Ethnic Networks and the Informal Labor Market

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Preliminary and incomplete. All comments are welcome.

Abstract

Although ethnic minorities face adverse labor market conditions, the pace of immigration has remained unchanged over the past decades. This issue is addressed here through a model in which disadvantaged minorities engage into the underground economy to overcome unemployment. More specifically, the present paper develops a dynamic model (based on Calvó-Armengol, Verdier and Zenou, 2007) in which agents from two different ethnic groups form a network through which they can exchange information on formal or informal job offers. Networks play a central role, as information about formal and informal job opportunities can only be obtained through word of mouth communication. The formal labor market discriminates against the minority group, which thus faces higher unemployment in equilibrium. However, I find that the minority group is more likely to undertake informal jobs than the majority group, hence avoiding too large unemployment rates. In addition, and contrary to the predictions of the benchmark model, tighter networks turn out to reduce informal employment. Numerical simulations finally allow me to confront various policies aiming at lowering undeclared employment: compared to an increase in the audit rate to detect informal jobs, anti-discrimination policies appear to be less costly in terms of unemployment.

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1 Introduction

Studies on economic integration and labor market success of immigrants in western economies all reveal that ethnic minorities face adverse labor market conditions. Both Chiswick (1980) and Borjas (1994), working respectively on UK and on USA data, show that workers from ethnic minorities earn significantly lower wages than majority workers. More recently, Pendakur and Pendakur (2011) report that Canadian-born individuals belonging to visible minorities face a substantial earning gap, which has not eroded over the past 20 years. Furthermore, in a study comparing France, Germany and the United Kingdom, Algan, Dustmann, Glitz and Manning (2010) reveal that in addition to having lower wages, first and second generation immigrants also face higher unemployment rates than natives.\(^1\) The literature provides various explanations to these low performances, from discrimination (Becker, 1971; Aeberhardt, Fougère, Pouget and Rathelot, 2010), spatial mismatch (Selod and Zenou, 2006; Zenou 2011), or cultural differences (Senik and Verdier, 2011), to ethnic identity (Bisin, Patacchini, Verdier and Zenou, 2011).

Although immigrants face poor labor market conditions in their host country, immigration has been stable or even increasing in all western countries over the past decades. As far as I am aware, the economic literature does not address this puzzle. However, sociologists give insights about why the pace of immigration remains unaffected in spite of these adverse economic conditions. Indeed, the sociological literature argues that one way to compensate for low wages and low labor demand is to enter the informal labor market (Tienda and Raijman, 2000). Portes and Haller (2005) also highlight the cushioning function of informal employment, that they describe as a common additional source of income when unemployment is high and social benefits meager. In economics as well, Lemieux, Fortin and Fréchette (1994), using Quebec City data, document that the participation rate of student and unemployed in the underground sector amounts to 28 percent, and rises to 32.4 percent for welfare recipients. All those studies suggest that informal economy is a way of improving one’s economic condition when facing adverse labor market conditions.

More specifically, I acknowledge that turning to undeclared activities in response to precarious economic situation is particularly relevant for ethnic minorities.

First, several studies, mostly in sociology, provide empirical support to an overrepresentation of ethnic minorities in the informal economy: in an OECD report, Lubell (1991) gives a few examples illustrating the fact that immigrants are to a large extent part of the informal sector. More recently, Baganha (2000) argues that working in the informal market is the prevailing mode of economic integration for immigrants in Portugal, Light and Gold (2000) estimate that 10 percent of the average American ethnic group’s workers is employed in the informal sector of ethnic ownership economy, and Tienda and Raijman (2000) find that 38 percent of Mexican immigrant households in Chicago work in the underground economy.

I now turn to more formal arguments supporting the idea that immigrants and ethnic minorities will be overrepresented in the underground economy. First, and as mentioned earlier, these groups face higher unemployment rates and lower wages than the majority group, and hence are more likely to use informal work as an economic safety net. Then, because informal jobs are characterized by the absence of any written contract, and, more broadly, because these jobs are not submitted to any labor legislation, engaging in informal activities allows to bypass red tape.\(^2\) Given that immigrants are more subject to red tape (e.g. obtaining a work permit) than natives, they can be more inclined to turn to informality for this reason as well. In addition to these structural factors, opportunity factors can be brought forward:\(^3\) first, there

\(^1\)Also refer to Verdugo (2009) for a more detailed description of immigrants labor market situation in France.

\(^2\)Note that avoiding red tape is one of the main reason for the existence of informal jobs, after tax evasion. See European Commission report on the Eurobarometer pilot survey on undeclared work (2007).

\(^3\)This classification of factors leading to informality is due to Renooy (1990), who distinguishes structural (financial pressure,
is evidence that immigrants and ethnic minorities are on average less educated than natives and majority group, and hence are more likely to perform undeclared jobs, as they are usually characterized by low-skilled workers (Boeri and Garibaldi, 2002). In addition, many studies stress the role of networks in the informal economy, and show that ethnic networks are particularly powerful in fostering underground economies.

Alternatively, the extensive participation of ethnic minorities in the informal economy can be explained by what is known in sociology as the double disadvantage theory. A standard theory in the literature on ethnic economies, is that economically disadvantaged groups are likely to turn to entrepreneurship and self-employment. This single disadvantage theory explains why entrepreneurship rates are so high among ethnic minorities. However, when disadvantaged individuals also lack essential resources to become self-employed (e.g. efficient network, skills, language, social capital), they turn instead to the informal economy (Light, 1979; Light and Rosenstein, 1995; Light, 2005).

Finally, it is worth coming back on the idea that ethnic networks can be particularly efficient when it turns to informal economy. As pointed out by Portes and Haller (2005), trust is a key element in informal transactions: in as much as the informal economy is characterized by the lack of any written contract, trust is the only way to sustain informally established relationships and to overcome commitment problems. As it turns out, sharing a common identity, and especially belonging to the same ethnic group is one of the best way to generate such trust in informal exchanges. Indeed, not only sanctions threats are more credible and hence more efficient within ethnic groups (e.g. Miguel and Gugerty, 2005), but migrants to a country also tend to be more socially cohesive: established contacts in the destination country is often a pre-requisite to immigration, and, once they arrive in a given country, migrants strengthen their links by developing community-based institutions (Munshi, 2003).

From what precedes, it seems reasonable to think that immigrants and ethnic minorities are more inclined to engage into undeclared activities. To put it another way, current estimates of the labor market situation of ethnic minorities may underestimate their true “activity” rate as well as their income. This in turn would be part of the explanation of why immigration (including illegal one) is stable or even increasing despite poor observed economic prospects. In this paper, I provide a theoretical background to the fact that ethnic minorities circumvent adverse labor market outcomes by undertaking undeclared jobs.

More precisely, this paper develops a dynamic model (inspired by Calvó-Armengol, Verdier and Zenou, 2007) in which agents belonging to two different ethnic groups randomly meet by pair at each period, and exchange information on two competing activities: formal and informal labor. Although workers from each group are similar in terms of skills, minority group workers face hiring discrimination. In this model, networks play a central role, as information about formal and informal job opportunities can only be obtained through word of mouth communication. There is indeed extensive evidence, both in the economic and in the sociological literature that social networks are primordial when it comes to job finding. Information

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5 Also known as the resource-constraint variant of the disadvantage theory.

6 This quote from Light and Rosenstein (1995) is self-explanatory: “A typical firm in the informal economy requires few resources. For example, fruit vendors at freeway entrances are self-employed, but their informal enterprise did not require extensive resources of money, skill, and knowledge. Anyone could do it. On the other hand, when people with resources confront [labor market] disadvantage, they mobilize those resources to produce a bona fide business firm.”

7 Greif (1993) also established that the 11th century Maghribi traders organized into a coalition to overcome the commitment problem.

8 Note also that even individuals turning to formal self-employment represent a non negligible share of the informal sector: using data from Denmark, Kleven, Knudsen, Kreiner, Pedersen and Saez (2011) show that the tax evasion rate is equal to 41.6% for total self-reported net income, while it is close to zero when income is reported by a third-party.

9 This evidence is presented in section 2.2 about information transmission.
about formal job offers circulate across ethnic groups, however, it is more difficult to get information from a member of the other group, as a result of segregation. On the contrary, information about informal job opportunities is shared only between members of the same ethnic group.

Because ethnic minority workers are discriminated against, they face higher unemployment rates than majority workers in equilibrium. Numerical simulations reveal that when informal wages are less attractive than formal wages, an equilibrium where minority workers only take part in the informal economy arise. This is in line with the idea that disadvantaged workers can undertake informal jobs in order to avoid unemployment.

Contrary to what is predicted in Calvó-Armengol et Al. (2007), I find that when individuals have a higher level of social interactions, informal employment rate can actually decrease, while in the benchmark model, crime rates are expected to rise as a consequence of tighter networks. This difference is due to the fact that in my model, networks also play a role in the formal economy.

The numerical simulations also allow to compare two different policies aiming at reducing undeclared employment rates. We find that direct policies increasing the audit rate to detect informal jobs will decrease informal employment rates, but at the expense of an increased unemployment rate, especially when social interactions are scarce. On the contrary, indirect policies reducing discrimination do not trigger such drawback.

The remainder of the paper is organized as follows. Section 2 presents the model. In particular, it explains further the network structure, information transmission mechanisms and individual incentives. In section 3, the steady-states are characterized, and I provide conditions for their existence in equilibrium. I simulate the model in section 4, and compare two different policies aiming at reducing undeclared employment rate. Finally, section 5 concludes.

2 The model

This model is an extension of Calvó-Armengol, Verdier and Zenou’s (2007), in which individuals can engage in three competing activities: declared work, unemployment and undeclared work.¹⁰ There are two main differences between declared and undeclared jobs: (a) undeclared (or informal) jobs are assumed to be more flexible than declared (or formal) jobs, and (b) formal wages are subject to taxation, while undeclared wages are not. However, tax evaders face a positive probability of being detected by fiscal authorities, in which case they have to pay a fine.

The population consists in a continuum of agents, homogenous in terms of skills. We can for instance think of low-skilled workers, who are more concerned by undeclared jobs (Boeri and Garibaldi, 2005). The European Commission report on the Eurobarometer pilot survey on undeclared work also concludes that the main three economic sectors into which respondents admitted to do undeclared work are household services (including housekeeping, gardening, baby-sitting, elderly-sitting), construction services and personnel services. Lemieux, Fortin and Fréchette (1994) as well, report that in Quebec City, workers with a regular sector job in primary industries have the highest participation rate in the underground sector (17.2 percent), followed by workers with a regular sector job in the construction industry (9.4 percent), and that two-thirds of the jobs in the underground economy are in construction and services. Moreover, in response of poor labor market conditions, low-skilled workers are less likely to become self-employed as they lack the necessary resources.

The population is composed of two ethnic groups, blacks and whites. I respectively denote $N_B$ and $N_W$.

¹⁰In Calvó-Armengol et Al. (2007), agents chose between employment, unemployment and crime.

¹¹Section 2.2 provides more details on this issue.
the number of blacks and whites in the population, with $N_W + N_B = N$. The introduction of ethnic heterogeneity is one of the major extensions to Calvó-Armengol et Al. (2007).\textsuperscript{12}

In this economy, agents belong to a network through which they hear about job opportunities, be they formal or informal. This is the second major departure from the original model, in which individuals rely on the network for crime opportunities only. There are two reasons why I allow formal job offers to grow through word of mouth communication. First, there is a large and growing literature providing a theoretical basis as well as empirical evidence of the fact that social contacts are a very important channel for job finding. I will come back on this literature in section 2.2 describing labor market flows, but I refer thereupon to Ioannides and Datcher Loury (2004) and Topa (2011) for extensive surveys of the literature. Second, this paper focuses on the role played by network structure on employment patterns in both regular and underground labor markets. Hence, I do not want to ignore the fact that formal job offers circulate through the network.

2.1 Structure of the network and social interactions

The network of agents is characterized by the strength of interpersonal ties. As defined by Granovetter (1973), “the strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding) and the reciprocal services which characterize the tie.” As such, relatives or best friends share strong ties with each other, while coworkers or people met in a bar share weak ties with each other. In this model, based on Montgomery (1994), each agent shares a strong tie with one unique other agent, and this link is formed once (at birth) and holds forever (e.g. siblings or best friends). Individuals holding a strong tie with each other belong to mutually exclusive two-person groups called dyads. I assume that the network exhibits homophily, implying that dyad partners are of the same ethnic group.\textsuperscript{13} On the contrary, individuals sharing weak ties with each other (e.g. random encounters) can belong to different ethnic groups.

Dyads are characterized according to the employment status of their members. As an individual can be in one of the three different states (formal employment, unemployment or informal employment), I can define six possible dyad states. More precisely, there will be $d_2$ dyads in which both members have a formal job, $d_1$ dyads in which one member has a formal job while the other is unemployed, $d_0$ dyads in which both members are unemployed, $d_{-1}$ dyads in which one member is unemployed, the other having an informal job, $d_{-2}$ dyads in which both members have an informal job, and $d_{±1}$ dyads in which one member has a formal job, the other doing undeclared work. I exclude the last type of dyads, as in Calvó-Armengol et Al. (2007) (conformity assumption). This restriction is due to the nature of the link between dyad partners: the strength of this link implies a great deal of conformity between dyad members, so that the labor market status of an agent will be highly influenced by the status of his dyad partner. In particular, an unemployed agent whose partner works in the formal labor market will never accept an undeclared job offer.

This simple setting allows us to define the aggregate state of the labor market. I denote $F^j_t$ the size of the population employed in a formal job, $U^j_t$ the number of unemployed and $I^j_t$ the number of workers employed in an informal job, at time $t$, for ethnic group $j \in \{B,W\}$. They can be normalized as $F^j_t + U^j_t + I^j_t = N^j$.

\textsuperscript{12} Zenou (2011) also develops a model of networked labor market with ethnic groups. However, in his model, agents can only be employed or unemployed, and face no other possible activity.

\textsuperscript{13} Race is the most salient characteristic along which homophilious networks form. See McPherson, Smith-Lovin, and Cook (2001) for an overview of research on homophily.
and I define them as follows

\[
\begin{align*}
F_j^t &= 2d_{2,t}^j + d_{1,t}^j \\
U_j^t &= 2d_{0,t}^j + d_{1,t}^j + d_{-1,t}^j \\
I_j^t &= 2d_{-2,t}^j + d_{-1,t}^j 
\end{align*}
\]  

(1)

where the number of declared workers, for instance, is equal to twice the number of dyads made of two declared workers \(d_{2,t}^j\), to which is added the number of dyads in which there is only one declared worker \(d_{1,t}^j\). I can now respectively define the formal employment rate, the unemployment rate and the informal employment rate:

\[
\begin{align*}
f_j^t &= \frac{F_j^t}{N_j^t}, \quad u_j^t = \frac{U_j^t}{N_j^t}, \quad i_j^t = \frac{I_j^t}{N_j^t}
\end{align*}
\]

The population normalization condition then becomes:

\[
u_j^t = 1 - f_j^t - i_j^t
\]

or, in terms of dyads:

\[
d_{0,t}^j = \frac{N_j^t}{2} - d_{2,t}^j - d_{1,t}^j - d_{-1,t}^j - d_{-2,t}^j
\]

(2)

Going back to the structure of the network, I mentioned above that in addition to sharing a strong tie with their dyad partner, agents share weak ties with any other individual outside of the dyad. More specifically, I assume that individuals randomly meet by pair repeatedly over time so that they can be matched to individuals outside of the dyad. In this case, the agents share a weak tie with each other. I denote \(1 - \omega\) the probability that an agent meets his dyad partner at each point in time, and \(\omega\) the complementary probability that he is matched with any other individual in the population, i.e. that he meets a weak tie. I insist on the fact that contrary to strong ties, weak ties do not necessarily belong to the same ethnic group. Once a pair of agents is randomly formed, the individuals can exchange information about job opportunities. This process is explained in the next section.

