Online Appendix: The Welfare Effects of Encouraging Rural-Urban Migration

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A. Appendix Tables and Figures

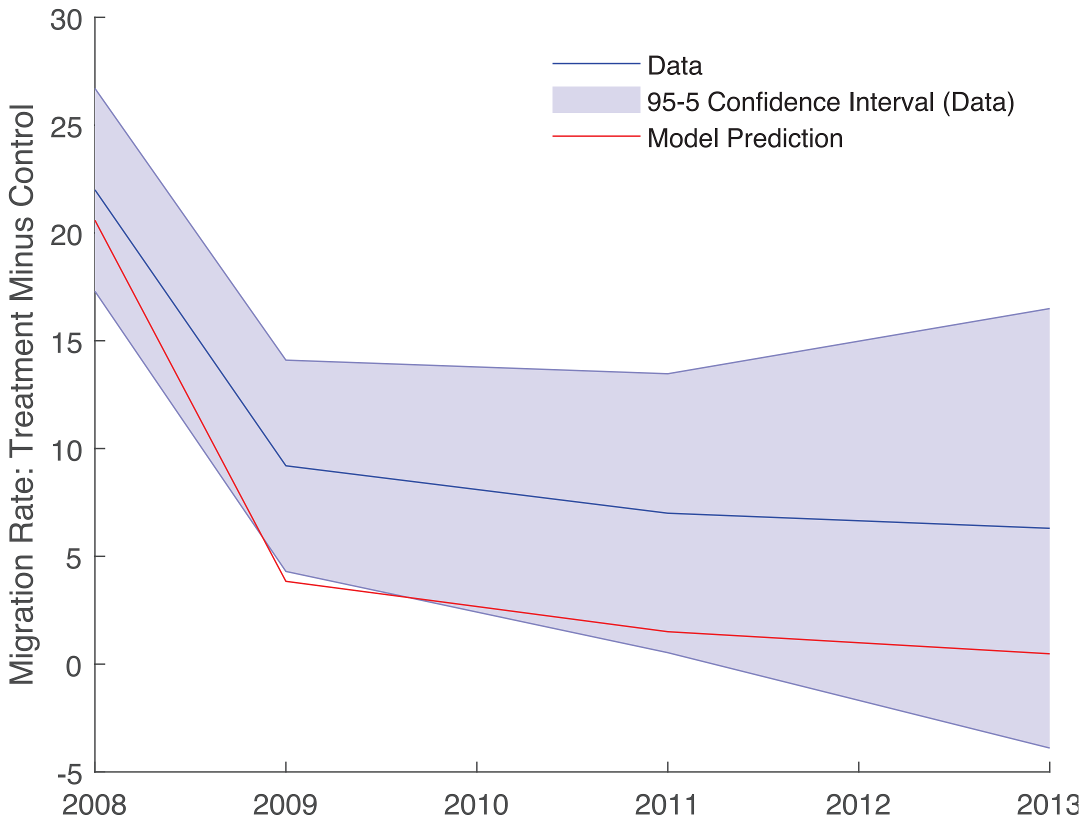

Figure A.1: Difference in Migration Rates in Treatment and Control Groups

Table A.1: Data and Model with Additive Migration Disutility

Moments	Data	Model Baseline	Model Additive
Control: Variance of log consumption growth in rural	0.19	0.19	0.19
Control: % of rural households with no liquid assets	47	47	47
Control: Seasonal migrants	36	36	40
Control: Consumption increase of migrants (OLS)	10	10	8
Treatment: Seasonal migration relative to control	22	21	13
Treatment: Seasonal migration relative to control in year 2	9	5	4
Treatment: Cons of induced migrants relative to control (LATE)	30	29	25
Control: Probability of repeat migration	68	71	69
Urban-Rural wage gap	1.89	1.89	1.91
Percent in rural	61	60	57
Variance of log wages in urban	0.56	0.56	0.56

Note: The table reports the moments targeted using simulated method of moments and their values in the data and in a version of the model with additive migration disutility.

Table A.2: Welfare in Models with $\bar{u} = 1$ and $\rho = 0$

		Baseline Model		$\bar{u} = 1$		$\rho = 0$	
		Welfare	Migr. Rate	Welfare	Migr. Rate	Welfare	Migr. Rate
Income Quintile	1	1.17	85	1.45	79	0.75	84
	2	0.45	62	0.82	73	0.37	67
	3	0.28	51	0.67	68	0.22	53
	4	0.20	45	0.50	64	0.16	46
	5	0.12	40	0.34	56	0.11	38
Average		0.44	57	0.75	68	0.32	58

Note: This table reports the welfare gains of migration subsidies by income quintile in a version of the model where $\bar{u} = 1$ and $\rho = 0$.

Table A.3: Data and Model with Different R values

Moments	Data	Model Baseline	Model R=0.90	Model R=1.0
Control: Variance of log consumption growth in rural	0.19	0.19	0.19	0.19
Control: Percent of rural households with no liquid assets	47	47	78	23
Control: Seasonal migrants	36	36	39	32
Control: Consumption increase of migrants (OLS)	10	10	06	12
Treatment: Seasonal migration relative to control	22	21	20	20
Treatment: Seasonal migration relative to control in year 2	9	5	5	5
Treatment: Consumption of induced migrants (LATE)	30	29	31	26
Control: Probability of repeat migration	68	71	72	69
Urban-Rural wage gap	1.89	1.89	1.87	1.93
Percent in rural	61	60	59	62
Variance of log wages in urban	0.56	0.56	0.56	0.56

Note: The table reports the main moments of the paper for alternative values of R. The baseline model has $R = 0.95$. The model is not re-estimated in the cases of $R = 0.90$ and $R = 1.0$.

Table A.4: Data and Model with Different β values

Moments	Data	Model Baseline	Model β=0.90	Model β=0.97
Control: Variance of log consumption growth in rural	0.19	0.19	0.19	0.19
Control: Percent of rural households with no liquid assets	47	47	78	38
Control: Seasonal migrants	36	36	36	36
Control: Consumption increase of migrants (OLS)	10	10	07	11
Treatment: Seasonal migration relative to control	22	21	21	21
Treatment: Seasonal migration relative to control in year 2	9	5	5	5
Treatment: Consumption of induced migrants (LATE)	30	29	30	28
Control: Probability of repeat migration	68	71	69	71
Urban-Rural wage gap	1.89	1.89	1.93	1.88
Percent in rural	61	60	62	60
Variance of log wages in urban	0.56	0.56	0.56	0.56

Note: The table reports the main moments of the paper for alternative values of β. The baseline model has $\beta = 0.95$. The model is not re-estimated in the cases of $\beta = 0.90$ and $\beta = 0.97$.

Table A.5: Elasticities of Targeted Moments to Parameters

	$1/\theta$	A_u	ρ	$\bar{u}$	π	λ	γ	σ	σ_ν
Urban-rural wage gap	1.6	-0.2	0.5	-0.0	0.1	0.0	0.2	-0.5	-0.1
Percentage in rural	0.9	-1.3	0.5	-0.5	-0.0	0.2	0.1	-0.4	0.0
Control: % of rural with no liquid assets	-1.0	0.6	4.3	-1.0	0.1	0.1	-0.2	-1.2	-0.0
Control: Seasonal migrants	-3.5	1.8	-0.3	-5.4	-0.9	1.8	-0.8	0.2	0.1
Treatment effect on seasonal migration	-1.6	2.1	-0.8	-1.3	0.4	-0.4	-0.1	1.0	-0.1
Treatment effect on seasonal migration, year 2	-2.4	3.3	-1.2	0.7	-0.7	0.5	0.3	1.6	-0.3
Consumption increase of migrants (OLS)	4.8	-3.5	4.3	8.2	0.5	-0.3	2.9	-3.0	-0.3
LATE - OLS	-3.2	1.8	0.4	-2.9	-0.2	0.4	-1.2	-0.3	-0.1
Control: Probability of repeat migration	0.0	0.2	0.2	-0.9	-0.4	0.7	0.2	-0.3	-0.3

Note: This table reports the elasticities of each targeted moment to each parameter, computed as the percent increase in each moment to a one percent increase in each parameter, starting from the estimated parameters of the model.

