

# Migrations and FDI: substitution and complementarity in an agent-based model

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# Outline

1. Motivation
2. Method: an agent-based model
3. The model
4. Main results
5. Conclusion

# 1. Motivation

## Background literature (I)

### FDI $\leftrightarrow$ Migrations

#### 1- FDI as a determinant of migrations

- ▶ Short run: FDI strengthen migrations:
  - ▶ ↗ wage (labor market channel)
  - ▶ ↘ migration cost (informational channel)
- ▶ Long run: FDI lessen migrations through the development of the FDI recipient country

Aroca and Maloney (2005); D'Agosto et al. (2006); Sanderson and Kentor (2008)

# 1. Motivation

## Background literature (II)

### 2- Migrations as a determinant of FDI

- ▶ Migrations increase FDI
  - ▶ ↘ cost (informational channel)

Docquier and Lodigiani (2010); Javorcik et al. (2011); De Simone and Manchin (2012); Kugler and Rapoport (2007, 2011)

# 1. Motivation

## Research question

**Under which conditions is there a substitution or a complementarity effect between capital and labor flows ?**

Definition of *substitution* (Wong, 2006)

- ▶ **In the quantitative sense:**  
when the exogenous increase of one factor implies the drop of the other factor
- ▶ **In the factor price equalization sense:**  
when the mobility of one factor is sufficient to allow for the equalization of remunerations

# 1. Motivation

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## 2. Method: an agent-based model

### Properties of ABM's

#### What is an ABM ?

- ▶ A computational simulation consisting in a virtual world with interacting heterogeneous agents.
- ▶ Agents have micro funded behaviors.
- ▶ The aggregation of the agents' actions gives rise to macro phenomena.
- ▶ Java, with Repast Symphony 2.1

## 2. Method: an agent-based model

### ABM's in migration

#### **ABM in migration**

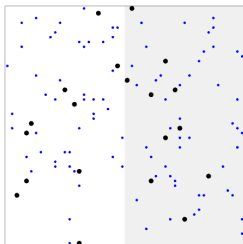
- ▶ Uncalibrated ABM on migrations  
Espindola et al. (2006); Silveira et al. (2006)
- ▶ Empirically funded ABM  
Klabunde (2012); Filho et al. (2011); Kniveton et al. (2011)



# 3. The model

## Overview (I)

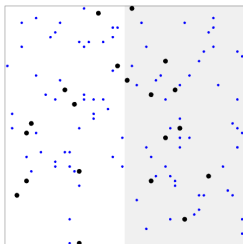
- ▶ a geographical space
- ▶ two identical countries ( $k$  and  $k'$ ) with the same technology:  
$$y_t^k = A (F_t^k)^\alpha (L_t^k)^{1-\alpha} \forall t, t = 1, \dots, T$$
- ▶ countries differ in their factors endowments:
  - ▶ nb of individuals ( $L$ ) and firms ( $F$ )
  - ▶ randomly placed in each country at the start of the simulation



# 3. The model

## Overview (II)

- ▶ heterogeneous individuals (with different characteristics):
  - ▶ geographical position
  - ▶ importance given to past information:  $b_i$
  - ▶ home preference:  $h_{i,t}$
  - ▶ risk aversion:  $r_{i,t}$
  - ▶ personal network:  $S_{i,t}$
- ▶ heterogeneous firms:
  - ▶ geographical position
  - ▶ importance given to past information:  $b_j$

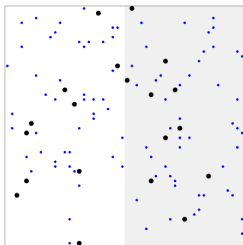


# 3. The model

## Overview (III)

- ▶ Agents' possible actions at each period:
  - ▶ individual:
    - ▶ Migrate/return or remain *in situ*  
(according to his characteristics and information)
  - ▶ firm:
    - ▶ Invest abroad, invest locally or do nothing  
(according to its characteristics)

