeta^{g,\{NE,F\}}$ and $\zeta^{g,\{I,F\}}$ are the intensities of search, by graduates not in employment and in informal firms, for jobs in formal firms. Defining tightness in the market for formal sector graduate jobs as $\theta_t^{g,F} = \frac{v_t^{g,F}}{s_t^{g,F}}$, hires are given by

$$h_t^{g,F} = m^{g,F} (\theta_t^{g,F})^{(1-\alpha^{g,F})} s_t^{g,F} \tag{1}$$

We assume that hires are proportional to search, so $h_t^{g,\{NE,F\}} = \frac{\zeta^{g,\{NE,F\}} ne_t^g}{s_t^{g,F}} h_t^{g,F}$ and $h_t^{g,\{I,F\}} = \frac{\zeta^{g,\{I,F\}} n_t^{g,I}}{s_t^{g,F}} h_t^{g,F}$.

Considering employment of graduates in the formal sector, job destruction occurs, at rate $\pi_t^{g,\{F,NE\}}$; so $\pi_t^{g,\{F,NE\}} n_t^{g,F}$ graduates leave formal sector employment and become non-employed. And $\pi_t^{g,\{F,I\}} n_t^{g,F}$ workers leave the formal sector for alternative jobs in the informal sector. Since $\pi_t^{g,\{F,F\}} + \pi^{g,\{F,NE\}} + \pi_t^{g,\{F,I\}} = 1$, employment of graduates in formal firms is therefore

$$n_{t+1}^{g,F} = \pi_{t+1}^{g,\{F,F\}} n_t^{g,F} + h_{t+1}^{g,F} \tag{2}$$

where $h^{g,F}$ is the number of graduates hired by formal firms. These hires come from non employed graduates and graduates employed by informal firms, so

$$h_t^{g,F} = h_t^{g,\{NE,F\}} + h_t^{g,\{I,F\}} \tag{3}$$

where $h_t^{g,\{NE,F\}}$ is the number of not employed graduates hired by formal firms and $h_t^{g,\{I,F\}}$ is the number of graduates hired from informal firms. These are given by $h_{t+1}^{g,\{NE,F\}} = \pi_{t+1}^{g,\{NE,F\}} ne_t^g$ and $h_{t+1}^{g,\{I,F\}} = \pi_{t+1}^{g,\{I,F\}} n_t^{g,I}$. We model the rate of job destruction as $\pi_t^{g,\{F,NE\}} = \pi^{g,\{F,NE\}} e^{\varepsilon_t^\tau}$; $\pi^{g,\{F,NE\}}$ is the steady-state rate of destruction of graduate formal jobs and ε_t^τ is a shock that captures the impact of the pandemic on the rate of job destruction. The job finding and retention rates, i.e., $\pi_t^{g,\{F,F\}}$, $\pi_t^{g,\{I,F\}}$, $\pi_t^{g,\{NE,F\}}$ and $\pi_t^{g,\{I,F\}}$ are endogenously determined by our model.

2.2 The Labour Market For Graduates in Informal Firms

Similar to formal firms, informal firms post $v_t^{g,I}$ vacancies for graduates. Search for these jobs comes from non-employed graduates and from graduates employed by formal firms, given by $s_t^{g,I} = \zeta^{g,\{NE,I\}} ne_t^g + \zeta^{g,\{F,I\}} n_t^{g,F}$, where $\zeta^{g,\{NE,I\}}$ and $\zeta^{g,\{F,I\}}$ are the intensities of search, by graduates not in employment and in formal firms, for jobs in informal firms. Defining tightness in the informal sector for graduate jobs as $\theta_t^{g,I} = \frac{v_t^{g,I}}{s_t^{g,I}}$, hires are given by

$$h_t^{g,I} = m^{g,I} (\theta_t^{g,I})^{(1-\alpha^{g,I})} s_t^{g,I} \tag{4}$$

Here, we also assume that hires are proportional to search, so $h_t^{g,\{NE,I\}} = \frac{\zeta^{g,\{NE,I\}} ne_t^g}{s_t^{g,I}} h_t^{g,I}$ and $h_t^{g,\{F,I\}} = \frac{\zeta^{g,\{F,I\}} n_t^{g,F}}{s_t^{g,I}} h_t^{g,I}$.