Table A.6: Seasonal Migration Rates

	Control	Treatment	Difference
Data	36	58	22***
			(2.39)
Model	36	57	21
Model of Bryan et al (2014) (initial conditions)	66	97	31
Model of Bryan et al (2014) (+ no subsistence)	83	98	15
Model of Bryan et al (2014) (long run)	50	50	0

Note: This table reports the seasonal migration rates in the control and treatment villages of Bryan et al (2014) expressed in percentage points, and the standard error and statistical significance of the difference, where ***,** and * mean significance at the 1-percent, 5-percent and 10-percent levels. The next four rows present the same statistics in the current model, the model of Bryan et al (2014) under the initial conditions (t=0), without the subsistence constraint, and in the long run ($t \geq 10$) with the subsistence constraint.

Table A.7: Data and Model with Subsistence Consumption

Moments	Data	Model Baseline	Model w/ Subsistence
Control: Variance of log consumption growth in rural	0.19	0.19	0.19
Control: Percent of rural households with no liquid assets	47	47	47
Control: Seasonal migrants	36	36	36
Control: Consumption increase of migrants (OLS)	10	10	10
Treatment: Seasonal migration relative to control	22	21	21
Treatment: Seasonal migration relative to control in year 2	9	5	04
Treatment: Cons of induced migrants relative to control (LATE)	30	29	30
Control: Probability of repeat migration	68	71	70
Urban-Rural wage gap	1.89	1.89	1.89
Percent in rural	61	60	60
Variance of log wages in urban	0.56	0.56	0.64

Note: The table reports the moments targeted using simulated method of moments and their values in the data and in the model. The final calibration reports the moments when a subsistence consumption requirement is added to preferences and set to equal 20 percent of average rural consumption.

Table A.8: Welfare with Subsistence Consumption

		Baseline Model		w/ Subsistence	
		Welfare	Migr. Rate	Welfare	Migr. Rate
Income Quintile	1	1.17	85	1.72	90
	2	0.45	62	0.53	63
	3	0.28	51	0.37	52
	4	0.20	45	0.23	44
	5	0.12	40	0.14	37
Average		0.44	57	0.60	57

Note: The table reports the welfare gains from migration subsidies in a model where a subsistence consumption requirement is added to preferences and set to equal 20 percent of average rural consumption.

Table A.9: Repeat Migration Patterns

	Pr(Migrate$_t$ | Migrate$_{t-1}$)	Pr(Migrate$_t$ | Not Migrate$_{t-1}$)
Data	0.68	0.26
Model	0.70	0.14
Model of Bryan et al (2014)	0.52	0.74

Note: This table reports patterns of repeat migration, measured by probabilities of migration conditional on migration the previous year, and on no migration in the previous year. The first row reports the conditional migration probabilities in the experiment of Bryan et al (2014). The second and third rows present the same probabilities in the current model and in the model of Bryan et al (2014).

B. Model Appendix

This Appendix provides a generic description of our model with relatively compact notation. We then discuss how this maps into the notation used in the body of the paper, the aggregate laws of motion, National Income and Product Accounting in the model, and our equilibrium concept. The generic description also clarifies the Social Planner's Problem and explains how we solve it.

B.1. The Spatial Incomplete Markets Model

The state variables for a household can be divided into objects that an individual productivity state, endogenous state variables, aggregate state variables, and then iid preference shocks.

- **Individual productivity state.** Each household is subject to productivity shocks, s that is described by the Markov transition probabilities $\pi(s', s)$. The generic representation is that s could be anything, as long as it's Markov. So it could be a vector that spans the location space (as in the Roy model) or just a scalar value.
- **Endogenous state variables.** There are three endogenous (individual) state variables. The first is the household's asset holdings, a. The second is a variable that describes the household's location j. The third is whether or not the household is an inexperienced migrant, x, and, thus, whether or not it suffers disutility $\bar{u}$. As I describe below, this will evolve according to the transition probability function $\varphi(x', x, j)$ which may depend upon a households location.
- **Aggregate state variables.** There is an index i which describes the aggregate state(s).
- **Transitory moving shock.** Each household is subject to additive i.i.d. moving shocks ν for each location j. Here these moving shocks are independently and identically distributed across time and is distributed Type 1 extreme value distribution with scale parameter σ_ν.

Given this representation, we can express the household's problem as

$$v_j(a, s, x, i) = \max_{j'} \left\{ v_{j'j}(a, s, x, i) + \nu_{j'} \right\}, \tag{1}$$

and then the value functions associated with a move from j to j' (here we are using right to left notation to denote the source j and destination j') is

$$v_{j'j}(a,s,x,i) = \max_{a' \in \mathcal{A}} \left\{ u(Ra + w_j(s,i) - a' - m_{j',j}\ ,\ x) + \beta\, \mathbb{E}[v_{j'}(a', s', x', i')] \right\}, \tag{2}$$

which says that the household chooses future asset holdings to maximize the expected present discounted value of utility. Utility depends upon consumption (the first argument) and experience status x (second argument). Given asset choices, a household's consumption equals the gross return on current asset holdings, Ra, plus labor income $w_j(s,i)$, minus future asset holdings and minus any moving costs incurred $m_{j',j}$ for going from j to j'. The asset holdings must respect the borrowing constraint and, thus, must lie in the set $\mathcal{A}$. Next period's state variables are the new asset holdings, the individual productivity shock, the experience level, and the aggregate state.

Associated with the this problem are the policy functions describing the optimal asset and migration choice. These will be denoted as: $g_{j',j}(a,s,x,i)$ and a migration indicator function $\iota_{j'j}(a,s,x,i,\nu)$. When integrating across the idiosyncratic preference shock in the migration indicator function gives rise to migration probabilities $\mu_{j',j}(a,s,x,i)$.

B.2. Mapping to the Baseline Model

The model presented in the body of the paper is a specific case of the representation above. This subsection specifies this mapping.

Locations. One way to think about the baseline model in the body of the paper is that there are three locations j: rural, seasonal migration, and urban. Then there is a technological restriction on the migration choices depending upon the location. So a rural households can: stay, transition to seasonal migration, or migrate to the urban area. Seasonal migrants can **only** move to the rural area. Urban migrants can: stay or migrate to the rural location. This implies that the matrix of migration cost (with the row denoting the source, column denoting the destination) would take the form:

$$\begin{pmatrix} m_{\text{rural}',\text{rural}} = 0 & m_{\text{seas}',\text{rural}} = m_T & m_{\text{urban}',\text{rural}} = m_P \\ m_{\text{rural}',\text{seas}} = 0 & m_{\text{seas}',\text{seas}} = \infty & m_{\text{urban}',\text{seas}} = \infty \\ m_{\text{rural}',\text{urban}} = m_P & m_{\text{seas}',\text{urban}} = \infty & m_{\text{urban}',\text{urban}} = 0 \end{pmatrix} \tag{3}$$

For example, households seasonally migrating can not remain seasonal migrants in out model, thus $m_{\text{seas}',\text{seas}} = \infty$. And then the associated migration probabilities $\mu_{j',j}$ take the following form:

$$\begin{pmatrix} \mu_{\text{rural}',\text{rural}} & \mu_{\text{seas}',\text{rural}} & \mu_{\text{urban}',\text{rural}} \\ \mu_{\text{rural}',\text{seas}} & 0 & 0 \\ \mu_{\text{rural}',\text{urban}} & 0 & \mu_{\text{urban}',\text{urban}} \end{pmatrix}$$

Individual Productivity Shocks. In the baseline model, we can represent the idiosyncratic state s as a pair (z, s) with $\pi(s', s)$ being non-zero for all $s' = (z, s')$ and zero for all $s' = (z', s')$ so that z is a permanent state. And thus the generic problem above describes the problem for a particular z. In the baseline model's setting, we then solving the problem many times for different zs. Below, we will explicitly carry around the dependence upon z to be consistent with the body of the paper.

Experience. In the basline model, we posited a particular process for the evolution of x or experience that is indexed by the location and hence is influenced by the migration choices. To remind ourselves how this works, if a household in rural area does not have experience, it stays inexperienced; if the household is experienced, it stays experienced next period with probability π and inexperienced with probability $1 - \pi$. If a household is in the urban area and has experience it stays experienced; inexperienced urban households stay inexperienced in the next period with probability λ and become experienced with probability $1 - \lambda$. If a household is a seasonal migrant and does not have experience, then it can acquire experience with probability λ and become experienced with probability $1-\lambda$.

The compact representation of this is as a location dependent Markov chain: $\varphi(x', x, j)$.