2.2 Information transmission and labor market flows

The literature offers a plethora of empirical studies supporting the idea of social networks playing a key role in job finding. As emphasized in Ioannides and Datcher Loury (2004) survey, the first stylized fact emerging from the literature is precisely that workers extensively use social contacts when searching for a job: Holzer (1988) finds that more than 85% of workers use their personal network for job search, while Corcoran, Datcher and Duncan (1980) and Granovetter (1995) both report that more than 50% of jobs are found through social contacts. More recently, Bayer, Ross and Topa (2005) estimate that living in the same block increase by more than 33% the probability to work at the same location. Most importantly perhaps in the context of this paper is the fact that finding job through referrals is particularly prominent for low-skilled workers (Corcoran, Datcher and Duncan, 1980; Granovetter, 1995; Topa, 2001; Wahba and Zenou, 2004; Battu, Seaman and Zenou, 2011).14 In light of this empirical evidence, I assume without loss of generality that formal jobs opportunities circulate only through the network, and hence I neglect the fact that declared jobs can be obtained through direct formal methods (e.g. employment agencies).15 Given the illegal nature of undeclared activities, underground job offers cannot be posted by employment agencies or be too widely

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14Also see Montgomery (1991), Calvó-Armengol and Jackson (2004) and Galenianos (2011) for theoretical work on the role of networks in the labor market.

15By contrast, Calvó-Armengol et Al. (2007), assumes that jobs can only be found through direct formal methods and that the information going through social contacts concerns crime opportunities only.
spread (on the Internet for instance) because they incur a risk of sanction by the authorities. Therefore, I also assume that formal jobs opportunities only circulate through the network.

I now turn to a more precise description of the job information transmission mechanisms. As social network is the only channel through which job information circulates, it should be clear that an unemployed worker can hear about a formal (respectively informal) job offer only if he is matched with a formal (resp. informal) employed worker who is himself aware of an offer.\footnote{There is no on-the-job search in this model.} Formal workers are aware of a formal job opportunity at an exogenous rate $\alpha_F$, and will transmit this information if they meet unemployed workers. However, I assume that employed workers will systematically transmit information to individuals of their own ethnic group, but they will communicate a job offer to someone of the other ethnic group with a probability $\beta \in (0, 1)$. In other words, the network features inbreeding bias.\footnote{Montgomery (1991) also assumes inbreeding bias, but along skills rather than ethnicity.} I further assume that the minority group faces discrimination on the formal labor market, so that they are less likely to get a job than the majority group once they are aware of an offer (Becker, 1957-1971; Aeberhardt et Al., 2010): once an unemployed worker from group $j \in \{B, W\}$ hears about a formal job opportunity, he will actually be employed at the following period with a probability $\lambda_j$, with $\lambda_B < \lambda_W$.

Similarly, underground job offers circulate through undeclared workers who hear about an opportunity at an exogenous rate $\alpha_I$, and who transmit it to unemployed workers if they are randomly matched to one. In the case of undeclared jobs however, I assume that the information circulates only within ethnic groups, and not across.\footnote{Another way of putting it is to say that $\beta = 0$ on the informal labor market.} This assumption illustrates the fact that because undeclared workers act beyond the law and face a risk of detection and punishment for evading taxes, they do not want to spread this kind of information too widely. Otherwise stated, they share undeclared job opportunities with people they really trust, and I assume that this cannot happen outside one’s own ethnic group. [Problem of embeddedness + importance of trust in malfeasance: Granovetter, 1985; Portes & Haller, 2005; Light & Rosenstein, 1995; Wiegand, 1994]

Let us note here that this information transmission protocol defines a Markov process, where I assume that at each period only one dyad partner can change his status. This implies that it will take at least two periods for a dyad to go from a state where both partners are employed in the formal sector to a state where they are both unemployed. Combined with the conformity assumption between dyad partners, it also means that a formal worker cannot become an informal worker at once and necessarily has to go through an unemployment spell between the two polar occupations.

I finally close the description of labor market flows with job destruction, which is assumed exogenous in both sectors. I denote $\delta_F$ the rate at which formal workers lose their job, and $\delta_I$ the rate at which an undeclared worker is fired. I assume that $\delta_I > \delta_F$ as the informal worker is not protected by any job contract, making it easier to lay him off. In addition, informal jobs can also be terminated by government authorities in case of audit, which happens at a rate $p$. In the end, informal workers lose their job at rate $\delta_I + p$.

### 2.3 Flows of dyads between states

From what precedes, I characterize the net flows of dyad from each state between $t$ and $t + 1$ for each ethnic group $j = B, W$ as follows:
\[
\begin{align*}
\dot{d}_{2t} &= h^F_2(f_{t_1}, f_{t_{-1}}) \lambda_{2t} d_{1t} - 2 \delta_F d_{2t}, \\
\dot{d}_{1t} &= 2 \delta_F d_{2t} + 2 q^F_2(f_{t_1}, f_{t_{-1}}) \lambda_{1t} \phi_1 d_{0t} - [h^F_1(f_{t_1}, f_{t_{-1}}) \lambda_{1t} + \delta_F] d_{1t}, \\
\dot{d}_{0t} &= \delta_F d_{1t} + (\delta_t + p) d_{-1t} - 2[q^F_1(f_{t_1}, f_{t_{-1}}) \lambda_{1t} \phi_1 + q^F_1(i_{t_1}) \psi_1] d_{0t}, \\
\dot{d}_{-1t} &= 2 q^F_1(i_{t_1}) \psi_1 d_{0t} + 2(\delta_t + p) d_{2t} - [\delta_t + p + h^F_1(i_{t_1}) \chi_1] d_{-1t}, \\
\dot{d}_{-2t} &= h^F_1(i_{t_1}) \chi_1 d_{-1t} - 2(\delta_t + p) d_{-2t},
\end{align*}
\]

where 
\[
\begin{align*}
h^F_2(f_{t_1}, f_{t_{-1}}) &= (1 - \omega + \omega (N_i f_{t_1} + \beta \frac{N_i}{N_t} f_{t_{-1}}))\alpha_F, \\
n^F_2(f_{t_1}, f_{t_{-1}}) &= \omega (N_i f_{t_1} + \beta \frac{N_i}{N_t} f_{t_{-1}})\alpha_F, \\
h^F_1(i_{t_1}) &= (1 - \omega + \omega \frac{N_i}{N_t} i_{t_1})\alpha_F, \quad \text{and} \quad q^F_1(i_{t_1}) = \omega \frac{N_i}{N_t} i_{t_1}\alpha_F.
\end{align*}
\]

Let us explain the first equation, to get the general intuition for this system: \( \dot{d}_{2t} \) is the change in the number of \( d_{2t} \) dyads (i.e., dyads where both members are declared workers) between \( t \) and \( t + 1 \). At each period, a \( d_{2t} \) dyad is destroyed if one of the two members looses his job, which happens at rate \( 2 \delta_F \). On the contrary, a \( d_{2t} \) dyad is created if the unemployed partner of a \( d_{1t} \) dyad becomes a formal worker. For this to happen, the unemployed worker needs to (a) hear of a job opportunity (at rate \( h^F_2(f_{t_1}, f_{t_{-1}}) \)), and (b) be hired with probability \( \lambda_{1t} \).

The function \( h^F_2(f_{t_1}, f_{t_{-1}}) \) represent the rate at which an unemployed worker hears about a formal job opportunity when his strong tie is a declared worker: this unemployed worker can first hear about a formal job opportunity through his dyad partner if they meet (with probability \( 1 - \omega \)) and if the partner is aware of a formal job opportunity (which happens at rate \( \alpha_F \)), i.e. at rate \( (1 - \omega)\alpha_F \). He can also get this information through any other randomly met (\( \omega \)) declared worker aware of a job offer (\( \alpha_F \)). If he meets a formal worker of his own ethnic group (share \( \frac{N_i}{N_t} f_{t_1} \) of the population) he will get the information for sure, while if he meets a formal worker of the other group (share \( \frac{N_i}{N_t} f_{t_{-1}} \) of the population) he has only a probability \( \beta \) to get the information, due to the inbreeding bias. To sum up, this unemployed worker from a \( d_{1t} \) dyad hears of a formal job opportunity from a weak tie at rate \( \omega (\frac{N_i}{N_t} i_{t_1} + \beta \frac{N_i}{N_t} i_{t_{-1}})\alpha_F \).

In this model I have assumed that the rate of arrival of formal job offers (\( \alpha_F \)) and the frequency of weak ties encounters (\( \omega \)) is the same for blacks and for whites, and I introduced a bias making it more difficult to get information from (inbreeding bias) or to meet someone (meeting bias) of the other ethnic group. I can therefore interpret \( \beta \) as an inverse measure of the degree of spatial segregation between blacks and whites (or as the degree of integration of the minority group)\(^{22}\) : the lower \( \beta \), the highest the segregation, hence the lower the probability to find an informal job through someone from a different ethnic group. \(^{23}\)

Although the intuition is the same for all other equations, I still need to explain the role of \( \phi_1 \), \( \psi_1 \) and \( \chi_1 \),

\(^{19}\)Note that only a \( d_{1t} \) dyad can become a \( d_{2t} \) dyad between \( t \) and \( t + 1 \), due to the fact that only one member can change status at each period.

\(^{20}\)I can also put it in the following way: he has a \( \frac{N_i}{N_t} f_{t_1} \) probability to meet a formal worker of his own group and a \( \beta \frac{N_i}{N_t} f_{t_{-1}} \) probability to meet one of the other ethnic group. In this case, I can also view \( \beta \) as a meeting bias, as in Curra
cini, Jackson and Pin (2009). This as a slightly different interpretation: in the case of the inbreeding bias, \( \beta \) means that one is less willing to transmit information to a member of a different group, while in the case of the meeting bias, \( \beta \) means that one is less likely to meet a member of the other ethnic group. In both cases, the consequence is that information circulates better within than across ethnic groups.

\(^{21}\)By contrast, Zenou (2011) makes the assumption that blacks spend less time with their weak ties than whites. This is due to the fact that in the urban land use equilibrium considered, blacks live far from the business district, which is also the place where random encounters can occur.

\(^{22}\)The idea behind this assumption differs slightly from Zenou (2011) in which spatial segregation implies that agents further away from the business district meet less weak ties, whether black or white. In our case, individuals from both groups can meet as many weak ties, but once they are in a context of meeting them, they go more easily towards /speak more to people of the same race.

\(^{23}\)For an illustrative purpose, I can think that blacks and whites go as often to pubs (so they have the same \( \omega \)), but that they go to different ones.
which are included in all equations but the first. These are choice variables: in the second line, $\phi_j$ is a dummy variable equal to one if the unemployed agent whose dyad partner is also unemployed decides to accept a job offer, and equal to zero otherwise. Similarly, in the third equation, $\psi_j$ is the dummy variable embodying the decision with respect to undeclared job opportunities. Finally, $\chi_j = 1$ if an unemployed worker whose strong tie is an undeclared worker accepts a job opportunity in the shadow economy, and $\chi_j = 0$ otherwise. The difference between $\chi_j$ and $\psi_j$ is that $\psi_j$ embodies one’s choice to enter the shadow economy when his dyad partner is unemployed as well, while $\chi_j$ represents the same choice but when one’s dyad partner is himself an undeclared workers. Otherwise stated, $\chi_j$ represents the choice of entering the informal sector under peer pressure. All three decision variables will be endogenized in what follows, when I introduce individuals incentives.

Using the population normalization condition (2), the system (3) reduces to the following four dynamic equations system:

$$
\begin{align*}
    d'_{2t_j} &= h_j^F(f_{1t_j}, f_{2t_j}, f_{3t_j}) \lambda_j d_{1t_j} - 2\delta_F d_{2t_j} \\
    d'_{1t_j} &= 2\delta_F d_{2t_j} + 2q_j^F(f_{1t_j}, f_{2t_j}, f_{3t_j}) \lambda_j \phi_j \left( N_j - d_{2t_j} - d_{1t_j} - d_{-1t_j} - d_{-2t_j} \right) - [h_j^F(f_{1t_j}, f_{2t_j}) \lambda_j + \delta_F] d_{1t_j} \\
    d'_{-1t_j} &= 2q_j^I(i_{1t_j}) \psi_j \left( N_j - d_{2t_j} - d_{1t_j} - d_{-1t_j} - d_{-2t_j} \right) + 2(\delta_I + p)d_{-2t_j} - [\delta_I + p + h_j^I(i_{1t_j}) \chi_j] d_{-1t_j} \\
    d'_{-2t_j} &= h_j^I(i_{1t_j}) \chi_j d_{-1t_j} - 2(\delta_I + p)d_{-2t_j} \\
\end{align*}
$$

\[ (4) \]

2.4 Incentives

As mentioned earlier, the choice variables $\phi_j$, $\psi_j$ and $\chi_j$ will be endogenously determined taking into account the incentives faced by individuals in their decision making. Declared workers earn a wage $w_F$, and pay a unit tax $t$ so that their net wage is $w_F(1 - t)$. Unemployed workers receive a financial payoff $b$, which can be considered as the unemployment insurance or as the value of leisure,\textsuperscript{24} such that $w_F(1 - t) > b$. Finally, undeclared workers earn a wage $w_I$, and evade from tax paying. However, they can be detected by fiscal authorities with probability $p$, which implies paying a fine $f$ defined as a share of the wage perceived. Therefore, the expected informal wage is given by: $w_I(1 - pf)$.

Agents make their decisions on the basis of their future employment prospects, but taking their dyad partner’s situation as given.\textsuperscript{25} In the long-run, individual values for each possible labor market status are given by the following Bellman equations, where the first subscript accounts for the individual’s status and the second one for his partner’s (for instance, $V_{10}^j$ is the lifetime expected utility of a declared group $j$ worker whose dyad partner is currently unemployed):

\textsuperscript{24} This may be a better interpretation of $b$, as individuals are unlikely to receive unemployment insurance after performing undeclared work.

\textsuperscript{25} I relax this assumption later.
∀

3 Steady state equilibrium analysis

There exist at most sixteen different steady-states, which can be reduced to ten different cases by symmetry.

3.1 Characterization of the steady-states (Proposition 1)

There exist at most sixteen different steady-states, which can be reduced to ten different cases by symmetry.

(i) A full unemployment steady-state where \( f_j^* = 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) when \( \phi_j, \psi_j, \) and \( \chi_j \in \{0,1\} \), \( \forall j \).

(ii) Steady-states where one group is fully unemployed, while the other takes part in the formal economy only, i.e. where \( f_j^* = 0, f_{-j}^* > 0 \) and \( i_j^* = i_{-j}^* = 0 \), \( \forall j \in \{W,B\} \), when \( \phi_j = 0, \phi_{-j} = 1 \) and \( \psi_j, \chi_j \in \{0,1\} \), \( \forall j \), and \( B_j^F < x_F(\omega) \), where \( x_F(\omega) \) is the unique positive root of a third order polynomial.