Considering employment of graduates in the informal sector, job destruction occurs, at rate $\pi_t^{g,\{I,NE\}}$; so $\pi_t^{g,\{I,NE\}} n_t^{g,I}$ graduates leave informal sector employment and become non-employed. And $\pi_t^{g,\{I,F\}} n_t^{g,I}$ workers leave the informal sector for alternative jobs in the formal sector. Since $\pi_t^{g,\{I,I\}} + \pi^{g,\{I,NE\}} +$

$\pi_t^{g,\{I,F\}} = 1$, employment of graduates in informal firms is therefore

$$n_{t+1}^{g,I} = \pi_{t+1}^{g,\{I,I\}} n_t^{g,I} + h_{t+1}^{g,I} \tag{5}$$

where $h^{g,I}$ is the number of graduates hired by formal firms. These hires come from non employed graduates and graduates employed by formal firms, so

$$h_t^{g,I} = h_t^{g,\{NE,I\}} + h_t^{g,\{F,I\}} \tag{6}$$

where $h_t^{g,\{NE,I\}}$ is the number of not employed graduates hired by informal firms and $h_t^{g,\{F,I\}}$ is the number of graduates hired from formal firms. These are given by $h_{t+1}^{g,\{NE,I\}} = \pi_{t+1}^{g,\{NE,I\}} ne_t^g$ and $h_{t+1}^{g,\{F,I\}} = \pi_{t+1}^{g,\{F,I\}} n_t^{g,F}$. We model the rate of job destruction as $\pi_t^{g,\{I,NE\}} = \pi^{g,\{I,NE\}} e^{\varepsilon_t^\tau}$; $\pi^{g,\{I,NE\}}$ is the steady-state rate of destruction of graduate formal jobs. The job finding and retention rates, i.e., $\pi_t^{g,\{I,I\}}$, $\pi_t^{g,\{F,I\}}$, $\pi_t^{g,\{NE,I\}}$ and $\pi_t^{g,\{F,I\}}$ are endogenously determined by our model.

2.3 The Labour Market For Non-graduates in Formal and Informal Firms

The labour market for non-graduates follow the same structure outlined in Subsections 2.1) and 2.2).

3 Wholesale Firms

3.1 Formal Wholesale Firms

All formal wholesale firms are competitive and identical. There is no rigidity in wholesale prices, so all formal wholesale firms set the same price. The objective function of the representative formal wholesale firm is

$$J_t^F = E_t \sum_{k=0}^{\infty} \frac{\beta^{t+k}\Lambda_{t+k}}{\Lambda_t} \Big\{ \frac{P_t^{F,W}}{P_t^F} Y_{t+k}^{W,F} - w_{t+k}^{g,F} n_{t+k}^{g,F} - w_{t+k}^{ng,F} n_{t+k}^{ng,F} - \gamma^{g,F} v_t^{g,F} - \gamma^{ng,F} v_t^{ng,F} \Big\} \tag{7}$$

where $Y^{W,F}$ is output, $P^{F,W}$ is the price of the output of formal wholesale firms, P^F is the price of the output of formal retail firms, $\gamma^{g,F}$ is the cost of posting a vacancy for a graduate and $\gamma^{ng,F}$ is the cost of posting a vacancy for a non-graduate.

We express the production function as

$$Y_t^{W,F} = A_t^{g,F} n_t^{g,F} + A_t^{ng,F} n_t^{ng,F} \tag{8}$$

where $A_t^{g,F} = A^{g,F} e^{\varepsilon_t^s}$, $A_t^{ng,F} = A^{ng,F} e^{\varepsilon_t^s}$ and ε_t^s is a shock to the productivity of workers. The formal firm chooses the number of vacancies for graduates to post to maximise (7) subject to (8) and (2). The optimality condition is

$$\frac{\partial J_{t+1}^F}{\partial v_t^{g,F}} = -\gamma^{g,F} + E_t \beta_{t,t+1} q_{t+1}^{g,F} \frac{\partial J_{t+1}^F}{\partial n_{t+1}^{g,F}} = 0 \tag{9}$$