Aggregate State. In the baseline model, things are simple in that $i = (\ A_{r,i},\ N_{r,i}\ )$ with $A_{r,i}$ deterministically transitioning from a good and bad season to mimic seasonal crop cycles. $N_{r,i}$ is an endogenous, aggregate state variable that depends upon location choices. It matters because of the decreasing returns to production in the rural area and, hence, it feeds back into the prices faced. In the stationary equilibrium, this will deterministically move with seasonal productivity and thus the index i is a sufficient statistic for the complete description of the aggregate states.

B.3. Production in the Baseline Model

There is one homogeneous good produced in rural and urban locations by competitive producers. Seasonal migrants work in the urban location. Locations differ in the technologies they operate. The rural technology is

$$Y_{ri} = A_{ri} N_{ri}^{\phi}, \tag{4}$$

where N_{ri} are the effective labor units working in the rural area in season i. The parameter $0 < \phi < 1$, so that there are decreasing marginal product of labor in the rural area. And A_{ri} is rural productivity in season i. The urban technology is given by:

$$Y_{ui} = A_u N_{ui}, \tag{5}$$

where A_u captures urban productivity and N_{ui} is the effective labor units supplied by households working in the urban area in that season i.

Wages. In season i, with N_r effective labor units in the rural area, wages per efficiency unit are

$$\omega_{ri} = A_{ri} \phi N_{ri}^{\phi - 1} \quad \text{and} \quad \omega_u = A_u. \tag{6}$$

Agents working in a particular location receive wages that are the product of (6) and the number of their efficiency units. Thus, the labor income that a household with transitory state s receives for working in location i is:

$$w_{ri}(s) = s\omega_{ri} \quad \text{and} \quad w_u(z, s) = z s^{\gamma} \omega_u, \tag{7}$$

Land Rents. There are rents that accrue to the owners of the fixed factor used in the rural production function. We assume that they are redistributed to "absentee landlords" in the economy. Below we discuss where this matters or not. For now, recognize that these rents are

$$\text{rents}_i = (1 - \phi) A_{ri} N_{ri}^{\phi}. \tag{8}$$

B.4. Laws of Motion and Accounting

First, define the migration probabilities for a given set of state variables as:

$$\mu_{j',j}(a, z, s, x, i) = \int_{\nu} \iota_{j',j}(a, z, s, x, i, \nu) d\nu, \tag{9}$$

where $\mu_{j',j}(a, z, s, x, i)$ is the probability mass of those moving from location j (rural, seasonal, and urban) to location j'. And these probabilities must respect the technological restrictions discussed around (3).

The distribution of households across states. Define the probability distribution of households across individual states in location j as $\lambda_j(a, z, s, x, i)$. This is the measure of households in location j with asset levels a, permanent shock z, individual shocks s, experience x, in season i. Furthermore, define the probability distribution of households in the next period as $\lambda_j(a, z, s, x, i')$ with the observation that the season deterministically changes with each time period.

The probability distribution $\lambda_j(a, z, s, x, i)$ evolves via the following law of motion:

$$\lambda_j(a', z, s', x', i') = \underbrace{\int\limits_x \int\limits_s \int\limits_{a:a'=g_{j,j}(a,z,s,x,i)} \mu_{j,j}(a, z, s, x, i)\lambda_j(a, z, s, x, i)\pi(s', s)\varphi(x', x, j)\, da\, ds\, dx}_{\text{stayers}} + \underbrace{\sum_{j' \neq j} \int\limits_x \int\limits_s \int\limits_{a:a'=g_{j,j'}(a,z,s,x,i)} \mu_{j,j'}(a, z, s, x, i)\lambda_{j'}(a, z, s, x, i)\pi(s', s)\varphi(x', x, j')\, da\, ds\, dx}_{\text{movers}} \tag{10}$$

The first bracket are those who stay in location j. This is the existing mass $\lambda_j(a, z, s, x, i)$ multiplied by the mass of households remaining in j or $\mu_{j,j}(a, z, s, x, i)$. This is then integrated over asset holdings of those households staying in j conditional on assets equalling a' tomorrow; the transition probability that s transits to s'; that experience transits from x to x' which depends upon the location of the household.

The second bracket is the flow into location j from all other locations j'. That is the movers from locations j' into location j. Again, this is the existing mass $\lambda_{j'}(a, z, s, x, i)$ and multiplied by the mass of households moving into j or $\mu_{j,j'}(a, z, s, x, i)$. And then integration takes place over asset holdings, shock transitions, and experience transitions.

Population and Labor Supply. Define the population of location j in season i as

$$\lambda_j(i) = \int\limits_x \int\limits_s \int\limits_z \int\limits_a \lambda_j(a, z, s, x, i)\, da\, dz\, ds\, dx. \tag{11}$$

Another useful statistic is the measure of efficiency types in location and by season

$$\lambda_j(z, s, i) = \int\limits_x \int\limits_a \lambda_j(a, z, s, x, i)\, da\, dx. \tag{12}$$

Then the effective labor units in the urban area are

$$N_{ui} = \sum_{j=[\text{urban,seas}]} \int_s \int_z zs^{\gamma} \, \lambda_j(z,s,i) \, dz \, ds, \tag{13}$$

which includes the seasonal and permanent urban workforce. And in the rural area:

$$N_{ri} = \int_s \int_z s \, \lambda_{\text{rural}}(z,s,i) \, dz \, ds. \tag{14}$$

Asset Holdings. In each season, aggregate net-asset holdings are

$$\mathcal{A}'_i = \sum_j \sum_{j'} \int_x \int_s \int_z \int_a g_{j',j}(a,z,s,x,i) \, \mu_{j',j}(a,z,s,x,i) \, \lambda_j(a,z,s,x,i) \, da \, dz \, ds \, dx. \tag{15}$$

inside of the summation and integration this is the mass of households moving from j to j' (which is given by the migration rate $\mu_{j',j}(a,z,s,x,i)$) multiplied by the measure of households in that location $\lambda_j(a,z,s,x,i)$) multiplied by the asset policy function associated with that migration choice $g_{j',j}(a,z,s,x,i)$. This is then integrated across current period asset holdings, individual shocks, experience levels and then summed across all location-destination pairs.

Connecting National Income and Consumption. Start from the production side of our economy. The value of aggregate production must equal aggregate payments to labor and payment to land owners who own the fixed factor that is used in rural area production.

$$Y_i = A_u N_{ui} + A_{ri} N_{ri}^{\phi} = \sum_j \int_z \int_s w_{ji}(z,s) \lambda_j(z,s,i) \, ds \, dz + \text{rents}_i \tag{16}$$

where the first term on the right side integrates over wage payments for each location, each shock state. The second term are the payments to land that is associated with rural location. Now by integrating over the consumers budget constraint and substituting (16) into the resource constraint, we arrive at the following:

$$Y_i - \text{rents}_i = C_i - R\mathcal{A}_i + \mathcal{A}'_i + \sum_j \sum_{j'} \int_x \int_s \int_a m_{j',j} \, \mu_{j',j}(a,s,x,i) \lambda_j(a,s,x,i) \, da \, ds \, dx \tag{17}$$

so aggregate labor income equals consumption minus (i) returns on assets (ii) new purchases of assets (iii) plus moving costs. Then defining moving costs each season as M_i and rearranging we have

$$Y_i = C_i + M_i + \Big[- R\mathcal{A}_i + \mathcal{A}'_i + \text{rents}_i \Big] \tag{18}$$

where C is like consumption in the standard GDP accounting identity, the moving cost is like investment, then the term in brackets represent net flows aborad or inward because (i) we are not clearing the asset market and (ii) who holds the rents are not explicitly accounted for.

B.5. The Decentralized Equilibrium

Here we define a **Stationary Decentralized Equilibrium** with the name signifying that this is the equilibrium which would arise in decentralized market economy in contrast to the allocations that would be chosen by a social planner.

A Stationary Decentralized Equilibrium. A Stationary Decentralized Equilibrium are asset and moving policy functions $\{ \ g_{j',j}(a,z,s,x,i), \iota_{j',j}(a,z,s,x,i,\nu) \ \}$, a probability distribution $\lambda_j(a,z,s,x,i)$, and positive real numbers $N_{ri}, N_{ui}, w_{ri}(s), w_u(z,s))$ such that

i The prices $(w_{ri}(s), w_u(z,s)))$ satisfy (6);

ii The policy functions solve the household's optimization problem in (1, 2);

iv The probability distribution $\lambda(a,j,z,s,x,i,\nu)$ induced by $\{ \ g_{j',j}(a,z,s,x,i), \iota_{j',j}(a,z,s,x,i,\nu), \pi(s',s), \varphi(x',x,j), \phi(\nu) \ \}$ satisfies (10) and is a stationary distribution;

iv Effective labor units in the rural and urban areas satisfy (13, 14).