(iii) A no-informal economy steady-state where \( f_j^* > 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) when \( \phi_j = 1 \) and

\[
\begin{align*}
\text{Equation 5:} \quad rV_{i1}^j &= w_F(1-t) + \delta_F(V_{01}^j - V_{i1}^j) \\
\text{Equation 6:} \quad rV_{01}^j &= b + h_j^F(f_j, f_{-j})\lambda_j(V_{11}^j - V_{01}^j) \\
\text{Equation 7:} \quad rV_{10}^j &= w_F(1-t) + \delta_F(V_{00}^j - V_{10}^j) \\
\text{Equation 8:} \quad rV_{00}^j &= b + q_j^F(f_j, f_{-j})\lambda_j\psi_j(V_{10}^j - V_{00}^j) + q_j^F(i_j)\psi_j(V_{j10}^j - V_{00}^j) \\
\text{Equation 9:} \quad rV_{i10}^j &= w_F(1-t) + (\delta_f + \rho)(V_{00}^j - V_{i10}^j) \\
\text{Equation 10:} \quad rV_{01}^j &= b + h_j^F(i_j)\chi_j(V_{10}^j - V_{01}^j) \\
\text{Equation 11:} \quad rV_{j10}^j &= w_F(1-t) + (\delta_f + \rho)(V_{00}^j - V_{j10}^j)
\end{align*}
\]

In these equations, \( r \) denotes the interest rate. Equation 5 tells that the lifetime expected utility of a formally employed worker whose strong tie is also formally employed is equal to his wage, plus the net value of losing his job (i.e. the value of being in a \( d_1 \) dyad compared to the value of being in a \( d_2 \) dyad). The other equations have similar interpretation.

3.1 Characterization of the steady-states (Proposition 1)

There exist at most sixteen different steady-states, which can be reduced to ten different cases by symmetry.

(i) A full unemployment steady-state where \( f_j^* = 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) when \( \phi_j, \psi_j, \) and \( \chi_j \in \{0,1\} \), \( \forall j \).

(ii) Steady-states where one group is fully unemployed, while the other takes part in the formal economy only, i.e. where \( f_j^* = 0, f_{-j}^* > 0 \) and \( i_j^* = i_{-j}^* = 0 \), \( \forall j \in \{W,B\} \), when \( \phi_j = 0, \phi_{-j} = 1 \) and \( \psi_j, \chi_j \in \{0,1\} \), \( \forall j \), and \( B_j^F < x_F(\omega) \), where \( x_F(\omega) \) is the unique positive root of a third order polynomial.

(iii) A no-informal economy steady-state where \( f_j^* > 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) when \( \phi_j = 1 \) and

\[
\begin{align*}
\text{Equation 12:} \quad d_{-2j}^* &= \frac{h_j^F(i_j^*)\chi_j}{2(\delta_f + \rho)} d_{-1j}^* \\
\text{Equation 13:} \quad d_{-1j}^* &= \frac{h_j^F(f_j^*, f_{-j}^*)\lambda_j}{2\delta_f} d_{1j}^* \\
\text{Equation 14:} \quad d_{-2j}^* &= \frac{h_j^F(i_j^*)\chi_j}{2(\delta_f + \rho)} d_{-1j}^* \\
\text{Equation 15:} \quad d_{-1j}^* &= \frac{2q_j^F(i_j^*)\psi_j}{(\delta_f + \rho)} d_{0j}^*
\end{align*}
\]

and

\[
\begin{align*}
\text{Equation 16:} \quad f_j^* &= \frac{2d_{-2j}^* + d_{1j}^*}{N_j} \quad \text{and} \quad i_j^* &= \frac{2d_{-2j}^* + d_{1j}^*}{N_j} \quad \text{and} \quad w_j^* = 1 - f_j^* - i_j^* \\
\text{Equation 17:} \quad d_{0j}^* &= \frac{N_j}{2} - d_{-2j}^* - d_{1j}^* - d_{-1j}^* - d_{-2j}^*
\end{align*}
\]
\( \psi_j, \chi_j \in \{0, 1\}, \forall j \). The equilibrium formal employment rates are characterized by the following relationship:

\[
 f_j^* = \frac{(Z^F + B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) (\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)}{(B_j^F)^2 + (Z^F + 2B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) (\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)}, \forall j
\]  

(\text{iv}) Steady-states where one group is fully employed, while the other takes part in the informal economy only, i.e. where \( f_j^* = f_{-j}^* = 0 \), \( i_j^* > 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{W, B\} \), when \( \phi_j, \phi_{-j}, \psi_j \in \{0, 1\}, \psi_j = 1, \chi_j = 0 \) and \( \frac{\delta_j + \psi_j}{\alpha_j} < \frac{N_j}{N} \), \( \forall j \), or when \( \phi_j, \phi_{-j}, \psi_j \in \{0, 1\}, \psi_j = 1, \chi_j = 1 \) and \( B_j^I < x_I(\omega) \), where \( x_I(\omega) \) is the unique positive root of a third order polynomial.

(\text{v}) Steady-states where one group is fully employed while the other takes part in both employment sectors, i.e. where \( f_j^* > 0, f_{-j}^* = 0, i_j^* > 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{W, B\} \), when \( \phi_j = 1, \phi_{-j} = 0, \psi_j = 1, \psi_j \in \{0, 1\}, \chi_j = 1 \) and \( B_j^I < x_{M}(\omega) \), where \( x_{M}(\omega) \) is the unique positive root of a third order polynomial.

(\text{vi}) Steady-states where one group works in the informal sector only while the other takes part in the formal labor market only, i.e. where \( f_j^* = 0, f_{-j}^* > 0, i_j^* > 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{W, B\} \), when \( \phi_j = \phi_{-j} = 1, \psi_j = 1, \psi_j \in \{0, 1\}, \chi_j = 0 \) and \( B_j^I < x_{F}(\omega) \), where \( x_{F}(\omega) \) is the unique positive root of a third order polynomial, \( \forall j \), or when \( \phi_j = \phi_{-j} = 1, \psi_j = 1, \psi_j \in \{0, 1\}, \chi_j = 1 \) and \( B_j^I < x_I(\omega) \) and \( B_j^F < x_{F}(\omega) \), where \( x_I(\omega) \) and \( x_{F}(\omega) \) are the unique positive roots of two different third order polynomials.

(\text{vii}) Steady-states where one group is involved in both sectors, while the other works in the formal sector only, i.e. where \( f_j^* > 0, f_{-j}^* > 0, i_j^* > 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{W, B\} \), when \( \phi_j = \phi_{-j} = 1, \psi_j = 1, \psi_j \in \{0, 1\}, \chi_j = 0 \) or when \( \phi_j = \phi_{-j} = 1, \psi_j = 1, \psi_j \in \{0, 1\}, \chi_j = 1 \).

\* if \( \chi_j = 0 \), \( f_j^* \) is defined by the following relationship:

\[
 f_j^* = \frac{N}{N_j} \frac{B_j^I}{(B_j^F)^2} (Z^F + B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) (\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)
\]

\* if \( \chi_j = 1 \), \( f_j^* \) is defined by the following relationship:

\[
 f_j^* = \frac{(B_j^F)^2 (Z^F + B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) (\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)}{(B_j^F)^2 (Z^F + 2B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) (\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) + (B_j^F)^2 (Z_j^F + 2B_j^F + \frac{N_j}{N} i_j^*) (\frac{N_j}{N} i_j^*)}
\]

(\text{viii}) An informal economy steady-state where \( f_j^* = f_{-j}^* = 0 \) and \( i_j^* > 0, i_{-j}^* > 0 \), \( \forall j \in \{W, B\} \) when \( \phi_j \in \{0, 1\}, \psi_j = 1, \psi_j = 1, \chi_j = 0 \) and \( \frac{\delta_j + \psi_j}{\alpha_j} < \frac{N_j}{N} \), \( \forall j \), or when \( \phi_j \in \{0, 1\}, \psi_j = 1, \psi_j = 1, \chi_j = 1 \) and \( B_j^I < x_{M}(\omega) \), where \( x_{M}(\omega) \) is the unique positive root of a third order polynomial.

(\text{ix}) Steady-states where one group is involved in both sectors, while the other works in the informal sector only, i.e. where \( f_j^* > 0, i_j^* > 0 \) and \( f_{-j}^* > 0, i_{-j}^* > 0 \), \( \forall j \in \{W, B\} \), when \( \phi_j = 1, \phi_{-j} = 0, \psi_j = 1, \psi_j = 0, \psi_j = 1, \chi_j = 1 \) and \( B_j^I < x_I(\omega) \) and \( B_j^I < x_M(\omega) \), where \( x_I(\omega) \) and \( x_M(\omega) \) are the unique positive roots of two different third order polynomials.

(\text{x}) A mixed steady-state where \( f_j^* > 0 \) and \( i_j^* > 0, \forall j \in \{W, B\} \), when \( \phi_j = \phi_{-j} = 1, \psi_j = \psi_{-j} = 1, \) and \( \chi_j = 0, \forall j \). In this case, \( f_j^* \) is characterized by the following relationship:

\[
 f_j^* = \frac{N}{N_j} \frac{B_j^I}{(B_j^F)^2} (Z^F + B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*) (\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)
\]
Alternatively, this steady-state arises when \( \phi_j = \phi_{-j} = 1 \), \( \psi_j = \psi_{-j} = 1 \), and \( \chi_j = 1 \), \( \forall j \). In this case, \( f_j^* \) is characterized by the following relationship:

\[
\begin{align*}
f_j^* = & \frac{(B_j^F)(Z_j^F + B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)((\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*))}{(B_j^F B_j^I)^2 + (B_j^I)^2(Z_j^F + 2B_j^F + \frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)((\frac{N_j}{N} f_j^* + \beta \frac{N_j}{N} f_{-j}^*)) + (B_j^F)^2(Z_j^I + 2B_j^I + \frac{N_j}{N} f_j^*)}.
\end{align*}
\]

### 3.2 Unemployed workers decisions

In order to derive the conditions under which the steady-states presented above arise in equilibrium, I need to know the conditions determining the value of the three choice variables \( \phi_j \), \( \psi_j \) and \( \chi_j \), i.e. the conditions under which unemployed workers are willing to accept or reject a formal or an informal job offer. To do that, I simply compare the lifetime expected utility of an unemployed worker to the one he would get from accepting a formal or an informal job offer. Combining equations 5 and 6, I get:

\[
V_{11}^j - V_{01}^j = \frac{w_F(1 - t) - b}{r + \lambda_j h_j^F(f_j, f_{-j}) + \delta_F} \tag{19}
\]

This difference is always positive given the assumption \( w_F(1 - t) > b \), meaning that an individual whose dyad partner is a declared worker will always be better off having a formal job than being unemployed.\(^26\) More importantly, given that the minority group face discrimination, the net value of being employed when one’s partner is employed is likely to be greater for blacks than for whites (i.e. \( V_{11}^B - V_{01}^B > V_{11}^W - V_{01}^W \)).\(^27\)

Similarly, using equations 10 and 11 I easily obtain:

\[
V_{11}^j - V_{01}^j = \frac{w_I(1 - pf) - b}{r + \delta_I + p + h_j(i_j)\chi_j} \tag{19}
\]

This relationship helps determine the conditions under which an unemployed agent will decide to accept an informal job offer, under peer pressure, that is to say when his dyad partner is himself an undeclared worker. Indeed, for such an unemployed worker to accept the job, the lifetime expected value of this job must be greater than the lifetime expected value of unemployment:

\[
\chi_j = 1 \iff V_{11}^j - V_{01}^j \geq 0 \iff w_I(1 - pf) \geq b \tag{20}
\]

This is quite intuitive as it means that an unemployed worker in a relationship with an undeclared worker will accept an informal job offer only if the expected wage associated with this offer is higher than the unemployment benefit, and does not take into account any outside option (here entering the formal labor market), due to the conformity assumption.

Finally, in order to determine the conditions under which an unemployed (whose partner is unemployed) will accept a formal or an informal job offer, I need to combine equations 7, 8 and 9. Solving this system

\(^26\)This explains why I did not introduce any choice variable for an unemployed matched with a formal worker: this would simply always be equal to one.

\(^27\)Consider for instance a steady-state where both groups have a positive employment rate. Given that blacks face discrimination and have access to a smaller network, their transition into formal employment is lower than whites’, for the same job destruction rate. Hence I will have \( f_B < f_W \), and \( \lambda B h_B^F(f_B, f_W) < \lambda W h_W^F(f_W, f_B) \).
leads to the following relationships:

\[ \phi_j = 1 \iff V_{10}^j \geq V_{00}^j \iff (r + \delta_I + p)[w_F(1-t) - b] \geq q_f^I(i_j)\psi_j [w_I(1-pf) - w_F(1-t)] \]  \hspace{1cm} (21)

and

\[ \psi_j = 1 \iff V_{10}^j \geq V_{00}^j \iff (r + \delta_F)[w_I(1-pf) - b] \geq q_f^F(f_j, f_{-j})\phi_j [w_F(1-t) - w_I(1-pf)] \]  \hspace{1cm} (22)

Both results are rather intuitive: from equation 21, I see that an unemployed worker whose partner is unemployed will accept a formal job offer if the net financial gain from becoming a declared worker is large enough compared to the informal wage net of the formal wage. Similarly, 22 tells us that for an unemployed worker whose dyad partner is unemployed to accept an informal job offer, the net financial gain from becoming an undeclared worker must be large enough compared to the formal wage net of the informal wage. Otherwise stated, he compares his immediate net gain (left hand side terms) to the gain he would make in the outside option, would he refuse the offer in one sector to wait for an offer in the other sector (right hand side terms) . It is also easy to show that \( w_I(1-pf) \geq w_F(1-t) \) is a sufficient condition for \( \psi_j = 1 \), and conversely, \( w_I(1-pf) \leq w_F(1-t) \) is a sufficient condition for \( \phi_j = 1 \).

### 3.3 Equilibria (Proposition 2)

I assume that \( w_F(1-t) > b, B_I^f < \min\{x_I(\omega), x_M(\omega)\} \) and \( B_{-I}^F < x_F(\omega) \). I introduce the following notations:

- \( q_j^F(\phi_j, \psi_j, \chi_j, \phi_{-j}, \psi_{-j}, \chi_{-j}) = q_j^F(f_j, f_{-j}, \phi_j, \psi_j, \chi_j) \), and
- \( q_j^I(i_j) = q_j^I(i_j, \phi_j, \psi_j, \chi_j) \), to indicate the values of the choice variables in equilibrium.

#### Suppose first that \( w_F(1-t) > w_I(1-pf) \):

- The full unemployment steady-state (i), i.e. \( f_j^* = 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) always arises in equilibrium.
- The no informal sector steady-state (iii), i.e. \( f_j^* > 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) always arises in equilibrium.
- The mixed steady-states (ii, iiw) where one group is fully employed while the other takes part in the informal labor market only, i.e. \( f_j^* > 0, i_j^* > 0, f_{-j}^* = 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{B,W\} \) arises in equilibrium if \( b \leq w_I(1-pf) \).
- The mixed steady-states (viiw) where one group is involved in both sectors, while the other works in the formal sector only, i.e. \( f_j^* > 0, i_j^* > 0, f_{-j}^* = 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{B,W\} \) arises in equilibrium as long as \( b \leq w_I(1-pf) - q_j^F\lambda_{-j} \leq \frac{w_F(1-t) - w_I(1-pf)}{\lambda_{-j}} \), with \( j \) is such that \( \frac{N_j f_{-j}^* + \beta N_{-j} f_{-j}^*}{N_j f_j^* + \beta N_{-j} f_{-j}^*} < \frac{\lambda_{-j}}{\lambda_j} \).
- The no formal sector steady-state (viii), i.e. \( f_j^* = 0 \) and \( i_j^* > 0 \), \( \forall j \in \{W,B\} \) arises in equilibrium if \( b \leq w_I(1-pf) \).
- The mixed steady-state (x), i.e. \( f_j^* > 0 \) and \( i_j^* > 0 \), \( \forall j \in \{W,B\} \) arises in equilibrium if

\[ b \leq w_I(1-pf) - \frac{\min(1,1,1,1,1)}{\lambda_j} \frac{w_F(1-t) - w_I(1-pf)}{w_I(1-pf)} \]

where group \( j \) is such that \( \frac{N_j f_{-j}^* + \beta N_{-j} f_{-j}^*}{N_j f_j^* + \beta N_{-j} f_{-j}^*} < \frac{\lambda_{-j}}{\lambda_j} \).