where $\frac{\partial J_t^F}{\partial n_t^{g,F}} = \frac{A_t^{g,F}}{\mu^F} - w_t^S + E_t \pi_{t+1}^{g,\{F,F\}} \beta_{t,t+1} \frac{\partial J_{t+1}^F}{\partial n_{t+1}^{g,F}}$ and where $\mu^F = \frac{P_t^F}{P_t^{F,W}}$. Noting that (9) implies $\frac{\partial J_{t+1}^F}{\partial n_{t+1}^{g,F}} =$

$\frac{\gamma^h}{E_t q_{t+1}^{g,F}}$, and so $\frac{\partial J_t^F}{\partial n_t^{g,F}} = \frac{A_t^{g,F}}{\mu^F} - w_t^{g,F} + E_t \pi_{t+1}^{g,\{F,F\}} \beta_{t,t+1} \frac{\gamma^{g,F}}{q_{t+1}^{g,F}}$, the optimality condition implies

$$\frac{A_t^{g,F}}{\mu^F} = w_t^{g,F} + \lambda_t^{g,F} \tag{10}$$

where $\lambda_t^{g,F} = \gamma^{g,F}(\frac{1}{q_t^{g,F}} - E_t \pi_{t+1}^{g,\{F,F\}} \beta_{t,t+1} \frac{1}{q_{t+1}^{g,F}})$ is the marginal cost of hiring a graduate for a formal firm. Using similar arguments, the optimality condition for non-graduates at formal firms is

$$\frac{A_t^{ng,F}}{\mu^F} = w_t^{ng,F} + \lambda_t^{ng,F} \tag{11}$$

where $\lambda_t^{ng,F} = \gamma^{ng,F}(\frac{1}{q_t^{ng,F}} - E_t \pi_{t+1}^{ng,\{F,F\}} \beta_{t,t+1} \frac{1}{q_{t+1}^{ng,F}})$ is the marginal cost of hiring a non-graduate for a formal firm.

3.2 Informal Wholesale Firms

We make the same assumptions for informal wholesale firms. All informal wholesale firms are competitive and identical, there is no rigidity in wholesale prices, so all informal wholesale firms set the same price. The objective function of the representative informal wholesale firm is

$$J_t^I = E_t \sum_{k=0}^{\infty} \frac{\beta^{t+k} \Lambda_{t+k}}{\Lambda_t} \Big\{ \frac{P_t^{I,W}}{P_t^I} Y_{t+k}^{W,I} - w_{t+k}^{g,I} n_{t+k}^{g,I} - w_{t+k}^{ng,I} n_{t+k}^{ng,I} - \gamma^{g,I} v_t^{g,I} - \gamma^{ng,I} v_t^{ng,I} \Big\} \tag{12}$$

where $Y^{W,I}$ is output, $P^{I,W}$ is the price of the output of informal wholesale firms, P^I is the price of the output of informal retail firms, $\gamma^{g,I}$ is the cost of posting a vacancy for a graduate and $\gamma^{ng,I}$ is the cost of posting a vacancy for a non-graduate.

The production function is

$$Y_t^{W,I} = A_t^{g,I} n_t^{g,I} + A_t^{ng,I} n_t^{ng,I} \tag{13}$$

where $A_t^{g,I} = A^{g,I} e^{\varepsilon_t^s}$, $A_t^{ng,I} = A^{ng,I} e^{\varepsilon_t^s}$ and ε_t^s is a shock to the productivity of workers. The informal firm chooses the number of vacancies for graduates to post to maximise (12) subject to (13) and (5). The optimality condition is

$$\frac{\partial J_{t+1}^I}{\partial v_t^{g,I}} = -\gamma^{g,I} + E_t \beta_{t,t+1} q_{t+1}^{g,I} \frac{\partial J_{t+1}^I}{\partial n_{t+1}^{g,I}} = 0 \tag{14}$$

