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Globalization and Formal-Informal Wage Gap

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Abstract

In this paper, we investigate the effect of globalization on the wage gap between informal and formal workers. We assume in our model that formal products are perceived of better quality than informal ones, while requiring higher efforts. Moreover formal firms have to pay social contributions on each worker, while informal firms do not have to.

We consider two opposite regimes: Autarky and Full Integration. Under each regime we fully characterize the equilibrium of a game where firms choose their status and quantities to be produced. We then calculate the formal and informal workers wages at equilibrium. First we prove that globalization raises all wages. Second we prove that globalization raises more (less) the formal workers' wages for high (low) quality gap/low(high) social contributions relative the informal workers' wages.

Keywords: Globalization, Informality, Quality gap, Wage gap.

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1 Introduction

According to ILO Global Wage Report (2018/2019), average real wages in the G20 grew by a total of about 55 per cent between 1999 and 2017, with large differences between emerging G20 economies (+ 200 %) and advanced ones (only 9 %). The studied period is characterized by an increasing globalization that seems to raise all wages in different proportions so as to close the wage gap between advanced and emerging economies. The most recent ILO Global Wage Report (2022/2023), studying the impact of COVID-19 associated with a tragic fall in trade, on wages (and purchasing power), points out that "the decline in real wages has come on top of significant wage losses incurred by workers and their families during the COVID-19 crisis. Low-wage earners, workers in the informal economy and women wage earners were the groups that suffered most". Regarding the period following the pandemic with recovering trade, the same report mentions that "the nominal wage increases observed in 2022 in each of the income groups among formal employees are almost always greater than those of the corresponding groups among informal employees".

Globalization thus seems to affect wages in different ways and proportions depending on countries and on categories within the same country. What is however puzzling to note is that the fall (COVID-19) as well as recovery (after pandemic) of globalization both seem to raise inequalities! Besides, informal work represents more than 60% of the world's employed population, ranging from 25.1% in Europe and Central Asia to 85.8% in Africa¹. It thus seems important to study the determinants of wages as well as wage inequalities in an economy with informal work, investigating the role of globalization in this respect.

We aim in this paper to investigate theoretically the effect of globalization on wages while considering explicitly an informal sector. The question is whether globalization increases or decreases wages in each sector and whether it leads to more or less inequality between the formal and informal workers.

The well-known theorem of Stolper-Samuelson does not answer the question in a satisfying way. Indeed it predicts a positive effect on the income of workers only in a labor abundant country, considering trade between different countries and assuming perfect competition be-

¹See ILO(2018a).

tween firms and a homogeneous good, with no room for differentiation nor for trade between initially identical countries. But introducing differentiation is one relevant way to tackle informality in a trade model with identical countries.

We investigate this question by adapting the model of Kahloul et al. (2017) to take into account informality. We consider an economy with two identical countries and two opposite regimes: Autarky and Full integration. There are two firms in each country that must choose whether to be formal or informal and the quantity to produce. We assume that relative to an informal firm, a formal firm offers a higher quality and has to pay social contributions over wages. We find the equilibrium of the game under each regime in terms of market structure and quantities produced and we calculate the wages at equilibrium. Comparative statics prove that while globalization always increases the formal and informal wages, its impact on the Formal- Informal wage gap is ambiguous and depends on the perceived quality gap between formal and informal firms and the social contributions' rate. This may solve the apparent puzzle on the effect of globalization observed before and after the pandemic. More precisely, globalization increases (decreases) the Formal- Informal wage gap, when the quality gap between formal and informal goods is high (low) enough and social contributions are low (high) enough.

The literature review. With respect to the theoretical literature, our paper may be related to two streams. Papers within the first stream study informality through vertical differentiation models but do not address the globalization question. The second stream addresses the effect of globalization on labor market considering explicitly informality, but without differentiation between formal and informal products.

In the first stream, all the papers consider, as we do, that consumers perceive a formal's product quality as higher than an informal product one. Only Fotoniata and Moutos (2013) consider explicitly a labor market with vertical differentiation between formal products of high quality produced only by adults and informal products using child labor.

Apart from Fotoniata and Moutos (2013), the other papers within this first stream either do not consider a labor market at all or consider a very simplified labor market with exogenous wages, without modeling the choice of workers between formal and informal firms. Banerji and Jain (2007) propose a model suggesting that the quality gap between formal and informal

firms is due to the factors' prices faced in production, and to the heterogeneity of consumers' preferences/incomes. For Daga and Mendi (2021), informal upstream firms compete with a formal upstream firm to supply inputs for a formal downstream firm. In Mishra (2022) and Cherfi-Feroukhi and Souam (2019) informal firms may be detected with some probability and if so, will have to pay a penalty. Mishra (2022) assumes that formal firms are more productive than informal ones and that firms choose the sector to operate in, as we do. Cherfi-Feroukhi and Souam (2019) propose a model with costless production, where a regulatory authority tries to maximize collective welfare through the choice of an optimal firm audit probability. They prove that a complete deterrence of the entry of informal firms is never optimal.

The papers in the second stream study the effect of globalization on the labor market considering explicitly an informal sector, but without vertical differentiation. Goldberg and Pavencic (2003) consider a model with identical firms facing uncertainty and deciding on the number of formal and informal workers. But the wages in the formal and informal sectors are assumed to be exogenous. Aleman-Castilla (2006), Paz (2014), Becker (2018) adapt Melitz (2003)'s international trade model considering explicitly an informal sector. Melitz (2003) assumes a continuum of firms differing in their productivity, with a possibility to export. A firm deciding to export has to assume additional costs. Aleman-Castilla (2006), Paz (2014) and Becker (2018) suppose that firms can choose to be formal or informal. Formal firms benefit from a bonus in productivity but assume higher costs and have to pay taxes and social contributions. The government may detect informal firms and when it does so, it makes them pay a penalty. The three papers consider a final output without differentiation. The intermediate goods may be formal or informal and the productivity of production of the final output is influenced by the proportion between the two kinds of intermediate goods. Hence the consumer is not directly concerned with formality and informality, while we assume that the consumers choose between formal and informal goods that they perceive of different qualities. The three papers differ regarding the meaning and consequences of trade liberalization and the firms allowed to take part in it.

All three papers study the effect of trade on wages in the formal and informal sectors, with diverging conclusions. Aleman-Castilla (2006) proves that the import tariff reduction increases

wages in both the formal and informal sectors, which is consistent with our results. Becker (2018) proves that trade always increases the difference between the average wage of formal and informal workers, while we may have an increase or a decrease of the wage gap under the effect of globalization. Paz (2014) is the only paper finding a non-monotonous effect of globalization on wages and on formal-informal wage gap, depending on the strategy of trade liberalization and parameters relative to the firms distribution.