The final object we define is the utilitarian social welfare function:

$$\mathcal{W}^{\text{DCE}} = \sum_j \int_a \int_x \int_s \int_z v_j(a,z,s,x,i)\lambda_j(a,z,s,x,i) dz\ ds\ dx\ da. \tag{19}$$

which is the average value of households across locations, shock states, experience, assets, and preference states.

B.6. The Decentralized Equilibrium with Government Intervention

This section describes the model with a government that implements a means-tested migration subsidy similar to the **?** experiment and finances it through a tax on labor income.

The households migration choice is the same as in (1), but the value function associated across different location options is:

$$v_{j'j}(a,z,s,x,i) =$$

$$\max_{a' \in \mathcal{A}} \left\{ u(Ra + (1-\tau)w_j(z,s,i) - a' - [m_{j',j} + \tilde{m}_{j',j}(a)]\ ,\ x) + \beta \mathbb{E}[v_{j'}(a', z, s', x', i')] \right\}, \quad (20)$$

where τ is the labor income tax rate and $\tilde{m}_{j',j}(a)$ is the migration subsidy that depends upon a households locatio-destination decision and asset holdings. In the context of **?**, the value of the migration subsidy is positive only for (i) rural households seasonally migrating ($j =$ rural, $j' =$ seas) and (ii) when assets are below $\bar{a}$ where $\bar{a}$ corresponds with a threshold chosen by **?** which is (approximately) the median level of assets in the rural village. For all other households the value of this subsidy is zero.

The Government's fiscal year budget constraint as:

$$\begin{aligned} G = & \sum_i \sum_j \int_s \int_z \tau w_j(z,s,i) \lambda_j(z,s,i) dz\ ds \\ & - \sum_i \sum_j \sum_{j'} \int_x \int_s \int_z \int_a \tilde{m}_{j',j}(a)\ \mu_{j',j}(a,z,s,x,i) \lambda_j(a,z,s,x,i)\ da\ dz\ ds\ dx = 0 \end{aligned} \quad (21)$$

where the first term are labor income tax receipts and the second term are the outlays of migration subsidies. We ask that the government balance its budget, fiscal year by fiscal year. We emphasize fiscal year which is comprised of the bad and good season. Thus, we are allowing the Government to collect taxes and pay out subsidies that must balance across all seasons, but that may not balance within a season.

A Stationary Decentralized Equilibrium with Government Intervention A Stationary Decentralized Equilibrium with Government Intervention are asset and moving policy functions $\{\ g_{j',j}(a,z,s,x,i), \iota_{j',j}(a,z,s,x,i,\nu)\ \}$, a probability distribution $\lambda_j(a,z,s,x,i)$, and positive real numbers $N_{ri}, N_{ui},\ w_{ri}(s), w_u(z,s))$ and government policy $\{\ \tilde{m}_{j',j}(a), \tau\}$ such that

i The prices $(w_{ri}(s), w_u(s)))$ satisfy (6);

ii The policy functions solve the household's optimization problem in (1, 20);

iv The probability distribution $\lambda(a,j,z,s,x,i,\nu)$ induced by $\{\ g_{j',j}(a,z,s,x,i), \iota_{j',j}(a,z,s,x,i,\nu), \pi(s',s), \varphi(x',x,j), \phi(\nu)\ \}$ satisfies (10) and is a stationary distribution;

iv Effective labor units in the rural and urban areas satisfy (13, 14).

v The Government's budget constraint (21) is satisfied.

The main differences relative to the Decentralized Equilibrium are that the policy functions must satisfy the households problem with taxes and subsidies in (20) and that the Government's budget constraint is satisfied in (21).

B.7. The Centralized Equilibrium

B.7.1. The Social Welfare Function

We focus on a utilitarian social planner placing weight $\psi(z)$ on households of permanent productivity type z. Define the social welfare function as

$$\mathcal{W}^{\mathcal{SP}} = \sum_{t=0}^{\infty} \sum_{j} \int_{z} \int_{s} \int_{x} \int_{\nu} \beta^t \psi(z) \; u_{j',j}(c_j(z,s,x,t),x,\nu) \lambda_j(z,s,x,\nu,t) \; d\nu \; dx \; ds \; dz. \tag{22}$$

Here social welfare is the average value of households utility across locations j, productivity states z and s, experience x, and preference shocks ν. The average is computed with respect to the measure of households $\lambda_j(z,s,x,\nu,t)$ with those shock states, experience levels, and preference shocks at date all dates t. Utility depends directly upon the consumption allocation $c_j(z,s,x,t)$, but also directly on the location j through the $\bar{u}$, and the idiosyncratic preference shock across moving options j'

We cast the Planners Problem in terms of the planner choosing consumption allocations and migration probabilities for each state and date. To cast the problem in terms of migration probabilities, we integrate out the preference shocks conditional on a set of migration probabilities for each household state. These migration probabilities prescribe an assignment of those households with the largest relative preference shock to migrate or not. So given set of states j,z,s,x,t, utility is

$$u(c_j(z,s,x,t),x) + E[\; \nu \mid \left\{\mu_{j',j}(z,s,x,t)\right\}_{j'}]. \tag{23}$$

where $\mu_{j',j}(z,s,x,t)$ is the migration probability going from location j to location j' and then $E[\; \nu \mid \left\{\mu_{j',j}(z,s,x,t)\right\}_{j'}]$ is the expected value of the preference shock conditional on the migration probabilities. So, for example, if the Planner dictates that all people migrate location j to location j', then this value is just the unconditional mean of a Type 1 extreme value shock. Now we can write the social welfare function as

$$\mathcal{W}^{\mathcal{SP}} = \sum_{t=0}^{\infty} \sum_{j} \int_{z} \int_{s} \int_{x} \beta^t \psi(z) \Big\{ u(c_j(z,s,x,t),x) + E[\, \nu \mid \{\mu_{j',j}(z,s,x,t)\}_{j'}] \Big\} \lambda_j(z,s,x,t) dx\, ds\, dz. \tag{24}$$

B.7.2. The Law of Motion and Feasibility

The Planning Problem maximizes (24) subject to the law of motion describing how the population evolves across states and locations and then how many resources the are available, i.e., feasibility. We describe each of these aspects of the environment below.

Law of Motion. The law of motion describing how the measure of households evolves across states and locations is

$$\begin{aligned} \lambda_j(z,s',x',t+1) = & \int_{s} \int_{x} \mu_{j,j}(z,s,x,t) \pi(s',s) \varphi(x',x,j) \lambda_j(z,s,x,t)\; dx\; ds \\ & + \sum_{j' \neq j} \int_{s} \int_{x} \mu_{j,j'}(z,s,x,t) \pi(s',s) \varphi(x',x,j') \lambda_{j'}(z,s,x,t)\; dx\; ds. \end{aligned} \tag{25}$$

This equation says, given the current distribution $\lambda_{j'}(z,s,x,t)$ in location j', the measure of households $\lambda_j(z,s',x',t+1)$ reflects the migration probabilities of households in each location, how their productivity evolves over time ($\pi' s$), and how their experience $\varphi(x',x,j)$ evolves.

Labor Supply, Aggregate Production, and the Resource Constraint. Given a distribution of households, the effective labor units in the urban and rural area are

$$N_{u,t} = \sum_{j=[\text{urban,seas}]} \int_{z} \int_{s} \int_{x} z s^{\gamma}\; \lambda_j(z,s,x,t)\; dx\; ds\; dz,$$

$$N_{r,t} = \int_{z} \int_{s} \int_{x} s\; \lambda_{\text{rural}}(z,s,x,t)\; dx\; ds\; dz\; . \tag{26}$$

with the urban area includes the seasonal and permanent urban workforce. Aggregate production of the final good is

$$Y_t = A_u N_{u,t} + A_{r,t} \left(N_{r,t}\right)^{\phi}. \tag{27}$$

Combining the amount of resources available in (27) with the consumption and moving decisions we have the following resource constraint:

$$
\begin{aligned}
Y_t \;\geq\; & \sum_j \int_z \int_s \int_x c_j(z,s,x,t)\lambda_j(z,s,x,t)\;dx\;ds\;dz \\
& + \;\sum_j \sum_{j'} \int_z \int_s \int_x m_{j',j}\;\mu_{j',j}(z,s,x,t)\lambda_j(z,s,x,t)\;dx\;ds\;dz.
\end{aligned} \tag{28}
$$

which says that production must be greater than or equal to consumption which is the first term on the righthand side of (28) and the moving costs associated with the migration of households across locations which is the second term on the righthand side. Here we compactly sum across all j' and j location pairs and reminding ourselves that the moving cost for staying in a location is zero, i.e., $m_{j,j} = 0$.