where $\frac{\partial J_t^I}{\partial n_t^{g,I}} = \frac{A_t^{g,I}}{\mu^I} - w_t^S + E_t \pi_{t+1}^{g,\{I,I\}} \beta_{t,t+1} \frac{\partial J_{t+1}^I}{\partial n_{t+1}^{g,I}}$ and where $\mu^I = \frac{P_t^I}{P_t^{I,W}}$. Noting that (14) implies $\frac{\partial J_{t+1}^I}{\partial n_{t+1}^{g,i}} = \frac{\gamma^h}{E_t q_{t+1}^{g,i}}$, and so $\frac{\partial J_t^I}{\partial n_t^{g,I}} = \frac{A_t^{g,I}}{\mu^I} - w_t^{g,I} + E_t \pi_{t+1}^{g,\{I,I\}} \beta_{t,t+1} \frac{\gamma^{g,I}}{q_{t+1}^{g,I}}$, the optimality condition implies

$$\frac{A_t^{g,I}}{\mu^I} = w_t^{g,I} + \lambda_t^{g,I} \tag{15}$$

where $\lambda_t^{g,I} = \gamma^{g,I}(\frac{1}{q_t^{g,I}} - E_t \pi_{t+1}^{g,\{I,I\}} \beta_{t,t+1} \frac{1}{q_{t+1}^{g,I}})$ is the marginal cost of hiring a graduate for an informal firm. Similarly, the optimality condition for non-graduates at informal firms is

$$\frac{A_t^{ng,I}}{\mu^I} = w_t^{ng,I} + \lambda_t^{ng,I} \tag{16}$$

where $\lambda_t^{ng,I} = \gamma^{ng,I}(\frac{1}{q_t^{ng,I}} - E_t\pi_{t+1}^{ng,\{F,F\}}\beta_{t,t+1}\frac{1}{q_{t+1}^{ng,F}})$ is the marginal cost of hiring a non-graduate for an informal firm.

4 The Bargained Wage

4.1 Graduate Formal Workers

Wage bargaining for formal sector graduates is determined by the sharing rule

$$(1-\vartheta^{g,F})S_t^{g,F} = \vartheta^{g,F}F_t^{g,F} \tag{17}$$

where $S_t^{g,F}$ is the surplus to the household from an additional graduate being employed in a formal firm, $F_t^{g,F}$ is the surplus to the formal firm and $\vartheta^{g,F}$ is the bargaining power.

The formal firm's surplus from the wage bargain is $F_t^{g,F} = \frac{\partial J_t^F}{\partial n_t^{g,F}}$. Because of the assumption of constant returns, we can combine this with the optimality condition for formal firms to obtain

$$F_t^{g,F} = \frac{P_t^{F,W}}{P_t^F}A_t^{g,F} - w_t^{b\{g,F\}} + E_t\beta_{t,t+1}\pi_{t+1}^{g,\{F,F\}}\frac{\gamma^F}{q_{t+1}^{f,F}} \tag{18}$$

and

$$E_tF_{t+1}^{g,F} = E_t\frac{\gamma^{g,F}}{q_{t+1}^{g,F}} \tag{19}$$

We can express household utility as

$$V_t^H = \frac{C_t^{1-\eta}}{1-\eta} + E_t\beta_tV_{t+1}^H \tag{20}$$

where $\beta_t = \beta e^{\varepsilon_{t+1}^d}$. Given that $n_{t+1}^{g,F} = \pi_{t+1}^{g,\{F,F\}}n_t^{g,F} + h_{t+1}^{g,F}$ and $h_t^{g,F} = h_t^{g,\{I,F\}} + h_t^{g,\{NE,F\}}$, the evolution of employment for graduate formal workers is

$$n_{t+1}^{g,F} = \pi_{t+1}^{g,\{F,F\}}n_t^{g,F} + \pi_{t+1}^{g\{I,F\}}n_t^{g,F} + \pi_{t+1}^{g\{NE,F\}}u_t^g \tag{21}$$