⇒ the aggregation of agents' actions over time gives rise to capital and labor macro flows between countries



### 3. The model

#### Individual schedule (I)

#### (1) Wage and expected wage in the origin country

- ▶ wage:  $w_{i,t}^k \sim \ln \mathcal{N} \left[ \mu_t^k, (\xi^k)^2 \right] \forall i, i = 1, \dots, n; \forall t, t = 1, \dots, T$ 
  - ▶  $\mu_t^k = \log(MP) - \frac{1}{2} (\xi^k)^2$
  - ▶  $MP = A(1 - \alpha) \left( \frac{F_t^k}{L_t^k} \right)^\alpha$
  - ▶ average wage:  $\bar{w}_t^k = \frac{\sum_{i=1}^{L_t^k} w_{i,t}^k}{L_t^k} \simeq MP$
- ▶ expected wage:  
$$\exp \left( w_{i,t+1}^k \right) = \exp \left( \bar{w}_{i,t+1}^k \right) = \bar{w}_t^k + b_i \left( \bar{w}_t^k - \bar{w}_{t-1}^k \right)$$

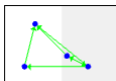
### 3. The model

#### Individual schedule (II)

#### (2) Network and expected wage abroad

- ▶ approximated wage abroad:  $\tilde{w}_{i,t}^{k'} = \frac{\sum_{n=1}^{M_{i,t}} w_{n,t}^{k'}}{\sum_{n=1}^n}$

- ▶  $M_{i,t} \subset N_{i,t}$



- ▶ expected wage abroad:

$$\exp(w_{i,t+1}^{k'}) = \exp(\tilde{w}_{i,t+1}^{k'}) = \tilde{w}_{i,t}^{k'} + b_i (\tilde{w}_{i,t}^{k'} - \tilde{w}_{i,t-1}^{k'})$$

### 3. The model

#### Individual schedule (III)

#### (3) Migration decision

- ▶ necessary conditions:

- ▶  $\exp(w_{i,t+1}^{k'}) - \exp(w_{i,t+1}^k) > 0$
- ▶  $w_{i,t}^k - c_t \geq 0$  with  $c_t = \omega \bar{w}_t$  (visa cost)

- ▶ sufficient condition:

$$P_{i,t} = \underbrace{\beta(1-h_{i,t})}_{\text{home preference}} + \underbrace{\gamma \frac{S_{i,t}}{S_t}}_{\text{network}} + \lambda \underbrace{\frac{\exp(w_{i,t+1}^{k'}) - \exp(w_{i,t+1}^k)}{\exp(w_{i,t+1}^k)}}_{\text{expected wage differential}} + \underbrace{\delta(1-r_{i,t})}_{\text{risk aversion}}$$

According to  $P_{i,t}$ : the individual draws a random number from a Bernoulli distribution. He migrates to a random place in the foreign country only if he draws 1.

### 3. The model

#### Individual schedule (IV)

#### (4) Moves inside his Moore neighborhood (at no cost)

- ▶ to have the possibility to extend his network i.e. to get better information



### 3. The model

#### Firm schedule (I)

#### (1) Capital remuneration and expected capital remuneration in the origin country

- ▶ capital remuneration:

$$\rho_{j,t}^k \sim \ln \mathcal{N} \left[ \sigma_t^k, (\zeta^k)^2 \right] \forall j, j = 1, \dots, n; \forall t, t = 1, \dots, T$$

- ▶  $\sigma_t^k = \log(MP) - \frac{1}{2} (\zeta^k)^2$

- ▶  $MP = A\alpha \left( \frac{L_t^k}{F_t^k} \right)^{1-\alpha}$

- ▶ average capital remuneration:  $\bar{\rho}_t^k = \frac{\sum_{j=1}^{F_t^k} \rho_{j,t}^k}{F_t^k} \simeq MP$