With an empirical approach, many papers deal with wages of formal and informal workers. There is an abundant literature on the formal-informal wage gap without the effect of trade: Bargain and Kwenda (2014) using panel data from Brazil, Mexico and South Africa, Baskaya and Hulagu (2011), Tansel and Kan (2012), Kahyalar et al. (2018) study Turkish data, Kumar and Ranjan (2015) consider Indian data, William and Gashi (2022) with Kosovan data. Baskaya and Hulagu (2011), Kumar and Ranjan (2015) and William and Gashi (2022) focus among others on wage differential between men and women in both the formal and informal sectors. Relevantly for us, Kahyalar et al. (2018) found education and experience to be key determinants of earnings. This is consistent with our model where the wages depend on the qualities produced which are themselves supposed to be increasing with the skills requested to produce them.

There are some empirical papers on the effect of trade on wages and on wage/income inequalities in a broad sense, with diverging conclusions. When informality is specifically taken into consideration, Paz (2014) shows empirically that trade impacts differently wage average in each sector, depending on the strategy of trade liberalization adopted: decrease of import tariffs or export tariffs. The formal-informal wage differential may increase or decrease under the effect of trade liberalization. Galiani and Sanguinetti (2003) studied the effect of trade on wage inequalities in a broad sense (not specifically between formal and informal sectors), testing whether those sectors more open to import are also the sectors, *ceteris paribus*, that are more concerned with a higher increase in wage inequality. They observed a raise in wage inequality of which only a small proportion is explained that way. Esquivel and Rodriguez-Lopez (2003) prove however that trade liberalization reduces the wage gap between skilled and unskilled labor in Mexico. The study of Heimberger (2020) is a meta-analysis on the ef-

fect of globalization on income (and not only wages) inequality. They found that, contrary to the Stolper-Samuelson model predictions, globalization contributes to the increase of the income inequality in developing as well as in advanced ones.

The paper is organized as follows. Section 2 describes the model. Section 3 provides the equilibrium outcomes under Autarky and Full Integration. Section 4 investigates the effect of trade on wages and formal-informal wage gap through comparative statics. Section 5 concludes. All proofs are provided in Appendix.

2 The Model

We adapt the model introduced by Kahloul et al. (2017) (used in many other papers such as Amir et al. 2022; Ghazzai et al., 2023; Kahloul et al., 2019; Lahmandi-Ayed and Laussel, 2018; Lahmandi-Ayed and Laussel, 2022) to the particular setting of informality. On the one hand, we think that the use of vertical preferences is appropriate in this case. Indeed, a formal and an informal product, even when identical in physical terms, are perceived differently by consumers who prefer the formal product to the informal one, when they are sold at the same price. On the other hand, the formal product needs more skilled workers than the informal product. The model of Kahloul et al. (2017) accounts for such a situation as they use vertical preferences and link increasingly the produced quality to the required effort of workers.

We consider two identical countries under two different regimes: (A) Autarky and (FI) Full Integration. Under Autarky, firms located in different countries exchange neither goods nor labor. Under Full Integration, economies are open and there is a perfect mobility of goods and labor between the two countries. Full Integration can also be perceived as a perfect mobility of capital allowing a firm to relocate its production (partially or totally) without any costs.

Two firms operate in each country. Firms produce a vertically differentiated good using labor as the unique input. We assume that producing one unit of the differentiated good requires one unit of labor. Thus, costs have constant returns to scale.

Firms need to choose their status: Formal or Informal. Two main differences exist between formal and informal firms. First, consumers perceive the formal good quality v_F as higher

than the informal quality v_I as explained earlier. Second, apart from wages, formal firms must bear an additional cost that corresponds to the social contributions. Indeed we assume that formal firms pay a proportion r of the workers' wages as social contributions. Informal firms, however, only pay wages. Thus, the total cost per worker for a formal firm is $w_F(1 + r)$ where w_F the wage of a worker. While it is only w_I , the worker's wage, for the informal firm.

Individuals in each country are potentially consumers and workers. Each individual is endowed with one unit of labor. Individuals are characterized by a couple (θ, α) where:

1. $\theta \in [0, 1]$ represents an individual's intensity of preference for the product quality. The higher θ , the more an individual is willing to pay for quality.
2. $\alpha \in [0, 1]$ represents an individual's sensitivity to effort, inversely related to her ability to work. The higher α , the more the individual has to make efforts to produce a given quality v , and therefore the lower his/her skills.

In each country, individuals (θ, α) are uniformly distributed over $[0, 1] \times [0, 1]$ with a density normalized to 1.²

When it comes to working and consumption decisions, first an individual may choose to remain idle (\bar{W}), to work in an informal firm (W_I) (if it exists) and therefore produce the low quality v_I or to work in a formal firm (W_F) (if it exists) and produce the high quality v_F while taking into consideration the efforts needed to produce each quality. Second an individual makes a choice between not consuming the differentiated product (\bar{C}), consuming one unit of the low quality variant (if offered) (C_I) or consuming one unit of the high quality variant (if offered) of the differentiated good (C_F).

The individual utility results from the consumption of the differentiated product and a composite numeraire and is given by:

$$V(x, t) = \theta v x + t, \tag{1}$$

where x is the consumption of the differentiated product of quality v and t is the consumption of the composite numeraire.

²Kahloul et al. (2017) assume $(\theta, \alpha) \in [0, \bar{\theta}] \times [0, \bar{\alpha}]$. We thus consider the simplified case with $\bar{\theta} = \bar{\alpha} = 1$.

tion of the numeraire good. The consumption bundle (x, t) belongs to the consumption set³ $\{0, 1\} \times \mathbb{R}$. A higher intensity of preference for quality θ translates into a higher impact of the quality ν on the individuals.

Individuals receive a wage w if they decide to work. In addition, they incur a training cost $\alpha\nu$ if they decide to work in a firm producing quality ν . Higher qualities are thus assumed to require higher training costs and for a given quality, higher sensitivity to effort α translates into higher training costs. An individual who chooses not to work does not receive any wage and has no training costs.

Under each regime (Full Integration or Autarky), firms play a two-stage game. At the first stage, firms choose simultaneously their qualities and therefore their status (formal or informal). At the second stage, they simultaneously choose the quantities q_i to produce.⁴ Wages are endogenous and are found by balancing the demand and supply on the labor market. We study the Sub-game Perfect Nash Equilibrium under each regime.

Under Autarky, two firms compete in each country in the goods and labor markets. Under Full Integration, goods and labor are perfectly mobile between countries. Hence, four firms compete in both the goods and labor global markets of the whole world composed of the two countries. It is worth noting that firms' location is meaningless under Full Integration and that Full Integration either corresponds to perfect mobility of capital (FDIs) or to perfect mobility of goods and labor between the two countries.