And following a similar logic, the evolution of employment for graduate informal workers and non-employed graduates are

$$n_{t+1}^{g,I} = \pi_{t+1}^{g\{F,I\}}n_t^{g,F} + \pi_{t+1}^{g,\{I,I\}}n_t^{g,I} + \pi_{t+1}^{g\{NE,I\}}u_t^g \tag{22}$$

$$u_{t+1}^g = \pi_{t+1}^{g,\{F,NE\}}n_t^{g,F} + \pi_{t+1}^{g\{I,NE\}}n_t^{g,I} + \pi_{t+1}^{g\{NE,NE\}}u_t^g \tag{23}$$

The surplus the household derives from successful conclusion of the graduate formal sector wage bargain is

$$S_t^{g,F} = \frac{1}{C_t^{-\eta}}(\frac{\partial V_t^H}{\partial n_t^{g,F}} - \frac{\partial V_t^H}{\partial u_t^g}) \tag{24}$$

Where

$$\frac{\partial H_t}{\partial n_t^{g,F}} = C_t^{-\eta} w_t^{b\{g,F\}} + \beta E_t \Big\{ \pi_{t+1}^{g,\{F,F\}} \frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} + \pi_{t+1}^{g,\{F,I\}} \frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} + \pi_{t+1}^{g,\{F,NE\}} \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}} \Big\} \tag{25}$$

and

$$\frac{\partial H_t}{\partial u_t^{g}} = C_t^{-\eta} b + \beta E_t \Big\{ \pi_{t+1}^{g,\{NE,F\}} \frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} + \pi_{t+1}^{g,\{NE,I\}} \frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} + \pi_{t+1}^{g,\{NE,NE\}} \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}} \Big\} \tag{26}$$

The household surplus for a graduate in a formal firm is

$$\begin{aligned} \frac{\partial H_t}{\partial n_t^{g,F}} - \frac{\partial H_t}{\partial u_t^{g}} = C_t^{-\eta}(w_t^{b\{g,F\}} - b) + \beta E_t \Big\{ [\pi_{t+1}^{g,\{F,F\}} - \pi_{t+1}^{g,\{NE,F\}}] \frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} + [\pi_{t+1}^{g,\{F,I\}} - \pi_{t+1}^{g,\{NE,I\}}] \frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} \\ + [\pi_{t+1}^{g,\{F,NE\}} - \pi_{t+1}^{g,\{NE,NE\}}] \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}} \Big\} \end{aligned} \tag{27}$$

Noting that $\pi_{t+1}^{g,\{F,F\}} + \pi_{t+1}^{g,\{F,I\}} + \pi_{t+1}^{g,\{F,NE\}} = \pi_{t+1}^{g,\{NE,F\}} + \pi_{t+1}^{g,\{NE,I\}} + \pi_{t+1}^{g,\{NE,NE\}} = 1$,[1] we can write

$$\begin{aligned} \frac{\partial H_t}{\partial n_t^{g,F}} - \frac{\partial H_t}{\partial u_t^{g}} = C_t^{-\eta}(w_t^{b\{g,F\}} - b) + \beta E_t \Big\{ [\pi_{t+1}^{g,\{F,F\}} - \pi_{t+1}^{g,\{NE,F\}}][\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} - \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}] \\ + [\pi_{t+1}^{g,\{F,I\}} - \pi_{t+1}^{g,\{NE,I\}}][\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} - \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}] \Big\} \end{aligned} \tag{28}$$

This can be simplified to

$$S_t^{g,F} = (w_t^{b\{g,F\}} - b) + \beta E_t \Big\{ [\pi_{t+1}^{g,\{F,F\}} - \pi_{t+1}^{g,\{NE,F\}}] S_{t+1}^{g,F} + [\pi_{t+1}^{g,\{F,I\}} - \pi_{t+1}^{g,\{NE,I\}}] S_{t+1}^{g,I} \Big\} \tag{29}$$