B.7.3. The Social Planners Problem

The **Social Planner's Problem** is the following:

$$
\mathcal{W}^* = \max_{c_j,\,\mu_{j',j}} \sum_{t=0}^{\infty} \sum_j \int_z \int_s \int_x \beta^t \psi(z) \Big\{ u(c_j(z,s,x,t),x) + E[\,\nu \mid \{\mu_{j',j}(z,s,x,t)\}_{j'}] \Big\} \lambda_j(z,s,x,t)\;dx\;ds\;dz
$$

$$
\text{subject to } (27)\;\; (28) \;\text{ and }\; (25) \;\text{ and an inital condition }\; \lambda_j(z,s,x,0). \tag{29}
$$

Here the planner is choosing consumption allocations and migration probabilities for each state and date and these allocations must respect the production technology, feasibility, and the law of motion and an initial condition. Finally, note that the planner only considers allocations that depend on the current state, not the entire history. Given the Markov structure on the shocks, we suspect that this is of no consequence, e.g., the history independence of consumption allocation is clear. Given this problem in (29), define the following allocation:

A Stationary Social Planner Allocation. A Stationary Social Planner Allocation are time invariant policy functions $\{\, c_j(z,s,x,i),\; \mu_{j',j}(z,s,x,i) \,\}$, a probability distribution $\lambda_j(z,s,x,i)$, and positive real numbers $N_{j,i}$ for rural and urban areas and season i where:

i The policy functions solve the Social Planner's Problem in (29);

ii The probability distribution $\lambda_j(z,s,x,i)$ associated with $\{\, \mu_{j',j}(z,s,x,i),\; \pi(s',s),\; \varphi(x',x,j),\; \phi(\nu) \,\}$ is a stationary distribution;

iii Effective labor units in the rural and urban areas satisfy (26).

B.7.4. Solution to the Social Planner's Problem

The approach to solving the planning problem proceeds in the following way. First, we formulate the problem in (29) using Lagrangian methods under the operating assumption that these methods are usable. Second, we then derive the necessary first order conditions associated the planner's consumption allocation and migration probabilities.

We express the **Social Planner's Problem** as:

$$\mathcal{L} = \sum_{t=0}^{\infty} \sum_{j} \int_{z} \int_{s} \int_{x} \beta^t \psi(z) \Big\{ u(c_j(z,s,x,t),x) + E[\,\nu \mid \{\mu_{j',j}(z,s,x,t)\}_{j'}] \Big\} \lambda_j(z,s,x,t)\; dx\; ds\; dz \tag{30}$$

$$+ \sum_{t=0}^{\infty} \chi(t) \Big\{ Y_t - \sum_{j} \int_{z} \int_{s} \int_{x} \Big[c_j(z,s,x,t) + \sum_{j'} m_{j',j}\; \mu_{j',j}(z,s,x,t) \Big] \lambda_j(z,s,x,t)\; dx\; ds\; dz \Big\}$$

$$+ \sum_{t=0}^{\infty} \sum_{j} \int_{z} \int_{s} \int_{x} \chi_{2j}(z,s,x,t) \Big\{ 1 - \sum_{j'} \mu_{j',j}(z,s,x,t) \Big\} \lambda_j(z,s,x,t)\; dx\; ds\; dz$$

$$- \sum_{t=0}^{\infty} \sum_{j} \int_{z} \int_{s'} \int_{x'} \beta^{t+1} \psi(z) \chi_{3j}(z,s',x',t+1) \Big\{ \lambda_j(z,s',x',t+1) \; -$$

$$\sum_{j'} \int_{s} \int_{x} \mu_{j,j'}(z,s,x,t) \pi(s',s) \varphi(x',x,j') \lambda_{j'}(z,s,x,t)\; dx\; ds \Big\}\; dx'\; ds'\; dz$$

where the first term is the social welfare function and then several constraints with the associated multipliers. Each contraint/multiplier are:

1. $\chi(t)$ is the Lagrange multiplier on the resource constraint.

2. $\chi_{2j}(z,s,x,t)$ are multipliers on the constraint that the destination migration probabilities leaving source j must sum to one.

3. $\chi_{3j}(z,s',x',t+1)$ are multipliers on the law of motion for the probability distribution, that is migration flows into j from all j' must equal the probability mass in j at date $t+1$. On this last multiplier, we do the following that will ease the algebra below:

scale the multiplier $\chi_{3j}(z, s', x', t+1)$ by $-\beta^{t+1}$ and the Pareto weight $\psi(z)$. This does not change the problem, but is only a scaling trick to see things quicker in the algebra below.

Consumption Allocations. Taking the first order condition of (30) with respect to consumption gives:

$$\beta^t \psi(z) u'(c_j(z, s, x, t), x) = \chi(t) \quad \forall\, j, j',\ s,\ x, \text{ and } t. \tag{31}$$

which says set the weighted, marginal utility of consumption for every location, productivity state, and experience state equal its marginal cost at each date. This condition has several implications. First, in a time-invariant, stationary allocation, for a given permanent productivity state z, in each season i:

$$u'(c_j(z, s, x, i), x) = u'(c_{\tilde{j}}(z, s', x', i), x') \;\forall\, j,\ s,\ x, \tag{32}$$

$$= u'(z, i)$$

so that marginal utility is equated within each season across households of permanent type z. What this implies is that "luck" or a persons history that led to a particular location, shock state s, or preference state x does not matter and consumption is equalized with those of the same z. Now across households of different z types, we have the condition that

$$\frac{u'(z, i)}{u'(z', i)} = \frac{\psi(z')}{\psi(z)} \tag{33}$$

so that the ratio of the marginal utility of consumption is inversely proportional to the Pareto weights. In the Utilitarian case, this condition implies that the marginal utility of consumption is the same across households.

One subtlety here is the distinction between the marginal utility of consumption and the level consumption. This disconnect arises because of how a household's experience status and location affect its marginal utility of consumption. For example, compare the marginal utility of a rural household versus a seasonal migrant with the same states and does not have experience

$$c_{\text{rural}}(z, s, x, i)^{-\alpha} = c_{\text{seas}}(z, s, x, i)^{-\alpha} \bar{u}. \tag{34}$$

But because the disutility of migration affects the marginal utility of consumption for non-experienced migrants, this implies that

$$c_{\text{rural}}(z,s,x,i) < c_{\text{seas}}(z,s,x,i) \tag{35}$$

so that **non-experienced migrants must be compensated for migrating** to equate the marginal utility of consumption across households.

Migration Probabilities. First, let us take stock of the challenge here. The key issue is that when deriving the first order conditions, the planner understands that (i) he can change utility today because the migration probabilities affect the value of the preference shocks that are felt and (ii) he has control of the distribution λ next period via the migration probabilities chosen today. Thus, via the chain rule there are two effects. The effect arising from a change in the migration rate given the distribution of households today. And then a the effect from how the distribution changes **tomorrow** because of the change in migration today. So:

$$\left\{\frac{\partial \Upsilon_1}{\partial \mu_{j',j}(z,s,x,t)}\right\}\lambda_j(z,s,x,t) + \sum_{j'}\left\{\ \Upsilon_2\ \right\}\frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} = 0 \tag{36}$$

where Υ_1 and Υ_2 are collections of terms. And the overall strategy is to find a solution that sets things on the inside of the brackets (for $\frac{\partial \Upsilon_1}{\partial \mu}$ and Υ_2) equal to zero.

This is the first $\frac{\partial \Upsilon_1}{\partial \mu}$ component, holding fixed the distribution:

$$\left\{\frac{\partial \Upsilon_1}{\partial \mu_{j',j}(z,s,x,t)}\right\}\lambda_j(z,s,x,t) = \left\{\ \beta^t \psi(z)\frac{\partial E[\ \nu \mid \ \{\mu_{j',j}(z,s,x,t)\}_{j'}]}{\partial \mu_{j',j}(z,s,x,t)} - \chi(t)m_{j',j}\right.$$

$$\left. - \chi_{2j}(z,s,x,t) + \psi(z)\beta^{t+1}\underbrace{\int_{s'}\int_{x'}\chi_{3j'}(z,s',x',t+1)\pi(s',s)\varphi(x',x,j)}_{\psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}\ \right\}\lambda_j(z,s,x,t) \tag{37}$$

Focusing on the right-hand side of the equation, the first term is how the expected value of the preference shocks change in that location. As the planner moves households more or less, the planner is affecting utility via the preference shock. The next the next term is the cost of moving evaluated at the social cost of those resources, i.e. $\chi(t)$. The next two terms reflect a source multiplier $\chi_{2j}(s,t)$ and a discounted, Pareto weighted, destination multiplier $\psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]$. This last term integrates across all future shock and experience states for a particular destination j', conditional on a households current state. As we show below, this represents the **expected** social value of the destination j'.