Finally, two technical assumptions are made about the quality gap between the formal and informal sector $\frac{\nu_F}{\nu_I}$ and the social contributions rate r . First, we assume that $\frac{\nu_F}{\nu_I} > \frac{9}{8}$. Formal firms are assumed to offer a higher enough quality than the informal ones. Second, we assume that $r < 1$ which means that the social contributions paid by the formal firms are not too high. These two assumptions ensure that a formal firm can survive at the quantity competition stages when it compete with informal firms. They also imply that if an entry stage is added prior to the two considered ones, under each regime, all firms would choose to enter.

³ \bar{C} corresponds to $x = 0$, C_I and C_F correspond to buying one unit respectively of the informal and the formal product.

⁴We chose quantity rather than price competition in this vertical differentiation model to allow for firms of the same quality/status to be active.

3 Equilibrium Outcomes

We calculate in this section the equilibrium outcomes under Autarky and Full Integration: market structure, quantities and profits.

3.1 Autarky

In Autarky, two firms compete in each country. Denote by (m, n) the outcome of the first stage of the game where m is the number of informal firms and n is the number of formal firms in each country. Three situations are possible at the first stage of the game: $(0, 2)$ which means that both firms are formal, $(1, 1)$ which means that one firm is formal and one firm is informal and $(2, 0)$ which means that both firms are informal.

For each (m, n) , we find the equilibrium quantities. Then, we determine the firms' profits. Finally, we find the couple (m^A, n^A) that corresponds to the market structure at equilibrium, i.e. the distribution of the firms between the two status.

Lemma 1 provides the equilibrium quantities and the associated profits for each (m, n) .

Lemma 1. *At equilibrium under Autarky, when m firms are informal and n firms are formal, with $m + n = 2$, the quantities of an Informal firm and a Formal firm and their respective profits, are given as follows:*

- *Quantities: for all $m \geq 1, n \geq 0$, $q_I^A(m, n) = \frac{v_F((2+r)(n+1)-2n)}{2(2+r)(v_F(n+1)(m+1)-v_I mn)}$; and for all $m \geq 0, n \geq 1$, $q_F^A(m, n) = \frac{2(m+1)v_F-(2+r)mv_I}{2(2+r)(v_F(n+1)(m+1)-v_I mn)}$.*
- *Profits: for all $m \geq 1, n \geq 0$, $\Pi_I^A(m, n) = \frac{v_I v_F^2 (2+r(n+1))^2}{2(2+r)^2 (v_F(m+1)(n+1)-v_I mn)^2}$; and for all $m \geq 0, n \geq 1$, $\Pi_F^A(m, n) = \frac{v_F(2v_F(m+1)-mv_I(2+r))^2}{4(2+r)(v_F(m+1)(n+1)-v_I mn)^2}$.*

We now determine the equilibrium at the first stage of the game. (m, n) corresponds to an equilibrium if and only if no firm has interest to change its status unilaterally. We have thus the following:

- $(0, 2)$ is an equilibrium if and only if $\Pi_F(0, 2) \geq \Pi_I(1, 1)$ i.e. each firm has no interest to be informal if its competitor is formal.

- (1, 1) is an equilibrium if and only if $\Pi_F(1, 1) \geq \Pi_I(2, 0)$ and $\Pi_I(1, 1) \geq \Pi_F(0, 2)$: each firm has no interest to have the same status as the competitor.
- (2, 0) is an equilibrium if and only if $\Pi_I(2, 0) \geq \Pi_F(1, 1)$: each firm has no interest to be formal if its competitor is informal.

Using the above mentioned conditions Lemma 2 gives the market structure at equilibrium as function of r (social contributions) and $\frac{v_F}{v_I}$ (quality gap). The results are depicted in Figure 1 in the $(r, \frac{v_F}{v_I})$ -space.

Denote by:

$$g(r, \frac{v_F}{v_I}) = (2 + r)(4\frac{v_F}{v_I} - 1)^2 - 18\frac{v_F}{v_I}(1 + r)^2,$$

$$h(r, \frac{v_F}{v_I}) = 9\frac{v_F}{v_I}(4\frac{v_F}{v_I} - (2 + r))^2 - 2(2 + r)(4\frac{v_F}{v_I} - 1)^2.$$

Lemma 2. *Under Autarky,*

- (0, 2) is an equilibrium if and only if $g(r, \frac{v_F}{v_I}) > 0$
- (1, 1) is an equilibrium if and only if $g(r, \frac{v_F}{v_I}) < 0$ and $h(r, \frac{v_F}{v_I}) > 0$.
- (2, 0) is an equilibrium if and only if $h(r, \frac{v_F}{v_I}) < 0$.

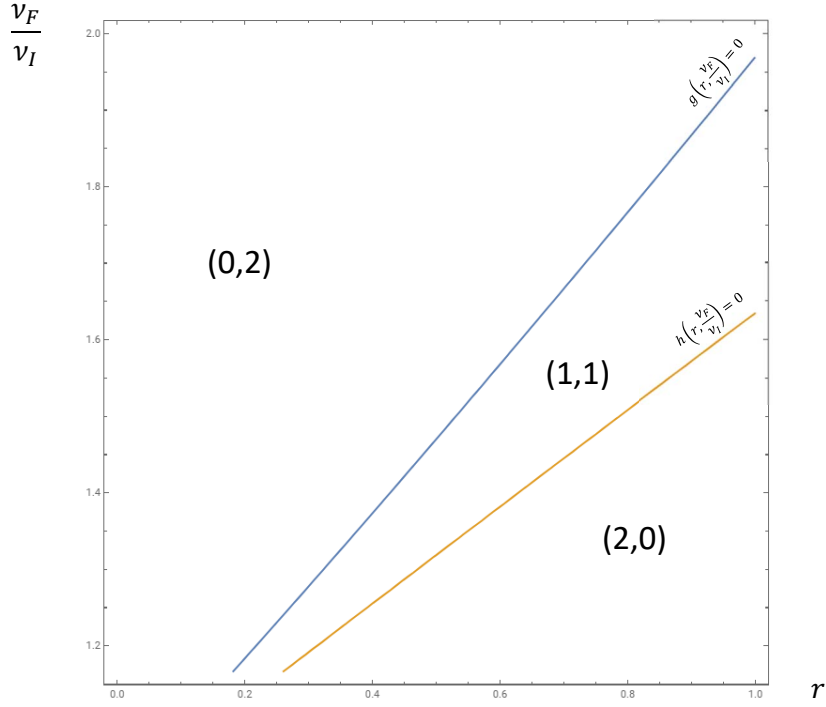


Figure 1: Market structure at equilibrium under Autarky.