#### Suppose now that \( w_F(1-t) \leq w_I(1-pf) \):

- The full unemployment steady-state (i), where \( f_j^* = 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W,B\} \) always arises in equilibrium.
- The no informal sector steady-state (iii), where \( f^*_j > 0 \) and \( i^*_j = 0 \), \( \forall j \in \{W,B\} \) always arises in equilibrium.

- Steady-states (iv) where one group is fully unemployed while the other takes part in the informal labor market only, i.e. \( f^*_j = 0, i^*_j > 0, f^*_{-j} = 0, \) and \( i^*_{-j} = 0, \forall j \in \{B,W\} \) always arises in equilibrium.

- Steady-states (vi) where one group specializes in the formal economy while the other specializes in the informal economy, i.e. \( f^*_j = 0, i^*_j > 0, f^*_{-j} > 0, \) and \( i^*_{-j} = 0, \forall j \in \{W,B\} \) arises in equilibrium if

\[
q_j(1-t) - \frac{q_j^i(0,1,1,1,1)}{(r+\delta_I+p)}[w_F(1-pf) - w_F(1-t)] < b \leq w_F(1-t) - \frac{q_j^f(1,1,1,0,1,1)}{(r+\delta_I+p)}[w_F(1-pf) - w_F(1-t)].
\]

- Steady-states (vii) where one group is involved in both sectors, while the other works in the formal sector only, i.e. \( f^*_j > 0, i^*_j > 0, f^*_{-j} > 0 \) and \( i^*_{-j} = 0, \forall j \in \{W,B\} \) arises in equilibrium if

\[
b \leq w_F(1-t) - \frac{q_j^f(1,1,1,1,1)}{(r+\delta_I+p)}[w_F(1-pf) - w_F(1-t)]
\]

and \( j \) characterized by \( t_jN_j i^*_j \leq t_{-j}N_{-j} i^*_{-j} \).

- The mixed steady-state (ix), i.e. \( f^*_j > 0 \) and \( i^*_j > 0, \forall j \in \{W,B\} \) arises in equilibrium if

\[
b \leq w_F(1-t) - \frac{q_j^f(0,1,1,1,1)}{(r+\delta_I+p)}[w_F(1-pf) - w_F(1-t)]
\]

where \( j \) is such that \( t_jN_j i^*_j \leq t_{-j}N_{-j} i^*_{-j} \).

### 4 Numerical simulations

#### 4.1 Forward-looking agents

In this section, I consider the case of forward-looking agents, as in Calvò-Armengol et al. (2007): I now suppose that agents make their employment decisions taking into account the fact that not only they but also their strong tie can experience a change in status. In this case, the Bellman equations become:

\[
\begin{align*}
V^j_{11} & = w_F(1-t) + \delta_F(V^j_0 - V^j_{11}) + \delta_F(V^j_{10} - V^j_{11}) \\
V^j_0 & = b + h^j_f(f^*_j, f^*_{-j})\lambda_j(V^j_1 - V^j_0) + \delta_F(V^j_0 - V^j_{-1}) \\
V^j_1 & = w_F(1-t) + \delta_F(V^j_0 - V^j_1) + h^j_f(f^*_j, f^*_{-j})\lambda_j(V^j_1 - V^j_0) \\
V^j_{00} & = b + h^j_f(f^*_j, f^*_{-j})\lambda_j(V^j_0 - V^j_{00}) + q^j_f(i^*_j, \psi_j)(V^j_{10} - V^j_{00}) + q^j_f(f^*_j, f^*_{-j})\lambda_j\phi_j(V^j_{01} - V^j_{00}) + q^j_f(i^*_j, \psi_j)(V^j_{01} - V^j_{00}) \\
V^j_{10} & = w_F(1-pf) + (\delta_I + p)(V^j_0 - V^j_{10}) + h^j_I(i^*_j, \chi_j)(V^j_{11} - V^j_{10}) \\
V^j_{01} & = b + h^j_I(i^*_j, \chi_j)(V^j_{11} - V^j_{01}) + (\delta_I + p)(V^j_{01} - V^j_{00}) \\
V^j_{11} & = w_F(1-pf) + (\delta_I + p)(V^j_{01} - V^j_{11}) + (\delta_I + p)(V^j_{10} - V^j_{11})
\end{align*}
\]

The intuition behind these equations is similar than in the myopic case. For instance, equation 28 is built on the fact the lifetime expected utility of an unemployed in a dyad with an undeclared worker can change either because this unemployed finds an informal job, or because his partner looses his job. In this exercise, I have assumed that when one worker considers the opportunity of his strong tie, he thinks as if it was for himself. That is why I represent the choices of either worker in a dyad by the same dummy variables.28

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4.2 Calibration

I now simulate the model, with a time period of one month. The interest rate is \( r = 0.00333 \), so that I have the standard 4% annual interest rate.

**Job market flows:** For simplicity, I set \( \lambda_W = 1 \) and \( \lambda_B = 0.6 \): conditional on having found a formal job opportunity, blacks are forty percent less likely than whites to actually get the job, because of discrimination. The figures chosen here reflect the empirical evidence that blacks unemployment duration can be up to forty percent higher than whites.\(^{29}\) The job destruction rate is equal to \( \delta_F = 0.03 \) in the formal sector, meaning that formal workers keep their job a bit less than three years,\(^ {30} \) while I set \( \delta_I = 0.04 \), such that informal jobs last on average two years and one month. This reflects the fact that informal jobs can be terminated more easily due to the lack of regulations. In addition, I set the audit rate to \( p = 0.03 \): an undeclared job is detected by fiscal authorities once every thirty-three month on average. This can seem very low, but the data show even worse: for instance, Jacquemet (2006) reports that in the construction sector in France, 26,177 establishments were controlled by government authorities in 2005. According to the French bureau of statistics (INSEE), this amounts to only 6.74% of total establishments in the construction sector in 2005.\(^ {31} \) Concerning the rate at which employees are aware of a job opportunity, I set \( \alpha_F = 1 \) and \( \alpha_I = 3 \): undeclared workers hear on average about three jobs opportunities per month, while declared workers hear about an opportunity once a month. This translate the idea that the informal labor market is more flexible than the formal one.

**Incentives:** A formal worker earns a wage \( w_F = 3.125 \) and pays a tax \( t = 0.2 \), so that his monthly net wage is \( w_F(1 - t) = 2.5 \). The unemployment benefit is worth \( b = 1.25 \), so that the replacement rate is equal to 0.5.\(^ {32} \) The undeclared wage is slightly lower than the post-tax formal wage \( w_I = 2.45 \), and I assume that \( f = 0.2 \) so that the fine paid in case of detection is equal to the (monthly) evaded amount. Note that with this set of values, I have \( w_F(1 - t) > w_I(1 - pf) \).

**Network:** I consider an economy where blacks represent a bit more that one fourth of the population, with \( N_B = 300 \) and \( N_W = 800 \). In the benchmark case, I set \( \omega = 0.1 \), meaning that individuals spend 10% of their time with people outside their dyad, and I assume that \( \beta = 0.5 \), indicating that when two individuals from different groups meet, they will actually exchange relevant job information half of the time (another way to view it is that segregation between blacks and whites is such that they meet only 50% of the time). This is just a benchmark case: I make these parameters vary in what follows.

4.3 Simulations

4.3.1 Characterization of the equilibria

When I simulate the model using the parameter values specified above, four equilibria emerge: the full-unemployment equilibrium \((i)\), the no-informal economy equilibrium \((iii)\), and a type \((vii)\) equilibrium where one group is involved in both sectors, while the other works in the formal sector only. More precisely, in the type \((vii)\) equilibrium that emerges, blacks is the only group participating in the informal economy. So, in this situation where informal wages are on expectation lower than formal wages, the non-discriminated

\(^{29}\) For instance, Bowlus and Eckstein (2002) estimate that 56% of the firms have disutility from employing blacks.

\(^{30}\) I use the same number as Calvò-Armengol et Al. (2007). This is based on Postel-Vinay and Robin (2002).

\(^{31}\) INSEE, Répertoire des Entreprises et des Etablissements.

\(^{32}\) The net wage and the unemployment insurance are as in Calvò-Armengol et Al. (2007), following Postel-Vinay and Robin (2002).
These equilibria are obtained for the following values of parameters: $\alpha = 1, \beta = 0.6, \delta = 0.03, \delta_1 = 0.04, p = 0.03, \alpha_F = 1, \alpha_I = 3, w_F = 3.125, t = 0.2, b = 1.25, w_I = 2.45, f = 0.2, N_B = 300, N_W = 800, \omega = 0.1$ and $\beta = 0.5$.

majority group do not engage in the informal economy, while the discriminated minority group goes toward undeclared jobs to avoid unemployment, even if the wage is not attractive.

The main characteristics of equilibria (iii) and (vii) are summarized in Table 1. In both equilibria, blacks have a lower formal employment rate and a higher unemployment rate than whites. In particular, blacks unemployment rate is more than twice as high as whites in the no informal economy equilibrium, but the gap decreases in the equilibrium where blacks participate in the informal labor market: in this equilibrium, whites unemployment rate is 0.12 point higher, while blacks unemployment rate is 2.19 points lower. However, in this second equilibrium, only 38.44 % of blacks are declared workers, compared to 95.99 % of whites, and more than half of the blacks are undeclared workers.\(^{33}\)

The lower unemployment rate of blacks in the second equilibrium directly translates the fact that black spend less time in $d_0$ dyads in equilibrium (vii): an unemployed black spend 2.14 % of his time with an unemployed dyadic partner in the second equilibrium, versus 3.78 % in the first equilibrium. Unemployed black workers spend also less time in a dyad with an employed worker, whether declared or undeclared: 6.67 % of the time in equilibrium (vii) versus 9.08 % in equilibrium (iii).

I can also note that $h^F_{ij}(f_j, f_{-j}) > q^F_{ij}(f_j, f_{-j}), \forall j \in \{B, W\}$ and $h^I_{B}(i_B) > q^I_B(i_B)$ (in the second equilibrium), meaning that most of the job opportunities come from one’s strong tie. This explains why employed workers spend most of their time with a worker employed on the same market.

---

\(^{33}\) I can regard these figures in a slightly different way: from the “government” point of view, undeclared workers can be considered as inactive, and declared and unemployed workers as the active population. In this case, blacks unemployment rate in the second equilibrium is 13.75 %.
Finally, and as mentioned earlier, the value of having a declared job with a dyad partner in a declared occupation ($V_{11}$) is always higher than the value of being unemployed with a formally employed worker ($V_{01}$), for both groups and in both equilibria. It is also larger than the value of having a declared job with an unemployed partner. I can also note that the value of being unemployed with a formally employed strong tie is always larger than the value of being unemployed with an unemployed partner, because in this case the chances of finding a formal job are lower.\footnote{This can be related to the network long run positive correlation in employment status exhibited in Calvò-Armengol and Jackson (2004).}

Now turning to the choice of becoming informal, Table 1 shows that the value of having an undeclared job when one’s partner is working informally is always larger than the value of being unemployed with an undeclared strong tie, for both groups. In other words, unemployed workers would always accept informal job opportunities under peer pressure in these equilibria. However, whites in a $d_0$ dyad will always turn down an informal job offer ($V^{W}_{00} > V^{W}_{0-1}$), whereas blacks in a $d_0$ dyad will always accept such offers ($V^{B}_{00} < V^{B}_{0-1}$). Indeed, for whites, it is always worth staying unemployed and wait for a formal job offer rather than accepting an informal one, given the values of the parameters: formal wages are more attractive than informal ones, and whites can easily find formal jobs. On the contrary, blacks suffer both from discrimination and from a smaller network, so that it is more difficult for them become declared workers. The first equilibrium presents a situation in which blacks perform well on the formal labor market, which increases their chances to find a formal job through a more informative network, and leads to an equilibrium where none of them is in the informal sector. The second equilibrium presents an alternative situation where they succeed relatively poorly on the formal labor market, and hence follow a path where their network becomes more and more efficient in finding informal job offers rather than formal ones. The fact that informal wages are lower than formal wages prevents them from being completely out of the formal labor market in equilibrium.

4.3.2 Role of network structure

I now focus on equilibrium (vii) where whites work in the formal sector only while blacks engage in both sectors. Figure 1 shows how blacks formal and informal employment rates are affected by the network structure (that is, the intensity of out-of-dyads encounters, $\omega$ and the extent of segregation, $\beta$).\footnote{I do not show whites employment rate on this graph for a matter of clarity, but the main patterns are described in what follows.} The blue lines correspond to the benchmark situation where $\beta = 0.5$ (i.e. weak ties from different ethnic groups share information half of the time). In this case, blacks undeclared employment rate (plain line) is always higher than their declared employment rate (dashed line): informal employment rate is around 56 % while formal employment rate is around 39 %. It appears that when segregation is high, increasing the frequency of random encounters does not affect blacks employment rates a lot. The intuition is simple: when individuals interact more outside their dyad, they can get more non-redundant information, and hence increase their chance to hear of a job opportunity. However, if across-group information transmission is low (segregation is high), then individuals hear of job opportunities mainly from workers of their own ethnic group. In this equilibrium where blacks participation in the formal labor market is low, increasing the frequency of random encounters is consequently rather inefficient in terms of formal job finding.

As far as whites are concerned, their (formal) employment rate is of course much higher than blacks, around 95 %. It also increases a bit faster with $\omega$, raising from 86.2 % when $\omega = 0.01$ to 96.6 % when $\omega = 0.25$ (compared to an increase from 33.2 % to 42.1 % for blacks).

The red lines in Figure 1 illustrate the low segregation case for blacks with $\beta = 0.9$. Three points are worth noting. First, the formal employment rate (dashed line) is not only higher than in the previous setting,
but it is now larger than the informal employment rate (plain line). Second, an increase in the frequency of random encounters is much more efficient in raising the formal employment when segregation is low: an increase in $\omega$ from 0.01 to 0.17 is associated with a rise in blacks formal employment rate of 20.3 points when $\beta = 0.9$ but of only 6.7 points when $\beta = 0.5$. Finally, the informal employment rate first increases and then decreases with $\omega$.

The first point comes from the fact that when there is less segregation, blacks benefit more easily from whites information. Hence, not only do they access to a significantly larger network, but this network is also providing them more formal job offers. The consequence is more frequent formal job offers and thus more formal employment.

The second point derives from the previous argument: when there is more between-group information transmission, an increase in the frequency of random encounters corresponds for blacks to enlarging the network and making it more efficient. On the contrary, the level of segregation does not make an important difference for whites: their formal employment rate is of the same order of magnitude as in the low segregation case, and it increases only by 8.9 points (versus 20.3 points for blacks). Indeed, having access to blacks information is less relevant for whites who already belong to a large and efficient network (to put it another way, blacks represent a marginal source of information for whites).