Let's set the term inside the brackets of (37) equal to zero by solving out for the migration rates as a function of the multipliers. The Type 1 extreme value assumption on the shocks implies that

$$E[\,\nu \mid \mu_{j',j}(z,s,x,t)] = -\sigma \sum_{j'} \mu_{j'j}(z,s,x,t) \log\left(\mu_{j'j}(z,s,x,t)\right) \tag{38}$$

and then its derivative with respect to the migration rate is:

$$\frac{\partial E[\,\nu \mid \mu_{j',j}(z,s,x,t)]}{\partial \mu_{j',j}(s,x,t)} = -\sigma \log\left(\mu_{j'j}(z,s,x,t)\right) - \sigma \tag{39}$$

and with the proposed strategy to set things in the brackets equal to zero implies that

$$-\sigma\beta^t\psi(z)\log\big(\mu_{j'j}(z,s,x,t)\big) = \beta^t\psi(z)\sigma + \chi(t)m_{j',j} + \chi_{2j}(z,s,x,t) - \psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]$$

$$\mu_{j'j}(z,s,x,t) = \exp\left(\frac{\beta^t\psi(z)\sigma + \chi(t)m_{j',j} + \chi_{2j}(z,s,x,t) - \psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}{-\sigma\beta^t\psi(z)}\right) \tag{40}$$

$$= \exp\left(\frac{\sigma\beta^t\psi(z) + \chi(t)m_{j',j} - \psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}{-\sigma\beta^t\psi(z)}\right) \Bigg/ \exp\left(\frac{\chi_{2j}(z,s,x,t)}{\sigma\beta^t\psi(z)}\right)$$

Where the last line follows from substituting out the source j, date t multiplier and properties of the $\exp$ function. The final step is to set $\chi_{2j}(z,s,x,t)$ source multiplier so that the migration probabilities sum to one. This implies that

$$\exp\left(\frac{\chi_{2j}(s,x,t)}{\sigma\beta^t\psi(z)}\right) = \sum_{j'} \exp\left(\frac{\sigma\beta^t\psi(z) + \chi(t)m_{j',j} - \psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}{-\sigma\beta^t\psi(z)}\right) \tag{41}$$

$$\Rightarrow \quad \chi_{2j}(s,t) = \sigma \log\left\{\sum_{j'} \exp\left(\frac{\sigma\beta^t\psi(z) + \chi(t)m_{j',j} - \psi(z)\beta^{t+1}\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}{-\sigma\beta^t\psi(z)}\right)\right\}. \tag{42}$$

And so the source multiplier takes the log-sum form that arises in discrete choice settings with Type 1 extreme value shocks. That is it reflects something like the ex-ante value of being in that location. After canceling terms, we have that

$$\mu_{j'j}(z,s,x,t) = \tag{43}$$

$$\exp\left(\frac{-u'(z,t)\, m_{j'j} + \beta \mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}{\sigma}\right) \Bigg/ \sum_{j'} \exp\left(\frac{-u'(z,t)\, m_{j'j} + \beta \mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]}{\sigma}\right).$$

The socially optimal migration rates take the familiar form associated with Type 1 extreme value shocks. And this can be separated into a source component (the denominator) and then destination j' components (the numerator). And the destination components depends on the costs of migration today relative to the discounted, expected value of the multiplier $\mathbb{E}\left[\chi_{3j'}(t+1)|z,s,x\right]$ in location j'.

Recapping: we have solved for the migration probabilities that set $\frac{\partial \Upsilon_1}{\partial \mu}$ in (36) equal to zero. We need the whole term to be set to zero, so the next step is to find the value of the multiplier(s) $\chi_{3j'}(z, s', x', t+1)$ so that Υ_2 in (36) is also equal to zero. Step by step we have:

$$\sum_{j'} \Big\{ \ \Upsilon_2 \Big\} \frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} = \tag{44}$$

$$\sum_{j'} \int_s \int_x \psi(z)\beta^{t+1} \Big\{ \underbrace{u(c_{j',j}(z,s,x,t+1),x) + E[\ \nu \mid \{\mu_{j',j}(z,s,x,t+1)\}_{j'}]}_{u_j(z,s,x,t+1)} \Big\} \frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} dx\ ds \ + \tag{45}$$

$$\sum_{j'} \int_s \int_x \chi(t+1) \Big\{ \underbrace{\frac{\partial Y_{t+1}}{\partial \lambda_{j'}(z,s,x,t+1)} - c_{j'}(z,s,x,t+1) - \sum_{j''} m_{j'',j'}\ \mu_{j'',j'}(z,s,x,t+1)}_{\kappa_{j'}(z,s,x,t+1)} \Big\} \frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} dx\ ds \tag{46}$$

$$+ \underbrace{\sum_{j'} \int_s \int_x \chi_{2j'}(z,s,x,t+1) \Big\{ 1 - \sum_{j''} \mu_{j'',j'}(z,s,x,t+1) \Big\} \frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} dx\ ds}_{=0} \tag{47}$$

$$- \psi(z)\beta^{t+1} \sum_{j'} \int_s \int_x \chi_{3j'}(z,s,x,t+1)\ \frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} dx\ ds \tag{48}$$

$$+ \psi(z)\beta^{t+2} \sum_{j'} \int_s \int_x \Big\{ \underbrace{\sum_{j''} \int_{s'} \int_{x'} \chi_{3j''}(z,s',x',t+2) \mu_{j'',j'}(z,s,x,t+1) \pi(s',s) \varphi(x',x,j') dx'\ ds'}_{\mathbb{E}[\chi_3(t+2)|z,s,x,j']} \Big\} \frac{\partial \lambda_{j'}(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} d \tag{49}$$

If we put this all to together than we have the following:

$$\sum_{j} \int_s \int_x \Big\{ \psi(z)\beta^{t+1} u_{j'}(z,s,x,t+1) + \chi(t+1)\kappa_{j'}(z,s,x,t+1)\ - \tag{50}$$

$$\psi(z)\beta^{t+1}\chi_{3j'}(z,s,x,t+1) + \psi(z)\beta^{t+2}\mathbb{E}\left[\chi_3(t+2)|z,s,x\right] \Big\} \frac{\partial \lambda_j(z,s,x,t+1)}{\partial \mu_{j',j}(z,s,x,t)} dx\ ds = 0. \tag{51}$$

And the proposed solution is to set

$$\chi_{3j'}(z,s,x,t+1) = u_{j'}(z,s,x,t+1) + u'(z,t+1)\kappa_{j'}(z,s,x,t+1) + \beta\mathbb{E}\left[\chi_3(t+2)|z,s,x\right]. \tag{52}$$

where we substituted in the for the multiplier $\chi(t+1)$ and then the Pareto weights and discount factors in the previous expression cancel. The multiplier $\chi_{3j}(z,s,x,t+1)$ takes on a recursive formulation where the multiplier equals utility, the κ term (more on this below), and then the expected, discounted multiplier tomorrow taking into account all the different possible moving options. Observe that our notion does not have a j in the expectation above, so this denotes given a realized states, integrate over shocks and different location possibilities.

Again, this expression collapses to the same expression as under the Utilitarian Planner. So, when the Pareto weights are Utilitarian, then $u'(z,t) = u'(t)$ and this is what we were working with previously. Now what matters is the marginal utility of the z-type agent in evaluating the net social benefits (the κ term) of having a household in location j.

Finally, notice that $\frac{\partial Y(t+1)}{\partial \lambda_j(z,s,x,t+1)}$ is simply the marginal product of labor in location j multiplied by the relevant idiosyncratic shock primitive, e.g. s for rural area. Then combining the recursive expression for the multiplier in (52), the definition of $\kappa_{j'}(z,s,x,t+1)$, the migration probabilities, and consumption allocations we have Proposition 1.