3.2 Full Integration

Now there is Full Integration between the two countries and four firms compete in the global market composed of the two countries, with complete economic integration in both the goods and labor markets. Thus, five situations are possible: (0, 4), (1, 3), (2, 2), (3, 1) and (4, 0). We proceed as under Autarky. We first find the equilibrium quantities for each (m, n) where $m + n = 4$. Then, we find the market structure at equilibrium (m^{FI}, n^{FI}) , i.e. the distribution of firms between the formal and informal status.

Lemma 3 provides the equilibrium quantities for each (m, n) .

Lemma 3. *At equilibrium under Full Integration, when m firms are informal and n firms are formal, with $m + n = 4$, the quantities of an Informal firm and of a formal one, and their respective profits are given as follows:*

- *Quantities: for $m \geq 1, n \geq 0$, $q_I^{FI}(m, n) = \frac{v_F((2+r)(n+1)-2n)}{(2+r)(v_F(n+1)(m+1)-v_I mn)}$; and for $m \geq 0, n \geq 1$, $q_F^{FI}(m, n) = \frac{2(m+1)v_F-(2+r)mv_I}{(2+r)(v_F(n+1)(m+1)-v_I mn)}$.*

- Profits: for $m \geq 1, n \geq 0$, $\Pi_I^{FI}(m, n) = \frac{v_I v_F^2 (2+r(n+1))^2}{(2+r)^2 (v_F(m+1)(n+1) - v_I m n)^2}$; and for $m \geq 0, n \geq 1$,
 $\Pi_F^{FI}(m, n) = \frac{v_F (2v_F(m+1) - m v_I (2+r))^2}{2(2+r)(v_F(m+1)(n+1) - v_I m n)^2}$.

We now determine the market structure resulting at equilibrium, i.e. the choice of firms at the first stage of the game. (m, n) corresponds to the market structure at equilibrium under Full Integration if and only if no firm has interest to change its status unilaterally. We have thus the following:

- $(0, 4)$ is an equilibrium if and only if $\Pi_F(0, 4) \geq \Pi_I(1, 3)$.
- (m, n) is an equilibrium with $m \geq 1$ and $n \geq 1$ if and only if $\Pi_I(m, n) \geq \Pi_F(m-1, n+1)$ and $\Pi_F(m, n) \geq \Pi_I(m+1, n-1)$.
- $(4, 0)$ is an equilibrium if and only if $\Pi_I(4, 0) \geq \Pi_F(3, 1)$.

The above conditions lead to Lemma 4 providing the market structure at equilibrium as function of social contributions and the quality gap ⁵. The results are depicted in Figure 2 in $(r, \frac{v_F}{v_I})$ -space. Denote by:

$$\begin{aligned} f_{04}(r, \frac{v_F}{v_I}) &= (2+r)(8\frac{v_F}{v_I} - 3)^2 - 50\frac{v_F}{v_I}(1+2r)^2 \\ f_{40}(r, \frac{v_F}{v_I}) &= 2(2+r)(8\frac{v_F}{v_I} - 3)^2 - 25\frac{v_F}{v_I}(8\frac{v_F}{v_I} - 3(2+r))^2 \\ f_{13}(r, \frac{v_F}{v_I}) &= (2+r)(4\frac{v_F}{v_I} - (2+r))^2(9\frac{v_F}{v_I} - 4)^2 - 2\frac{v_F}{v_I}(2+3r)^2(8\frac{v_F}{v_I} - 3)^2 \\ f_{22}(r, \frac{v_F}{v_I}) &= (2+r)(8\frac{v_F}{v_I} - 3)^2(3\frac{v_F}{v_I} - (2+r))^2 - 2\frac{v_F}{v_I}(1+r)^2(9\frac{v_F}{v_I} - 4)^2 \end{aligned}$$

Lemma 4. *Under Full Integration,*

- $(0, 4)$ is an equilibrium if and only if $f_{04}(r, \frac{v_F}{v_I}) \geq 0$
- $(1, 3)$ is an equilibrium if and only if $f_{04}(r, \frac{v_F}{v_I}) \leq 0$ and $f_{13}(r, \frac{v_F}{v_I}) \geq 0$.
- $(2, 2)$ is an equilibrium if and only if $f_{13}(r, \frac{v_F}{v_I}) \leq 0$ and $f_{22}(r, \frac{v_F}{v_I}) \geq 0$
- $(3, 1)$ is an equilibrium if and only if $f_{22}(r, \frac{v_F}{v_I}) \leq 0$ and $f_{40}(r, \frac{v_F}{v_I}) \leq 0$
- $(4, 0)$ is an equilibrium if and only if $f_{40}(r, \frac{v_F}{v_I}) \geq 0$

⁵The proof of Lemma 4 follows the same reasoning as the proof of Lemma 2.

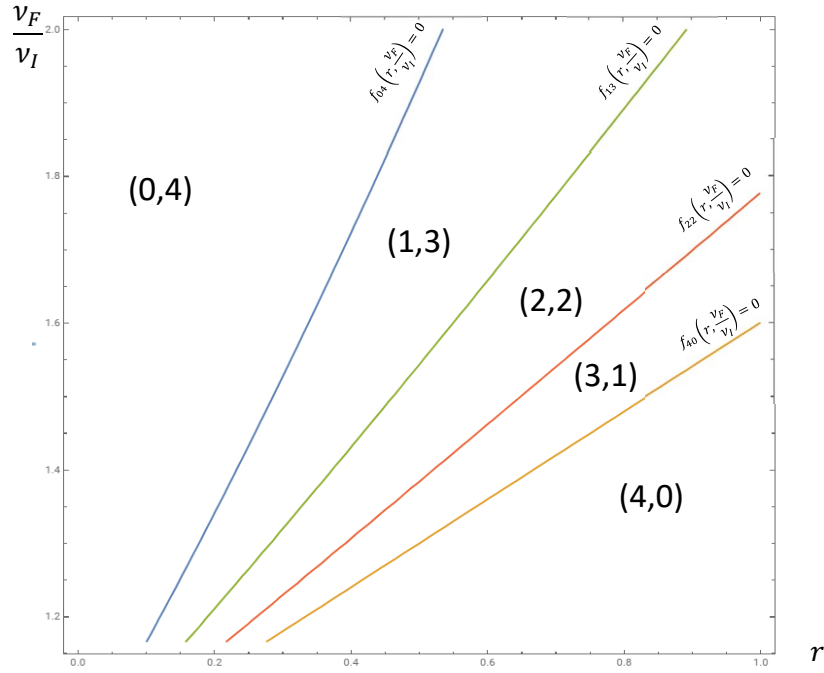


Figure 2: Market structure at equilibrium under Full Integration

3.3 Autarky Vs Full Integration

Examining Figures 1 and 2, we notice that as we turn clockwise, firms gradually leave the formal sector to join the informal sector. Indeed, when the social contributions' rate is low and/or the quality gap is high, all firms are formal both under Autarky and Full Integration. In this case, the advantage in terms of consumers' perceptions of being formal is higher than the additional cost of formality. When we turn clockwise, social contributions increase and/or the quality gap decreases i.e. the advantage of being formal decreases and/or the additional cost of formality increases. Firms start leaving the formal sector to the informal one. When the social contributions are high and/or the quality gap is low all firms become informal.