Using (17) and (19) to write $S_t^{g,F} = \frac{\eta^{g,F}}{(1-\eta^{g,F})}\{\frac{P_t^W}{P_t} A_t^{g,F} - w_t^{g,F} + E_t \beta_{t,t+1} \pi_{t+1}^{g,\{F,F\}} \frac{\gamma^F}{q_{t+1}^{g,F}}\}$ and $E_t S_{t+1}^{g,F} = \frac{\eta^{g,F}}{(1-\eta^{g,F})} E_t \frac{\gamma^{g,F}}{q_{t+1}^{g,F}}$ and $E_t S_{t+1}^{g,I} = \frac{\eta^{g,I}}{(1-\eta^{g,I})} E_t \frac{\gamma^{g,I}}{q_{t+1}^{g,I}}$, we obtain

$$w_t^{g,I} = \eta^{g,F}\{\frac{P_t^W}{P_t} A_t^{g,F} + \zeta^{g,\{NE,F\}} \gamma^{g,F} E_t \beta_{t,t+1} \theta_{t+1}^{g,F}\} + \tilde{\eta}^{g,I} \gamma^{g,I} E_t \beta_{t,t+1} \theta_{t+1}^{g,I} + (1-\eta^{g,F}) b \tag{30}$$

where $\tilde{\eta}^{g,I} = \eta^{g,I}(\frac{1-\eta^{g,F}}{1-\eta^{g,I}})(\zeta^{g,\{F,I\}} - \zeta^{g,\{NE,I\}})$

The real wage for formal sector graduates depends on their marginal product $(\frac{P_t^{F,W}}{P_t^F} A_t^{g,F})$ and the marginal cost of hiring replacement workers (proportional to $\gamma^{g,F}\theta_{t+1}^{g,F}$). It also depends on the cost of hiring graduates in informal firms (proportional to $\gamma^{g,I}\theta_{t+1}^{g,I}$). This latter effect arises because the value to the household of an additional employed graduate, rather than an additional not employed graduate, depends on the impact this hire has on the probability that this worker is employed in the informal sector in the next period.

[1] this still holds, I believe

4.2 Graduate Informal Workers

The wage bargain for graduate informal workers is similar to the bargain for graduate informal workers. It is determined by the sharing rule

$$(1-\vartheta^{g,I})S_t^{g,I} = \vartheta^{g,I}F_t^{g,I} \tag{31}$$

where $S_t^{g,I}$ is the surplus to the household from an additional graduate being employed in an informal firm, $F_t^{g,I}$ is the surplus to the informal firm and $\vartheta^{g,I}$ is the bargaining power.

The informal firm's surplus from the wage bargain is $F_t^{g,I} = \frac{\partial J_t^F}{\partial n_t^{g,I}}$. Because of the assumption of constant returns, we can combine this with the optimality condition for informal firms to obtain

$$F_t^{g,I} = \frac{P_t^{I,W}}{P_t^I}A_t^{g,I} - w_t^{b\{g,I\}} + E_t\beta_{t,t+1}\pi_{t+1}^{g,\{I,I\}}\frac{\gamma^I}{q_{t+1}^{I,I}} \tag{32}$$

and

$$E_tF_{t+1}^{g,I} = E_t\frac{\gamma^{g,I}}{q_{t+1}^{g,I}} \tag{33}$$

The household utility and evolution of employment is the same as equations (20) to (23).

The surplus the household derives from successful conclusion of the graduate informal sector wage bargain is

$$S_t^{g,I} = \frac{1}{C_t^{-\eta}}\left(\frac{\partial V_t^H}{\partial n_t^{g,I}} - \frac{\partial V_t^H}{\partial u_t^g}\right) \tag{34}$$

Therefore

$$\frac{\partial H_t}{\partial n_t^{g,I}} = C_t^{-\eta}w_t^{b\{g,I\}} + \beta E_t\left\{\pi_{t+1}^{g,\{I,I\}}\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} + \pi_{t+1}^{g,\{I,F\}}\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} + \pi_{t+1}^{g,\{I,NE\}}\frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}\right\} \tag{35}$$

As with the formal graduate job, if the wage bargain is not agreed, the household gains an additional unemployed graduate. This worker gains employment in a high productivity job in the next period with probability $\pi_{t+1}^{g,\{NE,F\}}$; and finds employment in a low productivity job with probability $\pi_{t+1}^{g,\{NE,I\}}$. So

$$\frac{\partial H_t}{\partial u_t^g} = C_t^{-\eta}b + \beta E_t\left\{\pi_{t+1}^{g,\{NE,I\}}\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} + \pi_{t+1}^{g,\{NE,F\}}\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} + \pi_{t+1}^{g,\{NE,NE\}}\frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}\right\} \tag{36}$$