B.7.5. Algorithm for Computation

The basic idea is to look for a stationary allocation and use an approach like value function iteration to compute the multipliers $\chi_{3j}(z,s,x)$. Given the multipliers, we can compute migration probabilities, household locations, production, aggregate consumption, then check if allocations are feasible or not (and updating if they are not). Here are the details:

1. The first step is a guess of consumption and the common component (wage per efficiency unit) if you will of the marginal product of labor. We only need to guess two consumption levels and then two mpls. Now, the initial guess of the two consumption levels are specific to a permanent type—say the lowest type of z. But then the idea is to use (32) and unwind the implied consumption levels for all other z's so that Pareto weight adjusted marginal utilities of consumption are equated across households.

   More specifically: $c_j(1,s,x,m)$ and $c_j(1,s,x,nm)$ are the initial guesses where the 1 is standing in for the lowest z household. From here we know that for given experience,

$c_j(1, s, x, m)$ fills in for all different transitory shocks s, all locations. Then from the specification on utility, we know that

$$c_j(1, s, x', m) = \left(\frac{1}{\bar{u}} \times c_j(1, s, x', m)^{-\gamma} \right)^{\frac{-1}{\gamma}} \tag{53}$$

where x' would be the inexperienced state. Do the same for the non-monga season. Now we have assigned consumption to all guys (across locations, transitory shocks, experience levels, seasons) within a permanent state z. Now to infer what consumption must be for z-type 2 guys, we have that

$$c_j(2, s, x, m) = \left(\frac{\psi(1)}{\psi(2)} \times c_j(1, s, x, m) \right)^{\frac{-1}{\gamma}} \tag{54}$$

and this relationship holds for every s, x, m combination of consumption. This the process works iteratively for each different z level.

2. The $\chi_{3j}(z, s, x)$'s then are just like a value function. So guess a χ_{3j} for each location, experience, shock state.

3. Take χ_{3j}'s, compute the expected value of a transition to a new location, so $\mathbb{E}\left[\chi_{3j'}(t+1)|z, s, x\right]$. In words, this would be like what is the expected value of going the rural area (j') next period, given your current state z, s, and x.

4. Compute the migration probabilities using the expected values from 2. and marginal utility of consumption implied by the consumption guess in 1.

5. Update the χ_{3j}'s using (**??**) and (**??**) by computing all the objects on the right-hand side (given our guesses) and implying a new updated χ'.

   A couple of details: $u_{j'}(z, s, x, t+1)$ integrates out the preference shock. So this reflects expected utility given the migration probabilities for that location, i.e., it's the log sum thing. Second, $\mathbb{E}\left[\chi_3|z, s, x\right]$ is the expected values across all possible destinations given states today. So it is migration probabilities multiplied by $\mathbb{E}\left[\chi_{3j'}|z, s, x\right]$.

6. Given updated $\chi_{3j}{}'$, return to 2. and iterate until χ'_{3j} and χ_{3j} are close. This works well, different initial guesses go to the same place, etc.

7. Given the migration probability implied by the χ'_{3j}s, construct the stationary allocation, compute aggregate production, consumption and mpl's. Check if production is consistent with consumption and mpl's, if not update the guess of consumption and mpl's and return to 1.

B.7.6. Robustness to Alternative Social Planner Weights

In the main analysis we restricted attention to weighting schemes in which the planner gives equal weight to all households. This amounts to choosing weights $\psi(z) = \exp(\alpha/z)$ with a value of $\alpha = 0$. Here we explore how the planner's solution compares to the competitive equilibrium allocation under alternative values of α.

Table B.10: Alternative Pareto Weights

	Welfare Gains				
Weight (α)	Migration Fixed	Benchmark	Δ	Rural Share	Seasonal Migration
-0.65	32.7	34.0	1.3	53.2	27.8
-0.50	35.5	36.9	1.4	54.3	27.7
-0.25	40.7	42.3	1.6	53.9	27.0
0.00	46.6	48.5	1.9	53.6	26.8
0.25	53.2	55.3	2.1	53.4	26.9
0.50	60.3	62.7	2.4	53.2	27.5
0.65	64.9	67.5	2.6	53.2	27.8

Note: This table reports the solutions to the planner's problem under alternative weights α. The middle row with $\alpha = 0.00$ corresponds to the solution reported in the body of the paper. Higher values of α correspond to higher weight on households with high permanent productivity draws z. The first column reports the welfare gains from moving to the planner's solution from the competitive equilibrium allocation with migration fixed. The second reports the welfare gains including the planner's migration choices, and the third column reports the difference between the second and first. The last two columns report the share of households in rural areas and seasonal migration rates under the planner's solutions.

Table B.10 reports the solution to the planner solutions with weights running from -0.65 (with higher weight on higher z households) to 0.65 (with lower weight on higher z households). The first column of the tables reports the welfare gains from moving to the planner's solution from the competitive equilibrium allocation but holding migration rates as in the competitive allocation. The planner's solution delivers higher average welfare gains when the weight on higher z households is lower (i.e. when α is higher). This is because the planner redistributes consumption from high-z to low-z households, which is more valuable when the planner values the low-z households more.

The second column of B.10 reports the welfare gains from the planner's solution including the planner's location and migration choices. These are also increasing in α. Our main interest is in the difference between the planner's solution with different location and migration decisions and without them, and this difference is reported in column (3). The differences run from 1.3 percent in equivalents to 2.6 percent, which are not that different from the values in the benchmark case of 1.9 percent. In none of these cases do we find substantially larger welfare gains than in the benchmark case reported in the main body of the paper. For this reason we conclude that the modest welfare gains from better allocating workers across space are basically robust to the planner's choice of weights.

The last two columns report the share of households in rural areas and seasonal migration rates under the planner's solutions. These exhibit very little variation as α rises. In all cases the planner chooses fewer workers in the rural area than in the competitive allocation. The planner similarly chooses lower (rather than higher) seasonal migration rates for rural households for all values of α. We therefore conclude that the planner's preferences for worker locations and migration rates are also robust to the choice of weights.

C. Empirical Evidence on the Source of Migration Disutility

Our model infers that many rural residents experience significant non-monetary disutility from migration, and this plays an important role in our interpretation of the evidence of Section 2. This is also crucial for our welfare calculations, in that some of the large consumption gains from migration are offset by this disutility. Therefore, we explore whether the large disutility is plausible, and what the source of that disutility might be. To do so, we collect new survey data from **?**'s (**?**) experimental sample of migrants on their preferences for specific migration attributes. This allows us to better characterize what this disutility may represent, for the same sample of households used to estimate our model.

Conducting field experiments that vary a number of non-monetary attributes of the migration experience (such as quality of living conditions, wages, risk, family separation) would be practically challenging and prohibitively expensive, so our approach in this section is to conduct discrete-choice experiments (DCE) on the migrant sample. The DCE presented respondents with a series of hypothetical scenarios in which we randomly varied a few key attributes associated with one of two migration options. The surveys presented respondents with (hypothetical) options for the fall 2015 lean season and asked them to indicate which migration choice they would make. The attributes we presented under each option randomly varied the probability of finding employment in the city, the wage if employed, how frequently the migrant could return to visit family (to minimize separation), and access to a hygienic latrine in their residence at the migration destination, which is a useful proxy for the quality of housing amenities that the migrant would experience in the city.

There is a reasonable concern that, in DCEs, people's responses to hypothetical questions may not accurately reflect their real-world behavior. They may, for example, express an interest in migrating in response to a hypothetical question, even though they may be more hesitant if the actual choice ever presented itself. We are therefore careful not to make any inferences about people's overall migration propensity. Instead, in analyzing people's responses to the hypothetical scenarios, we infer the *relative weights* people place on quality of living conditions relative to wages or concerns about family separation.

Each respondent was asked to choose one of two migration options or a third, "opt-out" no-migration option. The experimental setup for the hypothetical options was created to mimic the circumstances under which the equivalent decision would be made in the real world. For example, two options may both feature a 33 percent chance of employment, with Choice #1 offering a lower wage if employed but better amenities (more regular family contact and a hygienic latrine in the residence) compared to Choice #2.