Figure 3 is what we obtain when we superimpose Figures 1 and 2. This allows to compare the equilibria under each regime (Autarky and Full Integration), for each zone of the $(r, \frac{v_F}{v_I})$ -space.

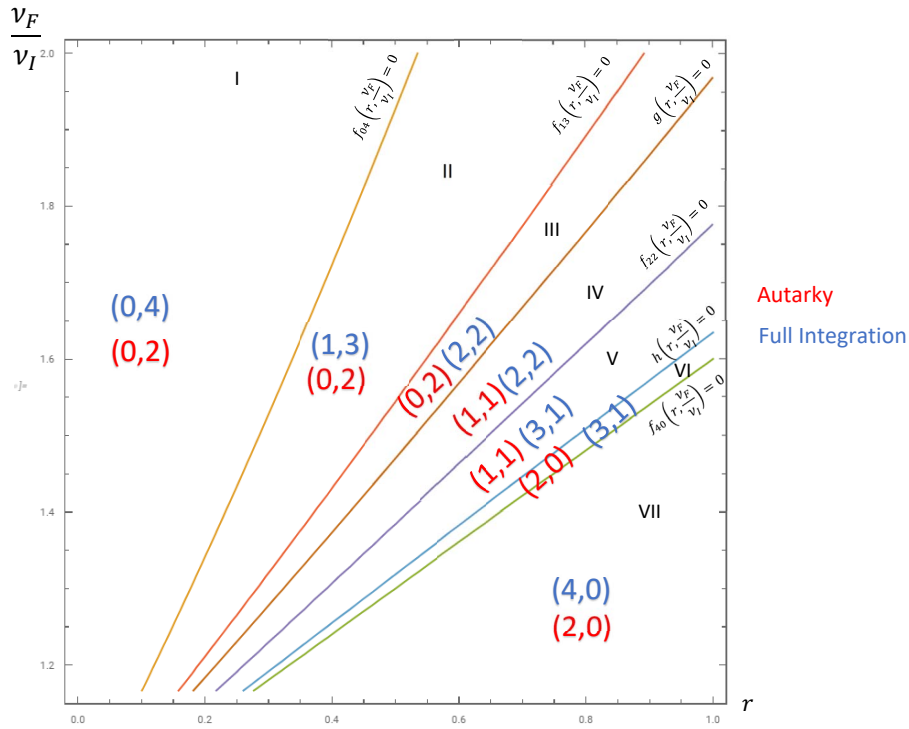


Figure 3: Firms' distribution between the formal and informal status: Autarky Vs Full Integration

In Figure 3, as we turn clockwise, at the beginning (from Zone (I) to Zone (II)), firms start to leave the formal status under Full Integration before Autarky. The trend is reversed later (from Zone (V) to Zone (VI)). When one turns clockwise, there is a pressure on formal firms to move to informality, under both regimes, as we already explained. Full Integration implies more competition than Autarky. More competition may be alleviated by more differentiation. In Zone (I), all firms are formal, whether under Autarky or under Full Integration. When one moves from Zone (I) to Zone (II), one firm leaves formality to informality under Full Integration but the market structure remains the same under Autarky. Because of more competition under Full Integration, firms are more eager to leave the formal status when one turns clockwise, as they are more motivated to seek more differentiation. The trend remains the same until Zone (V). In Zone (V) there are two formal firms and two informal ones under Autarky and 3 informal firms and only one formal firm under Full Integration. When one moves from Zone (V) to Zone (VI), the market structure remains the same under Full Integration, but all firms become informal under Autarky. Because of fiercer competition under Full Integration

the remaining formal firm refrains longer from moving to informality to avoid the situation with no differentiation (4 informal firms). What pushes a firm to leave the formal status to the informal one, under Full Integration, from Zone (I) to Zone (II) (relaxing competition through product differentiation), precisely prevents the last formal firm from leaving the formal status when one moves from Zone (V) to Zone (VI).

4 Effect of Globalization on Wages

We first determine the wages under each regime and for each possible market structure. Then in each zone of Figure 3, we compare the wages of the formal sector and the informal one as well as the wage gap between the formal and informal sector when we move from Autarky to Full Integration.

Denote by $w_I^A(m, n)$ and $w_F^A(m, n)$ the wages respectively in the informal and formal sectors under Autarky when the market structure is (m, n) (m being the number of informal firms and n the number of formal ones within each country, with $m + n = 2$). Similarly, denote by $w_I^{FI}(m, n)$ and $w_F^{FI}(m, n)$ the wages under Full Integration (with m the number of informal firms and n the number of formal ones in the world, with $m + n = 4$). Lemmas 5 and 6 give the wages under each regime. Wages are obtained easily. When both types of firms co-exist, wages are provided by Equations 2. When only one type of firms is viable, formal firms or informal firms, the wages are given by Equations 3 and 4, respectively. We then use the quantities provided in Lemmas 1 and 3 to compute the wages under both regimes for any market structure (m, n) .

$$\begin{cases} w_I = v_I \sum_{j=1}^{m+n} q_j \\ w_F = v_I \sum_{j=1}^m q_j + v_F \sum_{j=m+1}^{m+n} q_j \end{cases} \quad (2)$$

$$w_F = v_F \sum_{j=1}^n q_j \quad (3)$$

$$w_I = v_I \sum_{j=1}^m q_j \quad (4)$$

Lemma 5 (Wages under Autarky). *For each market structure (m, n) , under Autarky, wages are*

given by:

- (2, 0): $w_I^A(2, 0) = \frac{v_I}{3}$;
- (1, 1): $w_I^A(1, 1) = \frac{2(3+r)v_F v_I - (2+r)v_I^2}{2(2+r)(4v_F - v_I)}$ and $w_F^A(1, 1) = \frac{4v_F^2 + r v_I v_F}{2(2+r)(4v_F - v_I)}$;
- (0, 2): $w_F^A(0, 2) = \frac{2v_F}{3(2+r)}$.