- ▶ expected capital remuneration:

$$\exp \left( \rho_{j,t+1}^k \right) = \exp \left( \bar{\rho}_{j,t+1}^k \right) = \bar{\rho}_t^k + b_j (\bar{\rho}_t^k - \bar{\rho}_{t-1}^k)$$



### 3. The model

#### Firm schedule (II)

#### (2) Expected profitability of a foreign investment

$$\blacktriangleright \exp(\rho_{j,t+1}^{k'}) = \exp(\bar{\rho}_{j,t+1}^{k'}) = \bar{\rho}_t^{k'} + b_j (\bar{\rho}_t^{k'} - \bar{\rho}_{t-1}^{k'})$$

# 3. The model

## Firm schedule (III)

### (3) Investment decision

- ▶ only the highly productive firms can realize investments (10% of the firms)
- ▶ a firm can realize a foreign investment or a local investment

### 3. The model

#### Firm schedule (IV)

#### Foreign investment

- ▶ necessary conditions:

- ▶  $\exp(\rho_{j,t+1}^{k'}) - \exp(\rho_{j,t+1}^k) > 0$
- ▶  $\rho_{j,t}^k - f_t \geq 0$  with  $f_t = z\bar{\rho}_t$

- ▶ sufficient condition:

$$P_{j,t} = \eta \underbrace{\frac{E(\rho_{j,t+1}^{k'}) - E(\rho_{j,t+1}^k)}{E(\rho_{j,t+1}^{k'})}}_{\text{remuneration differential}} + \underbrace{v \frac{L_t^{k'k}}{L_t^k}}_{\text{share of mig.}} + \underbrace{t \frac{F_{j,t}^{kk'}}{F_t^{k'}}}_{\text{mkt share abroad}} + \underbrace{\tau \frac{\bar{w}_t^{k'} - \bar{w}_t^k}{\bar{w}_t^{k'}}}_{\text{labor cost diff.}}$$

According to  $P_{j,t}$ : the firm draws a random number from a Bernoulli distribution. It realizes an FDI to a random position in the other country only if it draws 1.

### 3. The model

#### Firm schedule (V)

#### Local investment (at no cost)

- ▶ necessary condition:

- ▶  $\exp(\rho_{j,t+1}^{k'}) - \exp(\rho_{j,t+1}^k) < 0$

- ▶ sufficient condition:

According to  $(1 - P_{j,t})$  : the firm draws a random number from a Bernoulli distribution. It realizes an investment to a random position in its country only if it draws 1.

## 4. Main results

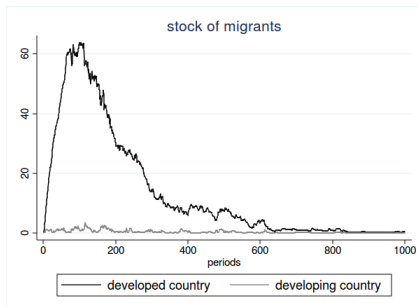
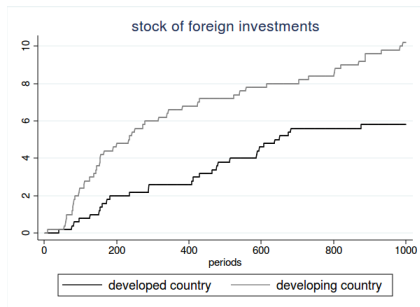
### Simulation parameters

- ▶ A (northern) developed country
- ▶ A (southern) developing country
- ▶ wage differential between the High income and the Low & Middle income countries groups in 2010 (WDI, World Bank, 2013)

number of individuals in the developed country	$L_t^k$	1080
number of individuals in the developing country	$L_t^{k'}$	450
number of firms in the developed country	$F_t^k$	225
number of firms in the developing country	$F_t^{k'}$	90