The third point reveals that increasing the frequency of random encounters boosts undeclared employment rate when $\omega$ is very low, but lowers the undeclared employment rate when $\omega$ is above a certain threshold (here, the threshold that I denote $\overline{\omega}$ henceforth is such that $0.04 \leq \overline{\omega} \leq 0.045$). This finding is more surprising, but can be interpreted as follows: when $\omega$ is below $\overline{\omega}$, individuals meet so few weak ties that their formal employment prospects are really low, even if there is little segregation. This situation is comparable to the high segregation case, where an increase in the rate of random encounters increases informal employment rate. However, when $\omega$ is above $\overline{\omega}$, both the frequency of random encounters and the level of formal employment rate make blacks transition rate toward formal employment fast enough to make them turn to this activity at the expense of informal activity (remind that in the case considered here, formal jobs are more profitable than informal ones, in terms of expected income).

### 4.3.3 Increasing the audit rate or reducing discrimination?

In this section, I still study the equilibrium where both ethnic groups have a positive formal employment rate, and where blacks also participate in the informal economy, but I am now interested in how to reduce blacks informal employment rate. I consider two different policies: a direct policy consisting in increasing the audit rate ($p$), and an indirect one consisting in reducing discrimination ($\lambda_B$). The first directly affects the informal employment rate by accelerating the separation rate in this sector, as well as decreasing the expected informal wage. The second one, that can be thought of as affirmative action policies imposing minorities quotas, is indirect: it increases the transition rate toward formal employment, which in turns reduces the incentives to accept an undeclared job opportunity. This is obvious from equation 22: an increase in $\lambda_B$ increases the right-hand side of the inequation, so that, all else being equal, the condition for $\psi_B = 1$ becomes more difficult to satisfy.

Figure 2 shows how blacks’ formal and informal employment rates and unemployment rate varies with the audit rate, for different levels of social interactions. The blue lines depict the situation when the frequency of random encounters is very low ($\omega = 1\%$), while the red lines stand for the case where $\omega = 10\%$.\textsuperscript{36} As expected, when the fiscal authorities control firms more often, the informal employment rate decreases, while

\textsuperscript{36}I show the simulation with $\omega = 0.1$ to ease the comparison with the benchmark case (c.f. Table 1). I also run the simulations for $\omega = 0.15$ and $\omega = 0.2$: the resulting graphs are very close to those obtained in the $\omega = 0.1$ case.
Figure 1: Effect of network structure on blacks formal and informal employment rates.
(equilibrium: $f^*_W > 0$, $f^*_B > 0$, $i^*_W = 0$ and $i^*_B > 0$)

$$r = 0.00333, \lambda_W = 1, \lambda_B = 0.6, \delta_F = 0.03, \delta_I = 0.04, p = 0.03, \alpha_F = 1, \alpha_I = 3, w_F = 3.125, t = 0.2, b = 1.25, w_I = 2.45, f = 0.2, N_B = 300$ and $N_W = 800$. 

\[ \lambda_W = 1, \lambda_B = 0.6, \delta_F = 0.03, \delta_I = 0.04, p = 0.03, \alpha_F = 1, \alpha_I = 3, w_F = 3.125, t = 0.2, b = 1.25, w_I = 2.45, f = 0.2, N_B = 300 \text{ and } N_W = 800. \]
the formal employment rate increases.\textsuperscript{37} Both employment rates follow roughly the same trend whatever the value of $\omega$, and the audit rate above which the formal employment rate becomes larger than the informal one is smaller for $\omega = 0.1$. Whites employment rate barely increases with $p$,\textsuperscript{38} and is around 86.3 \% when $\omega = 0.01$ and around 96 \% when $\omega = 0.1$.

The most interesting point concerns the unemployment rate. The increase in the audit rate increases blacks unemployment rate,\textsuperscript{39} the more so for larger values of $\omega$: when the extent of social interactions is low ($\omega = 0.01$), the unemployment rate rises by 19.8 points when $p$ grows from 0.01 to 0.045, while it increases by only 3.7 points when $\omega = 0.1$. The increase in unemployment rate is due to the fact that an increase in $p$ does not directly affect the transition rate into formal employment, so that undeclared workers who loose their job after detection do not face a much higher probability to find a job. The only effect on formal job finding is through the network composition (i.e. the number of formal workers). However, when $\omega$ is too low, a change in network composition can barely affect the formal job finding rate, which explains that the unemployment rate strongly increases. Another mechanism is at play: when $\omega$ is larger, the information about undeclared job opportunities circulate more easily, so that the informal economy can “rebuild” faster.\textsuperscript{40}

Figure 3 illustrates the effect of a decrease in discrimination (i.e. an increase in $\lambda_B$) on blacks equilibrium labor market situation. Unsurprisingly, when $\lambda_B$ rises, blacks formal employment rate increases, while their informal employment rate decreases, for any value of $\omega$. However, I can see that the decline in informal employment rate and the rise in the formal employment rate are sharper for $\omega = 0.1$, suggesting that this policy is more efficient when people meet weak ties more often. Indeed, in this case, non-redundant information circulates more easily in the networks, intensifying the initial direct effect of less discrimination.

With this policy, I can also notice that the unemployment rates remain unchanged, precisely because the policy aims at facilitating access to formal jobs to the minority group.

In what follows, I try to compare more directly the effect of the two policies on blacks formal and informal employment rates. Let us come back to the benchmark case where $p = 0.03$ and $\lambda_B = 0.6$, and look at the effect of increasing each parameter by one third: $p$ goes from 0.03 to 0.04,\textsuperscript{41} while $\lambda_B$ varies from 0.6 to 0.8.

When $\omega = 0.01$, I initially have $f_B^* = 33.20$ \% and $i_B^* = 44.58$ \%. From this situation, a one third increase in $p$ generates a 43.4 \% increase in $f_B^*$ (+14.4 points) and a 46.6 \% decrease in $i_B^*$ (-20.8 points). By comparison, a one third increase in $\lambda_B$ triggers a 128 \% increase in $f_B^*$ (+42.5 points) and a 95.8 \% decrease in $i_B^*$ (-53.8 points). When $\omega = 0.1$, I initially have $f_B^* = 38.44$ \% and $i_B^* = 55.43$ \%. From this situation, a one third increase in $p$ generates a 45.7 \% increase in $f_B^*$ (+17.6 points) and a 33.8 \% decrease in $i_B^*$ (-18.8 points). By comparison, a one third increase in $\lambda_B$ triggers a 141 \% increase in $f_B^*$ (+54.2 points) and a 97 \% decrease in $i_B^*$ (-53.8 points).

So, starting from the benchmark equilibrium values, the effect of $\lambda_B$ in reducing the informal employment rate is not only three times as large as the effect of $p$, but it is also exactly compensated by the increase in the formal employment rate, hence avoiding the cost of an increase in unemployment.

\textsuperscript{37}Note that the indirect effect of $p$ on the formal employment rate can be seen through equation 21.

\textsuperscript{38}The increase is not due to a direct effect of $p$ as whites do not take part in the informal economy in this equilibrium, but to the fact that blacks formal employment rate increases.

\textsuperscript{39}The fact that increasing the audit rate generates a crowding out effect is in line with Boeri and Garibaldi (2005) and Kolm and Larsen (2006), although with different mechanisms.

\textsuperscript{40}To say it in Calvò-Armengol, Verdier and Zenou words: when $\omega$ is high, “undeclared work feeds itself with undeclared work”.

\textsuperscript{41}i.e. firms are audited every two years and one month on average instead of once every two years and eight months.
Figure 2: Effect of an increase in the audit rate for the minority group. 
(equilibrium: $f^*_W > 0$, $f^*_B > 0$, $i^*_W = 0$ and $i^*_B > 0$)

\[ r = 0.00333, \lambda_W = 1, \lambda_B = 0.6, \delta_F = 0.03, \delta_I = 0.04, \alpha_F = 1, \alpha_I = 3, w_F = 3.125, t = 0.2, b = 1.25, w_I = 2.45, f = 0.2, N_B = 300, N_W = 800 \text{ and } \beta = 0.5. \]
Figure 3: Effect of a decrease in discrimination for the minority group.
(equilibrium: $f_W^* > 0$, $f_B^* > 0$, $i_W^* = 0$ and $i_B^* > 0$)

$r = 0.00333$, $\lambda_W = 1$, $\delta_F = 0.03$, $\delta_I = 0.04$, $p = 0.03$, $\alpha_F = 1$, $\alpha_I = 3$, $w_F = 3.125$, $t = 0.2$, $b = 1.25$, $w_I = 2.45$, $f = 0.2$, $N_B = 300$, $N_W = 800$ and $\beta = 0.5$. 
5 Conclusion

Appendix

Proof of proposition 1:

Combining equations (12) to (16), I get:

\[ f_j^* = \frac{2q_j f_j^* (f_j^*, f_j^*) \lambda_j \phi_j}{N_j \delta_F} [h_j (f_j^*, f_j^*) \lambda_j + \delta_F]d_{0j} \]  

(30)

\[ i_j^* = \frac{2q_j (i_j^*) \psi_j}{N_j (\delta_j + p)^2} [h_j (i_j^*) \chi_j + \delta_I + p] d_{0j} \]  

(31)

(i) Full unemployment steady-state: if \( f_j^* = 0 \) and \( i_j^* = 0 \), \( \forall j \in \{W, B\} \), equations (30) and (31) are verified \( \forall \phi_j, \psi_j, \chi_j \in \{0, 1\}, \forall j \in \{B, W\} \). From equations (12) to (15) I also have \( d_{2j} = d_{1j}^* = d_{-1j}^* = d_{-2j}^* = 0 \), which implies that \( d_{0j} = \frac{N_j}{2} \), \( \forall j \in \{B, W\} \).

(ii) If \( f_j^* = 0, f_{-j}^* > 0 \) and \( i_j^* = 0, \forall j \in \{W, B\} \): equation (30) for group \( j \) becomes:

\[ 0 = \frac{2\omega \beta N_j f_j^* \phi_j}{N_j \delta_F} [(1 - \omega + \omega \beta \frac{N_j f_j^*}{N}) \phi_j + \delta_F]d_{0j} \]

Note first that \( d_{0j} \) cannot be equal to zero, otherwise \( d_{2j} = d_{1j}^* = d_{-1j}^* = d_{-2j}^* = 0 \) from equations (12) to (15), which then leads to a contradiction with (17). Hence, equation (30) holds if \( \phi_j = 0 \). On the contrary, in order for equation (30) to hold for group -\( j \), I must have \( \phi_{-j} = 1 \). Equation (31) is verified for both groups \( \forall \psi_j, \chi_j \in \{0, 1\}, \forall j \in \{B, W\} \).

- For group \( j \), \( \phi_j = 0 \) implies \( d_{2j} = d_{1j}^* = 0 \) (from 12 and 13), and \( i_j^* = 0 \) implies \( d_{-1j}^* = d_{-2j}^* = 0 \) (from 14 and 15), and hence \( d_{0j} = \frac{N_j}{2} \).

- For group -\( j \), knowing that \( \phi_{-j} = 1 \) and \( f_j^* = 0 \), I can rearrange equation (30) to get:

\[ \frac{N_j}{N} f_{-j}^* = \frac{N(B_E^j)^2}{2} \frac{1}{d_{0j}} - B_{Ej}^F - Z_F \]

where \( B_{Ej}^F = \frac{\delta_F}{\omega \alpha \beta \chi_{-j}} \) and \( Z_F = \frac{1-\omega}{\omega} \).

Plugging this expression in equations (12) and (13), I get expressions of \( d_{1j}^* \) and \( d_{-1j}^* \) only, that I can in turn use in equation (30), with \( d_{-1j}^* = d_{-2j}^* = 0 \) as \( i_j^* = 0 \). I finally obtain that \( d_{0j} \) solves \( \Gamma_F(d_{0j}) = 0 \), where \( \Gamma_F(x) \) is the following second order polynomial:

\[ -\frac{Z_F}{B_{Ej}^F} x^2 - \frac{N_j}{2} (\frac{N_j}{N} + Z_F) x + \frac{N(B_E^j)^2}{2} \]  

(32)

I now derive the conditions of existence of a \( d_{0j} \) such that \( 0 < d_{0j} < \frac{N_j}{2} \) and \( \Gamma_F(d_{0j}) = 0 \). I have \( \Gamma_F(0) = \frac{(N_B E^j)^2}{2} > 0, x < 0 \), where \( x = 0 \) is defined as \( \Gamma_F(x) = 0 \), and \( \Gamma_F(0) < 0 \), so \( \Gamma_F(x) = 0 \) has a unique positive root. This root will be smaller than \( \frac{N_j}{2} \) if and only if

\[ \Gamma_F(\frac{N_j}{2}) = \frac{1}{4} \left[ -\frac{Z_F}{B_{Ej}^F} N_j^2 - N_j (\frac{N_j}{N} + Z_F) N_j + N_j N^2 (B_E^j)^2 \right] < 0 \]

which is equivalent to \(-Z_F N_j^2 - (N_j + N Z_F) N_j B_{Ej}^F + N_j N^2 (B_E^j)^3 < 0 \). Let us denote \( \Upsilon(x) = -Z_F N_j - (N_j + N Z_F) N_j x + N_j N^2 x^3 \) this third order polynomial. I now show that \( \Upsilon(x) \) has a unique positive real root, that I will denote \( x_F(\omega) \). The first derivative of this polynomial is given by
\( \Upsilon'(x) = 3N_{-j}N^2x^2 - (N_{-j} + NZF)N_{-j} \). The discriminant of this second order equation is strictly positive, and \( \Upsilon'(x) \) has a negative and a positive real root, denoted \( x_1 \) and \( x_2 \) respectively. Given that \( \Upsilon'(0) < 0 \), I deduce that \( \Upsilon(x) \) is continuously decreasing \( \forall x \in [x_1, x_2] \) (in particular \( \forall x \in [0, x_2] \)), and continuously increasing \( \forall x \geq x_2 \). Finally, as \( \Upsilon(0) < 0 \), I can infer that \( \Upsilon(x) \) has a unique positive real root, \( x_F(\omega) \).

To conclude, there exists a unique \( d_{0,j}^* \) such that \( 0 < d_{0,j}^* < \frac{N_{-j}}{x_2} \) and \( \Gamma_F(d_{0,j}^*) = 0 \), if and only if \( B_{F,j}^* < x_F(\omega) \).

Note also that \( d_{0,j}^* < \frac{N_{-j}}{x_2} \) ensures that \( f_{-j}^* > 0 \).

(iii) No informal sector steady-state: if \( f_j^* > 0 \) and \( i_j^* = 0, \forall j \in \{W, B\} \), as stated above, equation (31) is satisfied \( \forall \psi_j, x_j \in [0, 1], \forall j \in \{B, W\} \), and I must have \( \phi_j = 1, \forall j \in \{B, W\} \) for equation (30) to hold. This case is much more complicated because the formal employment rate of each group enters in both groups’ \( d_0 \) dyads. Hence, I cannot analyze this steady-state separately for each group. I can still rewrite equation (30) as follows:

\[
 f_j^* = \frac{2}{N_j(B_j^*)^2} \left( N_j f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^* \right) \left( ZF_j + B_j^* + \frac{N_j}{N} f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^* \right) d_{0,j}^*, \forall j \in \{B, W\} 
\]

Using equation (2) with \( d_{-j} = d_{-1,j} = 0 \) I got:

\[
d_{0,j}^* = \frac{N_j}{2} \frac{(B_j^*)^2}{(B_j^*)^2 + (ZF_j + 2B_j^* + \frac{N_j}{N} f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^*)} \left( \frac{N_j}{N} f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^* \right)
\]

so, after some manipulation, \( f_j^* \) is finally characterized by:

\[
f_j^* = \frac{(ZF_j + B_j^* + \frac{N_j}{N} f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^*)}{(B_j^*)^2 + (ZF_j + 2B_j^* + \frac{N_j}{N} f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^*)} \left( \frac{N_j}{N} f_j^* + \beta \frac{N_{-j}}{N} f_{-j}^* \right)
\]

I can note here that in this steady-state, \( 0 < f_j^* < 1, \forall j \in \{B, W\} \). In addition, this expression allows us to state that if the relative discrimination rate \( \frac{N_{-j}}{N_j} \) is large enough, then \( f_W^* > f_B^* \).