Lemma 6 (Wages under Full Integration). *For each market structure (m, n), under Full Integration, wages are given by:*

- (4, 0): $w_I^{FI}(4, 0) = \frac{2v_I}{5}$;
- (3, 1): $w_I^{FI}(3, 1) = \frac{(14+6r)v_I v_F - 3(2+r)v_I^2}{2(2+r)(8v_F - 3v_I)}$ and $w_F^{FI}(3, 1) = \frac{8v_F^2 - 3r v_I v_F}{2(2+r)(8v_F - 3v_I)}$;
- (2, 2): $w_I^{FI}(2, 2) = \frac{(8+3r)v_I v_F - 2(2+r)v_I^2}{(2+r)(9v_F - 4v_I)}$ and $w_F^{FI}(2, 2) = \frac{6v_F^2 - (2-r)v_I v_F}{(2+r)(9v_F - 4v_I)}$;
- (1, 3): $w_I^{FI}(1, 3) = \frac{(14+4r)v_I v_F - 3(2+r)v_I^2}{2(2+r)(8v_F - 3v_I)}$ and $w_F^{FI}(1, 3) = \frac{12v_F^2 - (4-r)v_I v_F}{2(2+r)(8v_F - 3v_I)}$;
- (0, 4): $w_F^{FI}(0, 4) = \frac{4v_F}{5(2+r)}$

We now study the effect of globalization on wages. In each zone of Figure 3, we first compare formal and informal wages when we move from Autarky to Full Integration. Then we focus particularly on Zones IV and V of Figure 3 where both types of firms co-exist under both regimes. Therefore, these are the only zones where it is relevant to study the effect of globalization on the Formal-Informal wage gap (Proposition 1).

Proposition 1 (Effect of globalization on wages). *Globalization always increases the wages in both the formal and informal sectors. Globalization may increase or decrease the Formal- Informal wage gap. It increases it in Zone IV of Figure 3 and decreases it in Zone V.*

The fact that globalization increases wages for both formal and informal workers is not surprising. Indeed, globalization increases competition between firms on the labor market, as well as on the product one. This pushes upward quantities and wages and seems consistent with the impact on wages observed before and after the COVID-19 pandemic, as well as the findings of Aleman-Castilla (2006) and Becker (2018) about wages. Paz (2014) however proves that

the effect on wages depends on the sector (formal or informal) and on how trade liberalization occurs.

When it comes to the Formal-Informal wage gap, globalization increases the Formal-Informal wage gap for high quality gaps and low social contributions (Zone IV) and decreases it for low quality gaps and high social contributions (Zone V). A high quality gap means a high gain from being formal in terms of consumers perception relative to the extra-cost in terms of social contributions, and at the same time high skills of formal workers relative to informal ones. Hence a high quality gap provides a double motivation for formal firms to pay a higher wage: it sells a product better perceived by consumers but needing better skills, thus needs to motivate more skilled workers to work for it. This leads to an increase in the Formal-Informal wage gap in Zone IV and a decrease in Zone V.

Thus, we show that the relationship between globalization and the Formal-Informal wage gap is non-monotonous. To the best of our knowledge, only Becker (2018) shows that globalization has an ambiguous effect on wage inequality, but not considering specifically formal-informal wage gap. Aleman-Castilla (2006) and Paz (2014) prove that trade liberalization always widens the Formal-Informal wage gap. On the empirical side, without explicitly considering informality, Esquivel and Rodriguez-Lopez (2003) prove that globalization reduces the wage gap between skilled and unskilled workers; while Galiani and Sanguinetti (2003) and Heimberger (2020) show that globalization increases income inequalities in a broad sense.

5 Conclusion

We study in this paper the effect of globalization on the wages of the formal and informal workers. We show that while globalization rises all wages, it may increase or decrease inequalities between the formal and informal workers. Indeed, the Formal-Informal wage gap increases (decreases) with globalization for a high (low) quality gap between the formal and informal firms and low (high) social contributions.

Several extensions may be interesting to undertake. A natural extension of this paper is to test empirically the obtained theoretical results. The idea is to develop an empirical model

where the interaction between globalization and the social contributions has a significant effect on the Formal-Informal wage gap. It may also be interesting to study the effect on prices and on welfare, in theoretical as well as empirical terms. Finally, we can adopt more realistic assumptions such as a fixed cost and profit imposition on formal firms, or the possibility for informal firms only to take part in trade.

Appendix

Proof of Lemma 1: Three cases need to be distinguished depending of the three possible market structures under Autarky.

- The case (1, 1): One firm is formal and one firm is informal.

Table 1 provides for each individual his/her consumption and working decisions and indirect utility, depending on his/her characteristics (θ, α) , on the wages w_i they receive for the production of each variant of the product, the products' qualities v_i and the price p_i of each variant. To obtain the consumption and working decisions we proceed as in the proof of Proposition 2 of KLLL(2017) as we are using the same utility function and as individuals are facing the same choices in terms of consumption and work.

Table 1: Consumption/working decisions and indirect individual utilities (U) when formal and informal firms coexist.

Working α Consumption θ	W_F	$\frac{\omega_F - \omega_I}{v_F - v_I}$	W_I	$\frac{\omega_I}{v_I}$	\bar{W}	1
	\bar{C}	$U = \omega_F - \alpha v_F$		$U = \omega_I - \alpha v_I$		$U = 0$
$\frac{p_I}{v_I}$ C_I	$U = \theta v_I - \alpha v_F + \omega_F$ $-p_I$		$U = v_I(\theta - \alpha) + \omega_I$ $-p_I$		$U = \theta v_I - p_I$	
$\frac{p_F - p_I}{v_F - v_I}$ C_F	$U = v_F(\theta - \alpha) + \omega_F$ $-p_F$		$U = \theta v_F - \alpha v_I + \omega_I$ $-p_F$		$U = \theta v_F - p_F$	
1						

We will establish the result in the general form in terms of any $m \geq 1$ and $n \geq 1$ as in Lemma 1.