Table C.1: Estimated Marginal Effects on Migration

	Migration Opp. #1		Migration Opp. #2		No Migration	
	PP	ME	PP	ME	PP	ME
33% Prob. Employment	0.112***	0.000	0.587***	0.000	0.301***	0.000
	(0.019)	(.)	(0.056)	(.)	(0.061)	(.)
66% Prob. Employment	0.075***	-0.037***	0.716***	0.129***	0.209***	-0.092***
	(0.013)	(0.010)	(0.047)	(0.031)	(0.047)	(0.032)
100% Prob. Employment	0.045***	-0.067***	0.794***	0.207***	0.160***	-0.141***
	(0.009)	(0.013)	(0.036)	(0.037)	(0.035)	(0.040)
Family visit once in 60 days	0.074***	0.000	0.717***	0.000	0.209***	0.000
	(0.014)	(.)	(0.044)	(.)	(0.044)	(.)
Family visit twice in 60 days	0.075***	0.001	0.716***	-0.001	0.209***	0.001
	(0.013)	(0.007)	(0.047)	(0.025)	(0.047)	(0.024)
Family visit 4 times in 60 days	0.063***	-0.011	0.723***	0.005	0.214***	0.005
	(0.012)	(0.007)	(0.053)	(0.030)	(0.054)	(0.030)
No Latrine in residence	0.075***	0.000	0.716***	0.000	0.209***	0.000
	(0.013)	(.)	(0.047)	(.)	(0.047)	(.)
Pucca Latrine in residence	0.026***	-0.049***	0.906***	0.190***	0.068***	-0.141***
	(0.005)	(0.009)	(0.022)	(0.031)	(0.020)	(0.033)
Daily Wage (Taka), Opp # 2		-0.001***		0.003***		-0.002***
		(0.000)		(0.000)		(0.000352)
Observations	3462	3462	3462	3462	3462	3462

Note: The PP columns represent the predicted probabilities of migrating at each given condition, and the ME columns represent the marginal effects of changing migration conditions in each category. Both are measured while fixing the conditions of migration Choice #1 at the worst values, and fixing the conditions of migration Choice #2 at the median values. The sample includes only households from the control group.

We conducted these DCEs on a sample of 2,714 respondents, presenting each respondent with seven different choice sets for which the values of attributes are varied. We used the Choice Experiment tools in JMP12 (built on SAS) to generate algorithms that pick values for the attributes under each migration option in each choice problem in such a way that the power of the experiment is maximized. We observed a total of 18,998 choices, but to eliminate any bias stemming from recent induced migration experience, we used only choices made by respondents who resided in the control villages in the experiments. We estimated a multinomial logit model of migration choice as a function of the offered attributes of each location, using the remaining 3,462 observations.

Table C presents the predicted probabilities and estimated marginal effects from this multinomial logit regression. We report the marginal effects of improving each attribute associated with option #2.[1] The middle two data columns of Table C show the predicted probabilities (PP) and marginal effects (ME) on the propensity to migrate to destination #2. The first and last two data columns show the PP and ME on destination #1 and "No Migration" when the characteristics of destination #2 are varied.

The four attributes for each destination that we specified in our surveys are as follows. The first is the probability of employment, with three possible values that were randomly varied across the choice scenarios: 33%, 66% and 100%, which is meant to capture labor-income risk. The second is the daily wage, which could take one of five possible values running from 200 to 340 Taka per day. The third is living conditions in the city, which had two categories: either a *pucca* (hygienic) latrine in the residence, or no latrine. This is a context-relevant proxy for the overall quality of housing. The fourth is the extent of family separation, which had three possible categories: the ability to go back and visit family once, twice or four times during the monga. The daily wage is modeled as a continuous variable in the multinomial logit, while the other attributes are modeled as categorical variables.

Table C shows that an increase in employment probability at destination 2 from 33 percent to 66 percent or 100 percent (holding destination #1 characteristics fixed) increases the propensity to migrate to destination #2 by 19.7 and 20.7 percentage points. Labor-income risk is, therefore, a quantitatively important deterrent to migration. The next three rows show that the frequency of family visits has a negligible (and statistically insignificant) effect on migration choices.

In stark contrast, having a latrine in one's residence increases the probability of choosing destination # 2 by 19 percentage points. Housing conditions at the destination therefore appear to be an important determinant of migration choices. Finally, the probability of migrating to destination #2 increases by 0.3 percentage points for every additional Taka in daily wage that is offered, meaning a 15 percentage point increase in the migration probability for an extra 50 Taka in income. Thus, having a better housing option is similar to an additional 63 Taka per day in wages, which amounts to a 32 percent increase over the base value of 200 Taka per day that we used in our hypothetical DCE scenarios (and corresponds to roughly the average wages earned by migrants in the city). To the extent that rural-urban migrants generally face poor urban housing options (proxied by a lack of access to convenient latrines, which is a realistic worry in the slums of South Asian cities), this represents a

[1]We set all attributes associated with option #1 at their least attractive values, and those associated with option #2 at median values. The rationale for this is to effectively create only two relevant choices for the potential migrant: either migrate to destination 2, or stay at home. This binary choice most closely resembles the decisions made by agents in our model. Recall that we model a binary migration choice.

large non-monetary cost of migration and a substantial offsetting force to the higher wages earned by migrants. The large migration disutility that our model infers from people's actual migration and re-migration behavior does appear to be validated in the DCEs when these (potential) migrants are asked to explicitly consider the non-monetary dimensions of the migration experience.

D. Welfare Under Alternative Parameterizations

In this section we consider alternative parameterizations of the model that yield higher welfare gains from migration subsidies. The goal is to illustrate how our model allows for an interpretation of the experiments of Section 2 with credit constraints and migration risk driving migration outcomes. As we show below, such an interpretation would give rise to substantially larger welfare gains from migration subsidies than found in this paper, but at the cost of making counterfactual predictions about important aspects of the experimental data.

Table D.1: Welfare Gains Under Alternative Parameterizations

	Average Welfare Gains	LATE (Cons.)	OLS (Cons.)	Treatment Effect (Migration)	Seasonal Migration Control
Data	-	30	10	22	36
Benchmark calibration	0.44	29	10	21	36
+ Higher urban risk	0.09	34	64	19	11
+ No migration disutility	0.53	9	29	29	48
+ Higher urban TFP	1.53	38	51	21	78
+ Higher migration cost	2.21	17	36	64	36

Note: This table reports the average welfare gains implied by the model, the LATE and OLS effects of migration on consumption, seasonal migration in the control group, and the treatment effect on migration implied by the model for each specific calibration. Row 1 shows the data. Row 2 is the benchmark calibration that results from the simulated method of moments. Row 3 ("+ Higher urban risk") changes the parameter shaping the urban relative shock by setting $\gamma = 1.5$. Row 4 ("+ No migration disutility") further removes the disutility of migration by setting $\bar{u} = 1$. Row 5 ("+ Higher urban TFP") further doubles the level of urban TFP of 3.1 (instead of $A_u = 1.55$). Row 6 ("+ Higher migration cost") sets m_T so that the model matches seasonal migrant rates in the control group.

Table D summarizes the model's welfare predictions under these alternatives. The first row reproduces the main experimental moments on which we will focus, and the second row reports the model's predictions for the same moments plus the average welfare gain from the migration transfers. The third row raises γ from the estimated value of 0.52 up to 1.5, meaning that shocks are now relatively larger in the urban area. By itself this leads welfare gains to fall to 0.09 percent consumption equivalent, the OLS coefficient of consumption on migration to rise to a counterfactual 64 percent, and the treatment effect on migration to fall to a counterfactually low level of 19 percent. The fourth row sets $\bar{u} = 1$, which means there is no disutility from migration. Welfare gains raise substantially to 0.53 percent, but the LATE falls to a counterfactually low level of 9 percent, and the migration rate in the control group rises to 48 percent, well above the data. Clearly though, the lower value of $\bar{u}$ is an important driver of the model's welfare gains. The fifth row doubles A_u, the urban productivity, to a value of 3.1. The welfare gains now increase further to 1.53 percent, while other moments remain counterfactual, in particular the seasonal migration rate, which is now an implausible 78 percent.

To lower the migration rate back to a level similar to the data, the last row increases the migration cost to match the 36 percent migration rate in the control group again. This change also raises the amount of the migration transfer, by construction, since the migration subsidies are intended to cover the migration cost and actually induce migration. Under this parameterization, the welfare gains from the transfers rise to 2.21 percent, or five times what they are in the benchmark calibration. The source of the welfare gains now become relaxing credit constraints, which keep risk-averse migrants from reaching a much more productive urban area, in the spirit of the model of **?**. Yet the data do not support such an interpretation. As one example, the LATE effect of consumption on migration is counterfactually lower than the OLS coefficient, pointing to inaccurate sorting patterns for migrants. As another example, the treatment effect of migration is far too large, pointing to the counterfactually large migration costs in this calibration of the model.