I can quickly look at the two extreme subcases where there is no segregation \( (\beta = 1) \) or when there is complete segregation \( (\beta = 0) \) between the two groups:

- If \( \beta = 0 \), I am back to the previous case (ii) where \( d_{0,j}^* \) is the solution of the second order equation (32), \( \forall j \in \{B, W\} \).

- If \( \beta = 1 \): I can rewrite equation (18) as:

\[
 N_j f_j^* = \frac{2}{N(B_j^*)^2} \left( \frac{N_j}{N} f_j^* + \frac{N_{-j}}{N} f_{-j}^* \right) \left( ZF_j + B_j^* + \frac{N_j}{N} f_j^* + \frac{N_{-j}}{N} f_{-j}^* \right) d_{0,j}^*, \forall j \in \{B, W\}
\]

and then add the \( j \) and \(-j\) equations to get:

\[
 N_j f_j^* + \frac{N_{-j}}{N} f_{-j}^* = \frac{2}{N(B_j^*)^2} \left( \frac{N_j}{N} f_j^* + \frac{N_{-j}}{N} f_{-j}^* \right) \left( ZF_j + B_j^* + \frac{N_j}{N} f_j^* + \frac{N_{-j}}{N} f_{-j}^* \right) d_{0,j}^* + \frac{2}{N(B_{-j}^*)^2} \left( \frac{N_{-j}}{N} f_{-j}^* + \frac{N_j}{N} f_j^* \right) \left( ZF_j + B_j^* + \frac{N_j}{N} f_j^* + \frac{N_{-j}}{N} f_{-j}^* \right) d_{0,-j}^*,
\]

This is equivalent to:

\[
 N_j f_j^* + \frac{N_{-j}}{N} f_{-j}^* = \frac{N(B_j^* B_{-j}^*)^2 - 2(ZF_j + B_j^*)(B_{-j}^*)^2 d_{0,j}^* - 2(ZF_j + B_{-j}^*)(B_j^*)^2 d_{0,-j}^*}{(B_{-j}^*)^2 d_{0,j}^* + (B_j^*)^2 d_{0,-j}^*}
\]

(iv) If \( f_j^* = 0, f_{-j}^* = 0, i_j^* > 0 \) and \( i_{-j}^* = 0, \forall j \in \{B, W\} \): as in case (i), equation (30) is verified \( \forall \phi_j \in \{0, 1\}, \forall j \in \{B, W\} \). Equation (31) for group \(-j\) holds \( \forall i_{-j} = 0, 1 \), and I have \( d_{-2,j} = d_{1,-j} = d_{*1-j} = d_{*-2,j} = 0 \), and hence \( d_{0,-j}^* = \frac{N_{-j}}{x_2} \).

Turning to group \( j \), equation (31) holds when \( i_j = 1 \). In what follows, I denote \( Z_j^* = \frac{1}{\omega_j} \) and \( B_j^* = \frac{\delta_j + \nu_j}{\alpha_j \omega_j} \).
I distinguish two subcases according to the value of \( \chi_j \):

- If \( \chi_j = 0 \), I get \( d_{0j}^* = \frac{N}{2} B_j^f \), \( d_{-1j}^* = N_j i_j^* \), \( d_{-2j}^* = 0 \) and \( i_j^* = \frac{1}{2}(1 - \frac{N}{N_j} B_j^f) \). In this case, \( B_j^f < \frac{N_j}{N} \) is a sufficient condition to guarantee that \( i_j^* > 0 \) and \( d_{0j}^* < \frac{N_j}{2} \). In other words, this steady-state is defined if the separation rate associated to informal jobs is not to high compared to the probability to find an informal job.

- If \( \chi_j = 1 \), \( d_{0j}^* \) solves \( \Gamma_I(d_{0j}^*) = 0 \), where \( \Gamma_I(x) \) is the following second order polynomial:

\[
- \frac{Z_j^I}{B_j^f} x^2 - \frac{N}{2}(N_j + Z_j^I) x + \left( \frac{NB_j^f}{2} \right)^2 = 0
\]

By symmetry with case (ii) there exists a unique \( d_{0j}^* \) such that \( 0 < d_{0j}^* < \frac{N_j}{2} \) and \( \Gamma_I(d_{0j}^*) = 0 \), if and only if \( B_j^f < x_j(\omega) \), where \( x_j(\omega) \) is the unique positive root of the third order polynomial: \( T_I(x) = -Z_j^I N_j - (N_j + N Z_j^I) N_j x + N_j N^2 x^3 \). As before, that \( d_{0j}^* < \frac{N_j}{2} \) ensures that \( i_j^* > 0 \).

(\textit{vi}) If \( f_j^* > 0 \), \( f_{-j}^* = 0 \), \( i_j^* > 0 \) and \( i_{-j}^* = 0 \), \( \forall j \in \{ W, B \} \), equations \text{30} and \text{31} for group \(-j\) are verified for \( \phi_j = 0 \) and \( \forall \psi_{-j}, \chi_{-j} \in \{ 0, 1 \} \) and I have \( d_{0j}^* = \frac{N_j}{2} \).

For group \( j \), I must have \( \phi_j = \psi_j = 1 \). In what follows, I keep the notations \( B_j^F, B_j^I, Z_j^F \) and \( Z_j^I \) defined previously. I distinguish two subcases:

- If \( \chi_j = 0 \), I get \( d_{0j}^* = \frac{1}{2}N B_j^I \), \( N_j i_j^* = \frac{1}{2}N_j + \frac{Z_j^I B_j^I (B_j^F - B_j^I) (B_j^F - B_j^I)^2}{B_j^I} \) and \( N_j f_j^* = \frac{(B_j^F)^2}{B_j^I} - Z_j^F - B_j^I \).

- If \( \chi_j = 1 \), \( d_{0j}^* \) solves \( \Gamma_M(d_{0j}^*) = 0 \) where \( \Gamma_M \) is the following second order polynomial:

\[
\Gamma_M(x) = -(1 + \frac{Z_j^I}{B_j^I} + \frac{Z_j^F}{B_j^F}) x^2 - \frac{N}{2} \left( N_j + Z_j^I + Z_j^F \right) x + \frac{N^2}{2} \left( (B_j^I)^2 + (B_j^F)^2 \right) = 0
\]

I now show that there exists a unique \( d_{0j}^* \) such that \( 0 < d_{0j}^* < \frac{N_j}{2} \) and \( \Gamma_M(d_{0j}^*) = 0 \). I have \( \Gamma_M(0) > 0 \), \( x_0 < 0 \), where \( x_0 \) is defined as \( \Gamma_M(x_0) = 0 \), and \( \Gamma_M(0) < 0 \), so \( \Gamma_M(x) \) has a unique positive root. This root will be smaller than \( \frac{N_j}{2} \) if and only if

\[
\Gamma_M(\frac{N_j}{2}) = \frac{1}{4} - (1 + \frac{Z_j^I}{B_j^I} + \frac{Z_j^F}{B_j^F}) \frac{N_j^2}{2} - N(\frac{N_j}{N} + Z_j^I + Z_j^F) N_j + N^2((B_j^I)^2 + (B_j^F)^2) < 0
\]

which is equivalent to \( \Upsilon_M(B_j^I) < 0 \), where \( \Upsilon_M(x) = -Z_j^I N_j^2 B_j^F - [Z_j^I N_j^2 B_j^F - B_j^F (NN_j(Z_j^I + Z_j^F) + 2N_j^2 + N^2(B_j^F)^2)]x + N^2 B_j^F x^3 \). I now show that \( \Upsilon_M(x) \) has a unique positive real root, that I will denote \( x_M(\omega) \).

The first derivative of this polynomial is given by \( \Upsilon_M'(x) = 3N^2 B_j^F x^2 + 2N^2 B_j^F x + N^2((B_j^I)^2 + (B_j^F)^2) \).

If \( Z_j^F N_j^2 > B_j^F (NN_j(Z_j^I + Z_j^F) + 2N_j^2 + N^2(B_j^F)^2) \), then \( \Upsilon_M'(x) > 0 \). In addition, as \( \Upsilon_M(0) < 0 \), I deduce that \( \Upsilon_M \) has a unique positive root.

Else, if \( Z_j^F N_j^2 < B_j^F (NN_j(Z_j^I + Z_j^F) + 2N_j^2 + N^2(B_j^F)^2) \), then the discriminant of this second order equation is strictly positive, and \( \Upsilon_M(x) \) has one negative and one positive real root, denoted \( x_{M1} \) and \( x_{M2} \) respectively. Given that \( \Upsilon_M(0) < 0 \), I deduce that \( \Upsilon_M(x) \) is continuously decreasing \( \forall x \in [x_{M1}, x_{M2}] \) (in particular \( \forall x \in [0, x_{M2}] \), and continuously increasing \( \forall x > x_{M2} \). Finally, as \( \Upsilon_M(0) < 0 \), I can infer that \( \Upsilon_M(x) \) has a unique positive real root, \( x_M(\omega) \).

To conclude, there exists a unique \( d_{0j}^* \) such that \( 0 < d_{0j}^* < \frac{N_j}{2} \) and \( \Gamma_M(d_{0j}^*) = 0 \), if and only if \( B_j^f < x_M(\omega) \).

(\textit{vii}) If \( f_j^* > 0 \), \( \forall j \in \{ W, B \} \), \( i_j^* > 0 \) and \( i_{-j}^* = 0 \), I must have \( \phi_j = 1, \phi_{-j} = 1, \psi_j = 1 \) and \( \psi_{-j}, \chi_{-j} \in \{ 0, 1 \} \).
As in case (iii), the formal employment rate of each group enters in both groups’ $d_0$ dyads, so I cannot analyze this steady-state separately for each group. The relationship (18) characterizing $f^*_j$, $\forall j$ as a function of $d^*_0$, still holds for both groups. For group $-j$ which does not take part in the informal labor market, I have the same relationships as in case (iii).42 Then, for group $j$, I have two different cases:

* if $\chi_j = 0$, $f^*_j$ is defined by the following relationship:

$$f^*_j = \frac{N}{N_j} \frac{B^j_i}{(B^j_i)^2} (Z^F + B^j_j + \frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) (\frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j)$$

* if $\chi_j = 1$, $f^*_j$ is defined by the following relationship:

$$f^*_j = (B^j_i)^2 (Z^F + B^j_j + \frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) (\frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j)$$

\[ (B^j_i)^2 + (B^j_i)^2 (Z^F + 2B^j_j + \frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) (\frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) + (B^j_i)^2 (Z^j_j + 2B^j_j + \frac{N_j}{N} i^*_j) \frac{N_j}{N} i^*_j \]

(viii) No formal sector steady state: if $f^*_j = 0$ and $i^*_j > 0$, $\forall j \in \{W, B\}$, equations (30) and (31) hold $\forall \phi_j, \phi_{-j}, \chi_j, \chi_{-j} \in \{0, 1\}$ and require that $\psi_j = 1$, $\forall j$. This case is very simple since the only market is the informal one where communication about job offers occur within groups only. I can directly apply the results of case (iv) to both groups:

* If $\chi_j = 0$, $d^*_0 = \frac{N}{N_j} B^j_i$, and $i^*_j = \frac{1}{2} (1 - \frac{N}{N_j} B^j_i)$, $\forall j \in \{W, B\}$

* If $\chi_j = 1$, $d^*_0$ solves equation (34), $\forall j \in \{W, B\}$.

Note that in this steady-state, the two groups differ in their size and in their intra-group level of trust, both parameters affecting their chance to hear about a job opportunity in the informal sector. Then, as whites is the majority group, it is likely that their informal employment rate will be higher than blacks’, and that black’s will in turn face higher unemployment rate. This could be reversed if whites’ relative intra-group trust was very low.

(ix) $f^*_j > 0$, $f^*_j > 0$ and $i^*_j > 0$, $\forall j \in \{W, B\}$. For equations (30) and (31) to hold, I must have $\phi_j = 1$, $\phi_{-j} = 0$ and $\psi_j = 1$, $\forall j$. Here, I am back to cases (v) and (vi) for group $j$ and $-j$ respectively, and I have:

* If $\chi_j = 0$, $\frac{N}{N_j} f^*_j = \frac{(B^F_i)^2}{B^j_i} - Z^F - B^j_i$, $\frac{N_j}{N} i^*_j = \frac{1}{2} \frac{N}{N_j} + \frac{Z^F B^j_i (B^F_i + B^j_i) - (B^F_i)^2}{B^j_i B^F_i}$ and $i^*_j = \frac{1}{2} (1 - \frac{N}{N_j} B^j_i)$.

* If $\chi_j = 1$, $d^*_0$ solves equation (35) while $d^*_{-j}$ solves equation (34).

(x) Mixed steady-state: if $f^*_j > 0$ and $i^*_j > 0$, $\forall j \in \{W, B\}$: equations (30) and (31) require that $\phi_j = 1$ and $\psi_j = 1$, $\forall j$. Then, I have, as in case (vii), $\forall j \in \{W, B\}$:

* if $\chi_j = 0$, $f^*_j$ is defined by the following relationship:

$$f^*_j = \frac{N}{N_j} \frac{B^j_i}{(B^j_i)^2} (Z^F + B^j_j + \frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) (\frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j)$$

* if $\chi_j = 1$, $f^*_j$ is defined by the following relationship:

$$f^*_j = \frac{(B^j_i)^2 (Z^F + B^j_j + \frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) (\frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j)}{(B^j_i)^2 + (B^j_i)^2 (Z^F + 2B^j_j + \frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) (\frac{N_j}{N} f^*_j + \beta \frac{N-j}{N} f^*_j) + (B^j_i)^2 (Z^j_j + 2B^j_j + \frac{N_j}{N} i^*_j) \frac{N_j}{N} i^*_j}$$

Note however, that even if the relationships are the same than in case (vii), the values of $f^*_j$ and $i^*_j$ will be different, as now both groups take part in the informal sector.

**Proof of proposition 2:**

I assume that $w_F (1 - t) > b$. Using equations (20), (21), and (22), I now provide the conditions for the different values of the choice variables to arise in equilibrium.

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42 Note however that the equilibrium values will be different as group $j$ now participates in the informal market, so the value of the equilibrium formal employment rate of group $j$ is not the same here and in case (iii).
In what follows, I will denote \( w_F(1-t) \) as \( w_F \) and \( w_I(1-p_f) \) as \( w_I \) for a matter of space saving.

I also introduce the following notations:
- \( q_i^F(\phi_j, \psi_j, \chi_j, \phi_{-j}, \psi_{-j}, \chi_{-j}) = q_i^F(f_j(\phi_j, \psi_j, \chi_j, \phi_{-j}, \psi_{-j}, \chi_{-j}), f_{-j}(\phi_{-j}, \psi_{-j}, \chi_{-j}, \phi_j, \psi_j, \chi_j)) \), and
- \( q_i^F(\phi_j, \psi_j, \chi_j, \phi_{-j}, \psi_{-j}, \chi_{-j}) = q_i^F([i_j(\phi_j, \psi_j, \chi_j, \phi_{-j}, \psi_{-j}, \chi_{-j})]) \), to indicate the values of the choice variables in equilibrium.