Denote by q_h the quantity produced by firm h . Balancing the demand and supply in the market of the differentiated good, we obtain Equations 5.

$$\begin{cases} \frac{p_F - p_I}{v_F - v_I} - \frac{p_I}{v_I} = \sum_{j=1}^m q_j \\ 1 - \frac{p_F - p_I}{v_F - v_I} = \sum_{j=m+1}^{m+n} q_j \end{cases} \quad (5)$$

We easily express the prices in terms of the quantities in Equations 6

$$\begin{cases} p_I = v_I(1 - \sum_{j=1}^{m+n} q_j) \\ p_F = v_F(1 - \sum_{j=m+1}^{m+n} q_j) - v_I \sum_{j=1}^m q_j \end{cases} \quad (6)$$

Balancing the demand and supply in the labor market, we obtain Equations 7

$$\begin{cases} \frac{w_I}{v_I} - \frac{w_F - w_I}{v_F - v_I} = \sum_{j=1}^m q_j \\ \frac{w_F - w_I}{v_F - v_I} = \sum_{j=m+1}^{m+n} q_j \end{cases} \quad (7)$$

We easily express the wages in terms of the quantities in Equations 8

$$\begin{cases} w_I = v_I \sum_{j=1}^{m+n} q_j \\ w_F = v_I \sum_{j=1}^m q_j + v_F \sum_{j=m+1}^{m+n} q_j \end{cases} \quad (8)$$

Firms' profits are given by

$$\begin{cases} \Pi_h = (p_I - w_I)q_h & h = 1, \dots, m \\ \Pi_h = (p_F - (1+r)w_F)q_h & h = m+1, \dots, m+n \end{cases} \quad (9)$$

Substituting the prices and the wages by their expressions in terms of the quantities derived from Equations 6 and 8. We obtain the expressions of the profits in terms of the quantities:

$$\begin{cases} \Pi_h = v_I(1 - 2 \sum_{j=1}^{m+n} q_j)q_h & h = 1, \dots, m \\ \Pi_h = (v_F(1 - (2+r) \sum_{j=m+1}^{m+n} q_j) - v_I(2+r) \sum_{j=1}^m q_j)q_h & h = m+1, \dots, m+n \end{cases} \quad (10)$$

Writing the F.O.C with respect to quantities, we obtain Equations 11.

$$\begin{cases} -2q_h + 1 - 2 \sum_{j=1}^{m+n} q_j = 0 & h = 1, \dots, m \\ v_F(1 - (2+r) \sum_{j=m+1}^{m+n} q_j) - v_I(2+r) \sum_{j=1}^m q_j - v_F(2+r)q_h = 0 & h = m+1, \dots, m+n \end{cases} \quad (11)$$

We deduce that at equilibrium, for any $h = 1, \dots, m$, $q_h = q_I$ and for any $h = m+1, \dots, m+n$, $q_h = q_F$. Equations 11 becomes then

$$\begin{cases} -2(m+1)q_I - 2nq_F + 1 = 0 \\ -v_I(2+r)mq_I - v_F(2+r)q_F(n+1) + v_F = 0 \end{cases} \quad (12)$$

Solving Equations 12 gives the equilibrium quantities

$$\begin{cases} q_I^A(m, n) = \frac{v_F((2+r)(n+1)-2n)}{2(2+r)(v_F(n+1)(m+1)-v_I m)} \\ q_F^A(m, n) = \frac{2(m+1)v_F-(2+r)mv_I}{2(2+r)(v_F(n+1)(m+1)-v_I m)}. \end{cases} \quad (13)$$

Profits' expressions are obtained by substituting the quantities in Equations 13 in the profits of Equations 10.

- The case (2, 0): All firms are informal

In this case only the informal quality v_I is offered. Four groups of individuals appear depending on their consumption and working decisions. Individuals who buy the informal quality are characterized by $\theta > \frac{p_I}{v_I}$. Individual who work in the informal firm are characterized by $\alpha < \frac{w_I}{v_I}$.

We will proceed as in the previous case by establishing the results for any $m \geq 1$ informal firms. Balancing the supply and demand for the informal quality gives

$$1 - \frac{p_I}{v_I} = \sum_{j=1}^m q_j.$$

Balancing the supply and demand for labor give

$$\frac{w_I}{v_I} = \sum_{j=1}^m q_j.$$

We express p_I and w_I in terms of the quantities and we write the profit of an informal firm for $h = 1, \dots, m$ as

$$\Pi_h = (p_I - w_I)q_h = v_I(1 - 2 \sum_{j=1}^m q_j)q_h$$

The F.O.C of the profit Π_h with respect to the quantity q_h give $-2q_h + 1 - 2 \sum_{j=1}^m q_j = 0$ for $h = 1, \dots, m$. Thus, at equilibrium all firms produce the same quantity $q_h = q_I$ and we have $q_I = \frac{1}{2(m+1)}$ and we easily deduce that $\Pi_I = \frac{v_I}{2(m+1)^2}$.

We finally note that the expression of q_I given by Equations 13 equals $\frac{1}{2(m+1)}$ when we substitute n by 0.

- The case (0, 2): All firms are formal

In this case only the formal quality v_F is offered. Four groups of individuals appear depending on their consumption and working decisions. Individuals who buy the formal quality are characterized by $\theta > \frac{p_F}{v_F}$. Individual who work in the informal sector are characterized by $\alpha < \frac{w_F}{v_F}$.

We will proceed as in the previous case by establishing the results for any $n \geq 1$ formal firms. Balancing the supply and demand for the informal quality gives

$$1 - \frac{p_F}{v_F} = \sum_{j=1}^n q_j.$$

Balancing the supply and demand for labor give

$$\frac{w_F}{v_F} = \sum_{j=1}^n q_j.$$

We express p_F and w_F in terms of the quantities and we write the profit of a formal firm for $h = 1, \dots, n$ as

$$\Pi_h = (p_F - w_F(1 + r))q_h = v_F(1 - (2 + r) \sum_{j=1}^n q_j)q_h$$

The F.O.C of the profit Π_h with respect to the quantity q_h give $-(2 + r)q_h + 1 - (2 + r) \sum_{j=1}^n q_j = 0$ for $h = 1, \dots, n$. Thus, at equilibrium all firms produce the same quantity $q_h = q_F$ and we have $q_F = \frac{1}{(2+r)(n+1)}$. We easily deduce that $\Pi_I = \frac{v_F}{(2+r)(n+1)^2}$.

We finally note that the expression of q_F given by Equations 13 equals $\frac{1}{(2+r)(n+1)}$ when we substitute m by 0.

The survival of a formal firm under autarky ($q_2^A(m, n) > 0$) requires $\frac{v_F}{v_I} > \frac{(2+r)m}{2(m+1)}$ for $m = 0, 1$, which hold under the assumptions $r < 1$ and $v_F > \frac{2}{8}v_I$. ■

Proof of Lemma 2: We first obtain the expressions of $\Pi_F^A(0, 2)$, $\Pi_I^A(1, 1)$, $\Pi_F^A(1, 1)$ and $\Pi_I^A(2, 0)$ by substituting m and n by their values in the expressions of the profits given by Lemma 1.

$$\Pi_I^A(2, 0) = \frac{v_I}{18}; \Pi_F^A(0, 2) = \frac{v_F}{9(2+r)}; \Pi_I^A(1, 1) = \frac{v_I v_F^2 (2+2r)^2}{2(2+r)^2 (4v_F - v_I)^2} \text{ and } \Pi_F^A(1, 1) = \frac{v_F (4v_F - v_I (2+r))^2}{4(2+r) (4v_F - v_I)^2}.$$

We have that:

- (0,2) is an equilibrium if and only if $\Pi_F^A(0, 2) \geq \Pi_I^A(1, 1)$ which is equivalent to $g(r, \frac{v_F}{v_I}) \geq 0$.
- (1,1) is an equilibrium if and only if $\Pi_F^A(1, 1) \geq \Pi_I^A(2, 0)$ and $\Pi_I^A(1, 1) \geq \Pi_F^A(0, 2)$. Thus, (1,1) is an equilibrium if and only if $h(r, \frac{v_F}{v_I}) \geq 0$ and $g(r, \frac{v_F}{v_I}) \geq 0$.
- (2,0) is an equilibrium if and only if $\Pi_I^A(2, 0) \geq \Pi_F^A(1, 1)$ thus $h(r, \frac{v_F}{v_I}) \leq 0$

■

Proof of Lemma 3 This is an outline of the proof⁶. Let us consider the market structure (m, n) such that $m \geq 1$ and $n \geq 1$ (formal and informal firms coexist). Balancing the demand and supply in the market of the differentiated good gives Equations 14.

$$\begin{cases} 2\left(\frac{p_2 - p_1}{v_2 - v_1} - \frac{p_1}{v_1}\right) = \sum_{j=1}^m q_j \\ 2\left(1 - \frac{p_2 - p_1}{v_2 - v_1}\right) = \sum_{j=m+1}^{m+n} q_j \end{cases} \quad (14)$$

Balancing the demand and supply in the labor market, we obtain Equations 15.

$$\begin{cases} 2\left(\frac{w_1}{v_1} - \frac{w_2 - w_1}{v_2 - v_1}\right) = \sum_{j=1}^m q_j \\ 2\frac{w_2 - w_1}{v_2 - v_1} = \sum_{j=m+1}^{m+n} q_j \end{cases} \quad (15)$$

From Equations 14 and 15, we express the prices and the wages in terms of the quantities. We then fully express the profits of the formal and informal firms with respect to quantities.

⁶The complete proof of Lemma 3 follows the same reasoning as the proof of Lemma 1 and can be provided upon request.

The F.O.C of the profits give the equilibrium quantities⁷.

It is worth noting that the firms of the formal sector survive in all the situations where there are any, if and only if $q_F^{FI} > 0$. This is equivalent to $\frac{v_F}{v_I} > \frac{(2+r)m}{2(m+1)}$, for all m between 0 and 3, which hold thanks to the increasingness of $\frac{m}{m+1}$ with m and the assumptions $\frac{v_F}{v_I} > 9/8$ and $r < 1$. ■

Proof of Proposition 1: We first compare in each zones the formal wages and the informal wages when we move from Autarky to Full Integration.

In Zone I, only formal firms exist under both regime. We only compare formal wages. We have that $w_F^{FI}(0, 4) - w_F^A(0, 2) = \frac{2v_F}{15(2+r)} > 0$.

In Zone II, we only compare formal wages as no informal firm exists under Autarky. We have $W_F^{FI}(1, 3) - W_F^A(0, 2) = \frac{4v_F^2 + 3rv_I v_F}{6(2+r)(8v_F - 3v_I)} > 0$.

In Zone III, we only compare formal wages as no informal firm exists under Autarky. We have that $W_F^{FI}(2, 2) - W_F^A(0, 2) = \frac{(2+3r)v_I v_F}{3(2+r)(9v_F - 4v_I)} > 0$.

In Zone IV, we compare both the formal and informal wages. On one hand, $W_I^{FI}(2, 2) - W_I^A(1, 1)$ has the same sign as $\frac{v_F}{v_I}(10+6r) - (6+5r)$. This expression is always positive as $\frac{v_F}{v_I} > \frac{9}{8}$. On the other hand, $W_F^{FI}(2, 2) - W_F^A(1, 1)$ has the same sign as $12(\frac{v_F}{v_I})^2 - (r+12)\frac{v_F}{v_I} + 2r + 4$. This expression is always positive in Zone IV.

In Zone V, we have that $W_I^{FI}(3, 1) - W_I^A(1, 1)$ has the same sign as $4(1+r)\frac{v_F}{v_I}(2\frac{v_F}{v_I} - 1)$ which is positive as $\frac{v_F}{v_I} > \frac{9}{8}$ and we have that $W_F^{FI}(3, 1) - W_F^A(1, 1)$ has the same sign as $4(1+r)\frac{v_F}{v_I} > 0$.

In Zone VI, we only compare informal wages as no formal firm exists under Autarky. We have that $W_I^{FI}(3, 1) - W_I^A(2, 0)$ is of the same sign of $(2+r)\frac{v_F}{v_I} - (6+3r)$. This expression is positive as $\frac{v_F}{v_I} > \frac{9}{8}$.

In Zone VII, we only compare informal wages as no formal firm exists under both regimes. We have that $W_I^{FI}(4, 1) - W_I^A(2, 0) = \frac{v_I}{15} > 0$.

We now move to the comparison of the Formal-Informal wage gap. In Zone IV, the Formal- Informal wage gap under Autarky is given by $\Delta^A = w_F^A(1, 1) - W_I^A(1, 1) = \frac{4v_F^2 - (6+r)v_I v_F + (2+r)v_I^2}{2(2+r)(4v_F - v_I)}$. Under Full Integration, it is given by $\Delta^{FI} = w_F^{FI}(2, 2) - W_I^{FI}(2, 2) = \frac{6v_F^2 - 2(5+r)v_I v_F + 2(2+r)v_I^2}{(2+r)(9v_F - 4v_I)}$. We

⁷Equations 14 and 15 are only valid when both formal and informal firms coexist. The cases (4, 0) and (0, 4) are treated separately.

have that $\Delta^{FI} - \Delta^A$ is of the same sign as $12(\frac{v_F}{v_I})^2 - (22 + 7r)\frac{v_F}{v_I} + (10 + 7r) > 0$ in Zone IV.

In Zone V, the formal-informal wage gap under Autarky is given by $\Delta^A = w_F^A(1, 1) - W_I^A(1, 1) = \frac{4v_F^2 - (6+r)v_I v_F + (2+r)v_I^2}{2(2+r)(4v_F - v_I)}$. Under Full Integration, it is given by $\Delta^{FI} = w_F^{FI}(3, 1) - W_I^{FI}(3, 1) = \frac{8v_F^2 - (14+3r)v_I v_F + 3(2+r)v_I^2}{2(2+r)(8v_F - 3v_I)}$. We have that $\Delta^{FI} - \Delta^A$ is of the same sign as $4(1 + r)\frac{v_F}{v_I}(-\frac{v_F}{v_I} + 1) < 0$ as $\frac{v_F}{v_I} > \frac{9}{8}$.

■

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