Therefore

$$\begin{aligned}\frac{\partial H_t}{\partial n_t^{g,I}} - \frac{\partial H_t}{\partial u_t^g} = C_t^{-\eta}(w_t^{b\{g,I\}} - b) + \beta E_t\Big\{&[\pi_{t+1}^{g,\{I,I\}} - \pi_{t+1}^{g,\{NE,I\}}]\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} + [\pi_{t+1}^{g,\{I,F\}} - \pi_{t+1}^{g,\{NE,F\}}]\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} \\ &+[\pi_{t+1}^{g,\{I,NE\}} - \pi_{t+1}^{g,\{NE,NE\}}]\frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}\Big\}\end{aligned} \tag{37}$$

Noting that $\pi_{t+1}^{g,\{I,I\}} + \pi_{t+1}^{g,\{I,F\}} + \pi_{t+1}^{g,\{I,NE\}} = \pi_{t+1}^{g,\{NE,I\}} + \pi_{t+1}^{g,\{NE,F\}} + \pi_{t+1}^{g,\{NE,NE\}} = 1$, we can write

$$\begin{aligned}\frac{\partial H_t}{\partial n_t^{g,I}} - \frac{\partial H_t}{\partial u_t^g} = C_t^{-\eta}(w_t^{b\{g,I\}} - b) + \beta E_t\Big\{&[\pi_{t+1}^{g,\{I,I\}} - \pi_{t+1}^{g,\{NE,I\}}][\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,I}} - \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}] \\ &+[\pi_{t+1}^{g,\{I,F\}} - \pi_{t+1}^{g,\{NE,F\}}][\frac{\partial H_{t+1}}{\partial n_{t+1}^{g,F}} - \frac{\partial H_{t+1}}{\partial u_{t+1}^{g}}]\Big\}\end{aligned} \tag{38}$$

This can be simplified to

$$S_t^{g,I} = (w_t^{b\{g,I\}} - b) + \beta E_t \left\{ [\pi_{t+1}^{g,\{I,I\}} - \pi_{t+1}^{g,\{NE,I\}}] S_{t+1}^{g,I} + [\pi_{t+1}^{g,\{I,F\}} - \pi_{t+1}^{g,\{NE,F\}}] S_{t+1}^{g,F} \right\} \tag{39}$$

Using (31) and (33) to write $S_t^{g,I} = \frac{\eta^{g,I}}{(1-\eta^{g,I})}\{\frac{P_t^W}{P_t} A_t^{g,I} - w_t^{g,I} + E_t\beta_{t,t+1}\pi_{t+1}^{g,\{I,I\}}\frac{\gamma^I}{q_{t+1}^{g,I}}\}$ and $E_t S_{t+1}^{g,I} = \frac{\eta^{g,I}}{(1-\eta^{g,I})} E_t \frac{\gamma^{g,I}}{q_{t+1}^{g,I}}$ and $E_t S_{t+1}^{g,F} = \frac{\eta^{g,F}}{(1-\eta^{g,F})} E_t \frac{\gamma^{g,F}}{q_{t+1}^{g,F}}$, we obtain

$$w_t^{g,I} = \eta^{g,I}\{\frac{P_t^W}{P_t} A_t^{g,I} + \zeta^{g,\{NE,I\}}\gamma^{g,I} E_t \beta_{t,t+1}\theta_{t+1}^{g,I}\} + \tilde{\eta}^{g,F}\gamma^{g,F} E_t \beta_{t,t+1}\theta_{t+1}^{g,F} + (1-\eta^{g,I})b \tag{40}$$

where $\tilde{\eta}^{g,F} = \eta^{g,F}(\frac{1-\eta^{g,I}}{1-\eta^{g,F}})(\zeta^{g,\{I,F\}} - \zeta^{g,\{NE,F\}})$

4.3 The Non-graduates in Formal and Informal Workers

The wage bargain for non-graduates follow the same structure outlined in Subsections 4.1) and 4.2).