**Case (i)** The full unemployment steady-state \((f_j^* = 0 \text{ and } i_j^* = 0, \forall j \in \{W, B\})\) exists \(\forall \phi_j, \psi_j, \chi_j \in \{0, 1\}, \forall j \in \{W, B\}\).

Given the assumption \( w_F(1-t) > b \), I cannot have \( \phi_j = 0 \), which requires that \((r + \delta_I + p)|w_F - b| < 0 \).

So this steady-state cannot arise in equilibrium for \( \phi_j = 0, \forall j \in \{W, B\} \).

The condition for \( \phi_j = 1 \) when \( i_j^* = i_{-j}^* = 0 \) is given by: \((r + \delta_I + p)|w_F - b| > 0 \), equivalent to \( w_F \geq b \), which is always true. Note that the condition for \( \phi_{-j} = 1 \) is exactly the same, hence I cannot have \( \phi_j \neq \phi_{-j} \).

I then consider two different cases according to the value of \( \psi_j \):
- If \( \psi_j = 1 \) requires that \((r + \delta_F)|w_I - b| > 0 \) as \( f_j^* = f_{-j}^* = 0 \), equivalent to \( w_I \geq b \). Note that \( \lambda = \chi = 1 \). Combining what precedes, I can state that the full unemployment steady-state \((i)\) arises with \( \phi_j = \psi_j = \chi_j = 1, \forall j \in \{W, B\} \), if \( b \leq \min\{w_F, w_I\} \).
- If \( \psi_j = 0 \) requires that \((r + \delta_F)|w_I - b| < 0 \), equivalent to \( w_I(1-pf) < b \). This implies that \( \lambda = \chi - 1 \). Combining what precedes, I can state that the full unemployment steady-state \((i)\) arises with \( \phi_j = \psi_j = \chi_j = 0, \forall j \in \{W, B\} \) if \( w_I < b \leq w_F \).

To summarize, the full-unemployment steady-state \((i)\) always arises in equilibrium:
- if \( w_F > w_I \), \((i)\) arises in equilibrium:
  - if \( b \leq w_I \) with \( \phi_j = \psi_j = \chi_j = 1, \forall j \in \{W, B\} \),
  - or if \( w_I < b \leq w_F \), with \( \phi_j = 1, \psi_j = \chi_j = 0, \forall j \in \{W, B\} \).
- if \( w_F \leq w_I \), \((i)\) arises in equilibrium if \( b \leq w_F \), with \( \phi_j = \psi_j = \chi_j = 1, \forall j \in \{W, B\} \).

**Case (ii)** The steady-state where one group is fully unemployed while the other takes part in the formal labor market only \((f_j^* > 0, i_j^* = 0, \forall j \in \{W, B\})\) exists for \( \phi_j = \phi_{-j} = 1 \), and \( \forall \psi_j, \chi_j \in \{0, 1\}, \forall j \in \{W, B\} \). The condition for \( \phi_j = 1 \) is always satisfied as \( i_j^* = 0, \forall j \in \{W, B\} \). I consider six different cases:
- If \( \psi_j = \chi_j = 1, \forall j \in \{W, B\} \): the conditions for \( \lambda = \chi \) and \( \psi \) are respectively given by \( b \leq w_I \) and \( b \leq w_F - q_e^{(1,1,1,1,1)}(w_F - w_I), \forall j \).

  Combining with the condition on \( \phi_j \), I get the following condition:
  - if \( w_I < w_F \), \( w_I - q_e^{(1,1,1,1,1)}(w_F - w_I) \mid (r+\delta_F) \) \( w_F - w_I \) \( \leq 0 \), I need \( w_F < w_I \).
  - if \( w_F < w_I \), \( w_I - q_e^{(1,1,1,1,1)}(w_F - w_I) \mid (r+\delta_F) \) \( w_F - w_I \) \( \leq 0 \), I need \( w_F < w_I \), which is not possible.

Finally, if \( f_j^* > 1 \), \( f_j^* = \beta N_j f_j^* < \lambda \frac{\delta F}{\delta t} \) is the minimum, where \( j \) is such that:
- \( N_j f_j^* + \beta N_j f_j^* < \lambda \frac{\delta F}{\delta t} \).

---

43 This is due to the fact that job offers goes only through the network, i.e. that there is no exogenous job offer.
44 This is most likely to be the case for \( j = B \) and \( j = W \). Indeed, in this case, \( \frac{\lambda_B}{\lambda_W} \geq 1 \), and hence is the most likely to hold for \( j = B \) and \( j = W \).
• Case \( \psi_j = 1 \) and \( \chi_j = 0 \), \( \forall j \in \{W, B\} \): the condition becomes:

\[
 w_I < b \leq \min\{w_F, w_I - \frac{q_F^j(1, 1, 0, 1, 0, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I), \forall j \}
\]

I know from the previous case that \( w_I < w_I - \frac{q_F^j(1, 1, 0, 1, 1, 0)\lambda_j}{(r + \delta_F)}(w_F - w_I) \) requires \( w_F < w_I \), so I get a contradiction.

• Case \( \psi_j = 0 \) and \( \chi_j = 1 \), \( \forall j \in \{W, B\} \): all the conditions put together give:

\[
 \max\{w_I - \frac{q_F^j(1, 0, 1, 1, 0, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I), \forall j \} < b \leq \min\{w_F, w_I\}
\]

Any term on the left hand side (LHS) being lower than any term on the right hand side (RHS) requires that \( w_F > w_I \), and hence the minimum term on the RHS is \( w_I \). Then, using the previous case, I know that \( w_I - \frac{q_F^j(1, 0, 1, 1, 1, 0)\lambda_j}{(r + \delta_F)}(w_F - w_I) \) is the maximum on the LHS if \( j \) is such that \( \frac{N_j f_j^* + \beta N_j f_j^*}{N_j f_j^* + \beta N_j f_j^*} < \frac{\lambda_j}{\lambda_j} \). The previous condition hence reduces to \( w_I - \frac{q_F^j(1, 0, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq w_I \)

• Case \( \psi_j = 0 \) and \( \chi_j = 0 \), \( \forall j \in \{W, B\} \), the conditions are now given by:

\[
 \max\{w_I, w_I - \frac{q_F^j(1, 0, 1, 0, 1, 0)\lambda_j}{(r + \delta_F)}(w_F - w_I), \forall j \} < b \leq w_F
\]

I know from what preceded that when \( w_F > w_I \), then \( w_I - \frac{q_F^j(1, 0, 1, 0, 0)\lambda_j}{(r + \delta_F)}(w_F - w_I) < w_I \). Hence \( w_I \) is the maximum on the LHS, and the previous condition unravels to \( w_I < b \leq w_F \).

• Case \( \psi_j = 1 \), \( \psi_j - j = 0 \) and \( \chi_j = 1 \), \( \forall j \in \{W, B\} \) leads to the following condition:

\[
 w_I - \frac{q_F^j(1, 0, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq \min\{w_I, w_F, w_I - \frac{q_F^j(1, 1, 1, 0, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I)\}
\]

which unravels to \( w_I - \frac{q_F^j(1, 0, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) \) when \( w_F > w_I \) and \( j \) is such that \( \frac{N_j f_j^* + \beta N_j f_j^*}{N_j f_j^* + \beta N_j f_j^*} < \frac{\lambda_j}{\lambda_j} \).

• Case \( \psi_j = 1 \), \( \psi_j - j = 0 \) and \( \chi_j = 0 \), \( \forall j \in \{W, B\} \) leads to a contradiction and hence cannot arise.

To summarize, steady-state (iii) arises in equilibrium:

- If \( w_F > w_I \):
  - if \( b \leq w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) \), where \( j \) is such that \( \frac{N_j f_j^* + \beta N_j f_j^*}{N_j f_j^* + \beta N_j f_j^*} < \frac{\lambda_j}{\lambda_j} \), \( \phi_j = \psi_j = \chi_j = 1 \), \( \forall j \in \{W, B\} \),
  - or if \( w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq w_I \), where \( j \) is such that \( \frac{N_j f_j^* + \beta N_j f_j^*}{N_j f_j^* + \beta N_j f_j^*} < \frac{\lambda_j}{\lambda_j} \), \( \phi_j = 1 \), \( \psi_j = 0 \) and \( \chi_j = 1 \), \( \forall j \in \{W, B\} \),
  - or if \( w_F < b \leq w_F \), with \( \phi_j = 1 \), \( \psi_j = 0 \) and \( \chi_j = 0 \), \( \forall j \in \{W, B\} \),
  - or if \( w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) \) when \( w_F > w_I \) and \( j \) is such that \( \frac{N_j f_j^* + \beta N_j f_j^*}{N_j f_j^* + \beta N_j f_j^*} < \frac{\lambda_j}{\lambda_j} \), \( \psi_j = 1 \), \( \psi_j - j = 0 \) and \( \chi_j = 1 \), \( \forall j \in \{W, B\} \).
- If \( w_F \leq w_I \), if \( b \leq w_F \) with \( \phi_j = \psi_j = \chi_j = 1 \), \( \forall j \in \{W, B\} \), which is always true.

In this steady-state, there is no informal employment, so the formal employment rates in equilibrium will only depend on the decision to participate in the formal economy (\( \phi_j \) and \( \phi_j - j \)), and will not be affected by the values of the other choice variables. Hence \( q_F^j(1, 1, 1, 1, 1, 1) = q_F^j(1, 0, 1, 1, 1, 1) = q_F^j, \) and

\[45\] Following footnote 44, this is most likely: \( b \leq w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) \)

\[46\] Following footnote 44, this is most likely: \( w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq w_I \)

\[47\] Following footnote 44, this is most likely: \( w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) < b \leq w_I - \frac{q_F^j(1, 1, 1, 1, 1, 1)\lambda_j}{(r + \delta_F)}(w_F - w_I) \)
\( q^F_j(1,0,1,1,0,1) = q^F_j(1,1,1,1,0,1) = q^F_j. \) As a consequence, when \( w_F > w_I \), I have the following ranking:

\[
\frac{q^F_j}{(r + \delta_I + p)}(w_F - w_I) < w_I - \frac{q^F_j \lambda_j}{(r + \delta_I + p)}(w_F - w_I) < w_I < w_F, \text{ where } \frac{N_j f_j + \beta N_j f_j}{N_j f_j} < \frac{\lambda_j}{\lambda_i}, \text{ and so I can conclude that steady state (iii) always arises in equilibrium.}
\]

**(iv)** The steady-state where one group is fully unemployed while the other takes part in the informal labor market only \((f^*_j = 0, \ i^*_j > 0, \ f^*_j > 0, \ i^*_j = 0, \ \forall j \in \{B, W\})\) exists for \( \psi_j = 1 \) and \( \forall \phi_j, \phi_{-j}, \psi_{-j}, \chi_j, \chi_{-j} \in \{0, 1\} \). First, I can see that as \( i^*_j = 0 \), the RHS in the condition for \( \phi_{-j} \) (equation \( 21 \)) is zero, and given the assumption that \( w_F > b \), I must have \( \phi_{-j} = 1 \). Second, I can note that as \( f^*_j = f^*_j = 0 \), the RHS in the condition for \( \psi_j \) (equation \( 22 \)) is also equal to zero, so that I cannot have \( \psi_j = \psi_{-j} \). Then, the condition for \( \psi_j = \psi_{-j} = 1 \) is equivalent to \( w_I \geq b \), which in turn imposes that \( \chi_j = \chi_{-j} = 1 \) (see equation \( 20 \)). I finally study two cases according to the value of \( \phi_j \):

- **Case \( \phi_j = 1 \):** the conditions for \( \phi_j = \phi_{-j} = \psi_j = \psi_{-j} = \chi_j = \chi_{-j} = 1 \) can be summarized as follows:

\[
b \leq \min\{w_I, w_F, w_F - \frac{q^I_j(1,1,1,1,1,1)}{(r + \delta_I + p)}(w_I - w_F)\}
\]

It is easily checked that either \( w_I \) is the minimum, or it is \( w_F - \frac{q^I_j(1,1,1,1,1,1)}{(r + \delta_I + p)}(w_I - w_F) \) when \( w_I \geq w_F \).

- **Case \( \phi_j = 0 \):** the conditions become:

\[
w_F - \frac{q^I_j(0,1,1,1,1,1)}{(r + \delta_I + p)}(w_I - w_F) < b \leq \min\{w_I, w_F, \}
\]

It is easily checked that for the LHS to be lower than any of the RHS terms, I must have \( w_I \geq w_F \).

To summarize, steady-state (iv) arises in equilibrium:

- when \( w_F > w_I \): if \( b \leq w_I \), with \( \phi_j = \psi_j = \chi_j = 1, \forall j \)
- when \( w_F \leq w_I \):
  - if \( b \leq w_F - \frac{q^I_j(1,1,1,1,1,1)}{(r + \delta_I + p)}(w_I - w_F) \), with \( \phi_j = \psi_j = \chi_j = 1, \forall j \)
  - or if \( w_F - \frac{q^I_j(0,1,1,1,1,1)}{(r + \delta_I + p)}(w_I - w_F) < b \leq w_F \), with \( \phi_j = 0, \phi_{-j} = 1 \) and \( \psi_j = \chi_j = 1, \forall j \).

In this steady-state, there is no formal employment, so the informal employment rates in equilibrium will only depend on the decisions to participate in the informal economy (\( \psi_j, \psi_{-j} \) and \( \chi_j, \chi_{-j} \)), and will not be affected by the values of the other choice variable. Hence \( q^I_j(1,1,1,1,1,1) = q^I_j(0,1,1,1,1,1) = q^I_j \). As a consequence, when \( w_F \leq w_I \), I have \( w_F - \frac{q^I_j}{(r + \delta_I + p)}(w_I - w_F) < w_F \), and so steady state (iv) always arises in equilibrium (when \( w_F \leq w_I \)).

**(v)** The steady-state where one group is fully employed while the other work on both formal and informal markets, \((f^*_j > 0, \ i^*_j > 0, f^*_j > 0, \ i^*_j = 0, \ \forall j \in \{W, B\})\) exists for \( \phi_j = 1, \phi_{-j} = 0, \psi_j = 1, \) and \( \forall \psi_{-j}, \chi_j, \chi_{-j} \in \{0, 1\} \). Given that \( i^*_j = 0 \), the condition for \( \phi_{-j} = 0 \) cannot be satisfied under the assumption that \( w_F > b \). So this steady-state never arises in equilibrium.

**(vi)** The steady-state where one group specializes in the formal economy while the other specializes in the informal economy \((f^*_j = 0, \ i^*_j > 0, \ f^*_j > 0, \ i^*_j = 0, \ \forall j \in \{W, B\})\) exists for \( \phi_j = 0, \phi_{-j} = 1, \psi_j = 1, \) and \( \forall \psi_{-j}, \chi_j, \chi_{-j} \in \{0, 1\} \). Note that the condition for \( \psi_j = 1 \) is equivalent to \( w_I \geq b \) as \( \phi_j = 0 \), and implies that \( \chi_j = \chi_{-j} = 1 \). I then have two cases according to the value of \( \psi_j \):

- **Case \( \psi_j = 1 \):** the conditions for \( \phi_j = 0, \phi_{-j} = \psi_j = \psi_{-j} = \chi_j = \chi_{-j} = 1 \) can be summarized as follows:

\[
w_F - \frac{q^I_j(0,1,1,1,1,1)}{(r + \delta_I + p)}(w_I - w_F) < b \leq \min\{w_I, w_F, w_I - \frac{q^I_j(1,1,1,0,1,1)}{(r + \delta_I + p)}(w_F - w_I)\}
\]

For the LHS to be inferior to any of the three RHS term, I need \( w_I \geq w_F \). Then it is easily checked that \( w_F \) is the minimum of the RHS.

- **Case \( \psi_j = 0 \):** the conditions for \( \phi_j = \psi_j = 0, \phi_{-j} = \psi_j = \chi_j = \chi_{-j} = 1 \) can be summarized as
follows:

$$\max \left\{ w_I - q_{j} f_j(1,1,1,0,1,1) \lambda_{-j} \left( w_F - w_I \right), w_F - q_{j} f_j(1,0,1,1,1,1) \left( w_I - w_F \right) \right\} < b \leq \min \{ w_I, w_F \}$$

As in the previous case, I need $w_I \geq w_F$ so that $w_F - q_{j} f_j(1,0,1,1,1,1) \left( w_I - w_F \right)$ can be lower than any of the two terms in the RHS. However, $w_I - q_{j} f_j(1,1,1,0,1,1) \lambda_{-j} \left( w_F - w_I \right)$ is the minimum when $w_I < w_F$. I get a contradiction.

To summarize, steady-state $(w_I)$ arises when $w_I \geq w_F$, if $w_F - q_{j} f_j(1,0,1,1,1,1) \left( w_I - w_F \right) < b \leq w_F$, with $\phi_j = 0$, and $\psi_{-j} = \psi_j = \psi_{-j} = \chi_j = \chi_{-j} = 1$.

(vii) Steady-states where one group is involved in both sectors, while the other works in the formal sector only ($f_j^* > 0$, $f_{-j}^* > 0$, and $i_j^* = 0, i_{-j}^* = 0, \forall j \in \{W, B \})$, exist for $\phi_j = \phi_{-j} = \psi_j = 1$ and $\forall \psi_{-j}, \chi_j, \chi_{-j} \in \{0, 1 \}$. I distinguish four different possible cases according to the value of $\psi_{-j}$ and $\chi_j, \chi_{-j}$:

* Case $\psi_{-j} = \chi_j = \chi_{-j} = 1$: the conditions for $\phi_j = \phi_{-j} = \psi_j = \psi_{-j} = \chi_j = \chi_{-j} = 1$ go down to:

$$b \leq \min \left\{ \frac{w_I}{w_F - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j}} \left( w_F - w_I \right), w_I - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right) \right\}, \forall j$$

Suppose that $w_I$ is the minimum. Then I have $w_I \leq w_F - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$, which requires that $w_F \leq w_I$, hence a contradiction. The same argument applies for $w_F$ with $w_F - q_{j} f_j(1,1,1,1,1,1) \left( w_I - w_F \right)$. In the end, I find that $w_F - q_{j} f_j(1,1,1,1,1,1) \left( w_I - w_F \right)$ is the minimum when $w_I \geq w_F$, and $w_I - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$ is the minimum when $w_I < w_F$. In this case, $j$ is such that $\frac{N_j f_j^* + \beta N_j f_{-j}^*}{N_j f_j^* + \beta N_j f_{-j}^*} \lambda_{-j} < \lambda_j$.

* Case $\psi_{-j} = 1$ and $\chi_j = \chi_{-j} = 0$: I must have $w_I < b \leq \min \left\{ \frac{w_F}{w_F - q_{j} f_j(1,1,0,1,1,0) \lambda_{-j}} \left( w_F - w_I \right), w_I - q_{j} f_j(1,1,0,1,1,0) \lambda_{-j} \left( w_F - w_I \right) \right\}, \forall j$

As above, I cannot have $w_I \leq w_F - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$ and $w_F < w_I$ at the same time, hence a contradiction.

* Case $\psi_{-j} = 0$ and $\chi_j = \chi_{-j} = 1$: $w_I - q_{j} f_j(1,0,1,1,1,1) \left( w_F - w_I \right) < b \leq \min \left\{ \frac{w_F}{w_F - q_{j} f_j(1,1,1,0,1,0) \lambda_{-j}} \left( w_F - w_I \right), w_I - q_{j} f_j(1,1,1,0,1,0) \lambda_{-j} \left( w_F - w_I \right) \right\}$.

From the first subcase above, I know that for the LHS to be smaller than any of the four terms in the RHS I need $w_I < w_F$. Knowing that and from the first subcase above, I deduce that the minimum term on the RHS is $w_I - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$, and the previous condition unravels to $w_I - q_{j} f_j(1,0,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right) < b \leq w_I - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$. This further imposes that $\frac{N_j f_j^* + \beta N_j f_{-j}^*}{N_j f_j^* + \beta N_j f_{-j}^*} \lambda_{-j} < \lambda_j$.

* Case $\psi_{-j} = \chi_j = \chi_{-j} = 0$: $w_I - q_{j} f_j(1,0,1,0,1,0) \lambda_{-j} \left( w_F - w_I \right) < b \leq \min \left\{ \frac{w_F}{w_F - q_{j} f_j(1,1,1,1,1,0) \lambda_{-j}} \left( w_F - w_I \right), w_I - q_{j} f_j(1,1,1,1,1,0) \lambda_{-j} \left( w_F - w_I \right) \right\}$.

I cannot have $w_I < w_F$ and $w_I < w_F - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$ at the same time.

To summarize, steady-state $(w_I)$ arises in equilibrium:

- if $b \leq w_I - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$, with $\phi_j = \psi_j = \chi_j = 1$, $\forall j$, 48

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48Following footnote 44, this is most likely: $b \leq w_I - q_{j} f_j(1,1,1,1,1,1) \lambda_{-j} \left( w_F - w_I \right)$.
ψ be affected by the values of the other choice variable. Hence, $\psi_j = 1$,
$\psi_{-j} = 0$ and $\chi_j = \chi_{-j} = 1,
where group $j$ is characterized by $N_j f_{j}^{\tau} + \beta N_{-j} f_{j}^{\tau} < \frac{\lambda_{-j}}{\lambda_j}$, in both above subcases.

$\omega$when $w_F \leq w_I$: if $b \leq w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)$, with $\phi_j = \psi_j = \chi_j = 1, \forall j$.

In this steady-state, group $-j$ does not participate in the informal economy, so the formal employment rates in equilibrium will not depend on $\psi_{-j}$. In other words, $q_{F_{-j}}(1,1,1,1,1) = q_{F_{-j}}(1,0,1,1,1,1) = q_{F_{-j}}^{1}$. As a consequence, when $w_F > w_I$, steady state (vii) arises in equilibrium as long as $b \leq w_I - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_F - w_I)$, with $j$ is such that $N_j f_{j}^{\tau} + \beta N_{-j} f_{j}^{\tau} < \frac{\lambda_{-j}}{\lambda_j}$,

It is worth noting here that I am most likely to be in a situation where $-j$ corresponds to white and $j$ refers to blacks (see footnote 44), which implies that in this equilibrium, it is more likely that whites take part in the formal sector only, while blacks also engage in the informal economy.

(\textit{viii}) The no formal sector steady state ($f_{j}^{\tau} = 0$ and $i_{j}^{\tau} > 0, \forall j \in \{W, B\}$) exists $\exists \phi_j, \phi_{-j} \in \{0,1\}$, for $\psi_j = \psi_{-j} = 1$ and $\forall \chi_j, \chi_{-j} \in \{0,1\}$. Note that as $f_{j}^{\tau} = f_{j}^{\tau} = 0$, the condition for $\psi_j = 1, \forall j$ is equivalent to $w_I \geq b$, which imposes that $\psi_j = 1, \forall j$. I consider three possible cases:

$\star$ Case $\phi_j = \phi_{-j} = 1$ and $\psi_j = \chi_j = 1, \forall j$, sums up to $b \leq \min\{w_I, w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F), \forall j\}$.

It is easily checked that $w_F$ cannot be the minimum, and that $w_I$ is the minimum of the RHS terms when $w_F > w_I$, while $w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)$ is the minimum when $w_F \leq w_I$, with $j$ such that \(t_j N_j i_{j}^{\tau} \geq t_{-j} N_{-j} i_{-j}^{\tau}\).

$\star$ Case $\phi_j = 0, \phi_{-j} = 1$ and $\psi_j = \chi_j = 1, \forall j$: the conditions can be summarized as:

$$w_F - \frac{q_{F}(0,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F) < b \leq \min\{w_I, w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)\}$$

I know from the previous subcase that I must have $w_F \leq w_I$ to ensure that the LHS is smaller than any term in the RHS, and $j$ satisfies $t_j N_j i_{j}^{\tau} \geq t_{-j} N_{-j} i_{-j}^{\tau}$. It is also direct from the previous case that $w_F - \frac{q_{F}(0,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)$ is the smallest term on the RHS.

$\star$ Case $\phi_j = \phi_{-j} = 0$ and $\psi_j = \chi_j = 1, \forall j$: $\max\{w_F - \frac{q_{F}(0,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F), \forall j\} < b \leq \min\{w_I, w_F\}$.

As in the previous cases, this inequality holds for $w_F \leq w_I$, and $w_F - \frac{q_{F}(0,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F) < w_F - \frac{q_{F}(0,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)$ is true if and only if $j$ satisfies $t_j N_j i_{j}^{\tau} \geq t_{-j} N_{-j} i_{-j}^{\tau}$.

To summarize, steady-state (\textit{viii}) arises in equilibrium:

$\circ$ when $w_F > w_I$: if $b \leq w_I$, with $\phi_j = \psi_j = \chi_j = 1, \forall j$.

$\circ$ when $w_F \leq w_I$:

- if $b \leq w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)$, with $\phi_j = \psi_j = \chi_j = 1, \forall j$,

- or if $w_F - \frac{q_{F}(0,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F) < b \leq w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F)$, with $\phi_j = 0, \phi_{-j} = 1$ and $\psi_j = 1, \forall j$,

where $j$ satisfies $t_j N_j i_{j}^{\tau} \geq t_{-j} N_{-j} i_{-j}^{\tau}$ in all three subcases above.

In this steady-state, there is no formal employment, so the informal employment rates in equilibrium will only depend on the decisions to participate in the informal economy ($\psi_j, \psi_{-j}$ and $\chi_j, \chi_{-j}$), and will not be affected by the values of the other choice variable. Hence $q_{F_j}(1,1,1,1,1) = q_{F_j}(0,1,1,1,1) = q_{F_j}^{1}$, and $q_{F_{-j}}(1,1,1,0,1,1) = q_{F_{-j}}(0,1,1,0,1,1) = q_{F_{-j}}^{1}$. As a consequence, when $w_F \leq w_I$, I have $w_F - \frac{q_{F}(1,1,1,1,1)}{(r+\delta_f+p)} (w_I - w_F) < w_F - \frac{q_{F}(1,1,1,0,1,1)}{(r+\delta_f+p)} (w_I - w_F)$, and so steady state (\textit{viii}) always arises in equilibrium (when $w_F \leq w_I$).

\footnote{Following footnote 44, this is most likely: $w_I - \frac{q_{F}(1,0,1,1,1,1)\lambda_{W}}{(r+\delta_f+p)} (w_F - w_I) < b \leq w_I - \frac{q_{F}(1,1,1,1,0,1)\lambda_{B}}{(r+\delta_f+p)} (w_F - w_I)$.}
\((ix)\) Steady-states where one group is involved in both sectors, while the other works in the informal sector only \((f_j^* > 0, i_j^* > 0, f_{-j}^* = 0 \text{ and } i_{-j}^* > 0, \forall j \in \{W, B\})\), exist for \(\phi_j = 1, \psi_{-j} = 0, \psi_j = \psi_{-j} = 1\) and \(\forall \chi_j, \chi_{-j} \in \{0, 1\}\). Note first that as \(\phi_{-j} = 0\), the condition for \(\psi_{-j} = 1\) is equivalent to \(w_I \geq b\), which implies that \(\chi_j = \chi_{-j} = 1\). Combining the conditions for those different values to arise, I get the following condition:

\[
 w_I - \frac{q^f_J(1,1,1,1,0,1,1)}{(r + \delta_I + p)} (w_I - w_F) < b \leq \min \{w_I, w_I - \frac{q^f_J(1,1,1,1,0,1,1)}{(r + \delta_I + p)} (w_I - w_F), w_I - \frac{q^f_J(1,1,1,1,0,1,1)}{(r + \delta_I + p)} (w_I - w_F)\}
\]

I must have \(w_F \leq w_I\) for the LHS term to be lower than any of the RHS terms. Then, it is easily checked that \(w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F)\) is the minimum of the RHS. Finally, steady-states \((ix)\) arise in equilibrium when \(w_F \leq w_I\), if \(w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F) \leq b \leq w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F)\), with \(\phi_j = 1, \phi_{-j} = 0\) and \(\psi_j = \chi_j = 1, \forall j, j\) characterized by \(t_j N_j i_j^* \leq t_{-j} N_{-j} i_{-j}^*\).

\((x)\) The mixed steady-state \((f_j^* > 0 \text{ and } i_j^* > 0, \forall j \in \{W, B\})\) exists for \(\phi_j = \phi_{-j} = 1, \psi_j = \psi_{-j} = 1\) and \(\forall \chi_j, \chi_{-j} \in \{0, 1\}\). I then distinguish two cases according to the value of \(\chi_j, \chi_{-j}\):

\[\text{\textbullet Case } \chi_j = \chi_{-j} = 0: \text{ the conditions can be summarized as: } w_I - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_F - w_I) \text{ requires that } w_F < w_I, \text{ hence a contradiction.}\]

\[\text{\textbullet Case } \chi_j = \chi_{-j} = 1: \text{ the conditions then sum up to: } b \leq \min \{w_F, w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F) \forall j, w_I - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_F - w_I) \forall j \}
\]

From the previous case, I know that \(w_I\) cannot be the minimum. I get the same type of contradiction with \(w_F\) and \(w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F)\). I finally get that \(w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F)\) is the minimum when \(w_F \geq w_I\), where group \(j\) is such that \(t_j N_j i_j^* \leq t_{-j} N_{-j} i_{-j}^*\), while \(w_I - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_F - w_I)\) is the minimum when \(w_F > w_I\), where group \(j\) is characterized by \(i_j^* = i_{-j}^* = 0\), \(\lambda_i, j\), \(\lambda_{-i, j}\), \(\lambda_{i, -j}\), \(\lambda_{-i, -j}\). To summarize, steady-state \((x)\) arises in equilibrium:

\[\text{\bullet when } w_F > w_I: \text{ if } b \leq w_I - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_F - w_I), \text{ where group } j \text{ is such that } t_j N_j i_j^* \leq t_{-j} N_{-j} i_{-j}^*, \text{ with } \phi_j = \psi_j = \chi_j = 1, \forall j.\]

\[\text{\bullet when } w_F \leq w_I: \text{ if } b \leq w_F - \frac{q^f_J(1,1,1,1,1,1,1)}{(r + \delta_I + p)} (w_I - w_F), \text{ where } j \text{ is such that } t_j N_j i_j^* \leq t_{-j} N_{-j} i_{-j}^*, \text{ with } \phi_j = \psi_j = \chi_j = 1, \forall j.\]

References


\(^{50}\)Most likely: \(j = B\) and \(-j = W\).


[37] Lubell, Harold (1991), The informal sector in the 1980’s and 1990’s, Development Center of the OECD