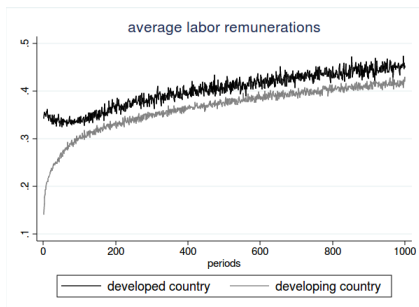
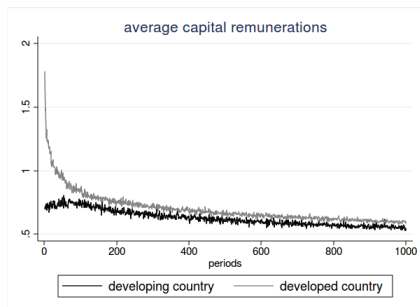
# 4. Main results

## Reproduction of standard theoretical results (I)



# 4. Main results

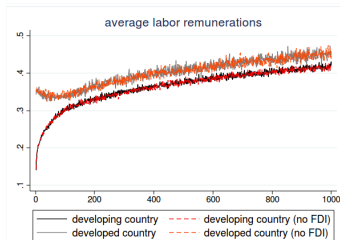
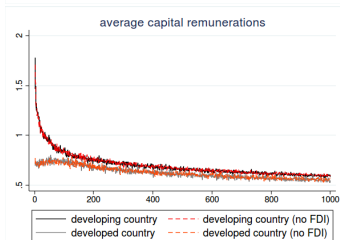
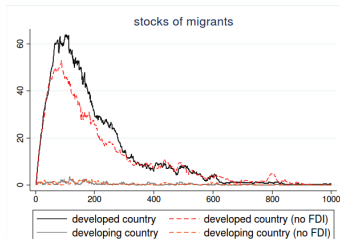
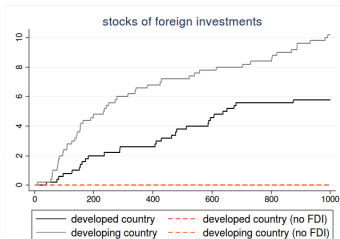
## Reproduction of standard theoretical results (II)



# 4. Main results

## Substitution and complementarity (I)

### Restrictions on FDI: prohibition of FDI

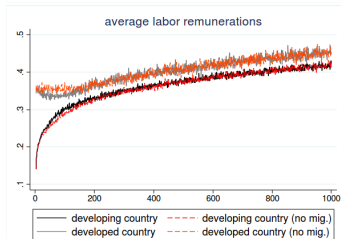
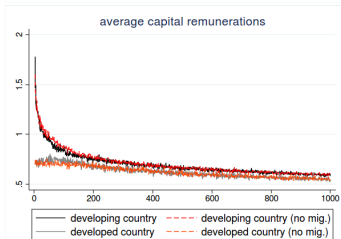
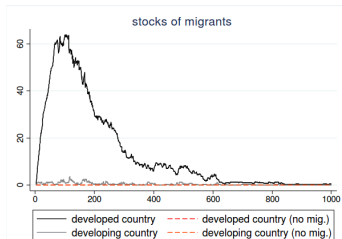
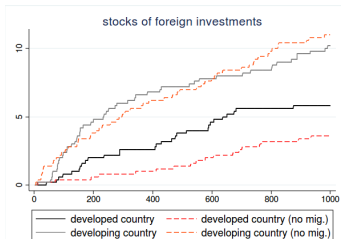




# 4. Main results

## Substitution and complementarity (II)

### Restrictions on labour mobility: prohibition of migrations



## 5. Conclusion

- ▶ Ergodic model
- ▶ Reproduction of standard stylized facts
- ▶ Complementarity and substitution
  - ▶ In the quantitative sense:
    - ▶ ↘ *FDI*
      - In the short run: FDI and migrations are complements
      - In the long run: no impact
    - ▶ ↘ *mig*
      - In the short run: FDI and migrations are complements
  - ▶ In the factor price equalization sense:
    - ▶ Migrations substitute FDI
    - ▶ FDI complement migrations

# Migrations and FDI: substitution and complementarity in an agent-based model

Léa Marchal

Clérmont-Ferrand, January 23-24, 2014

# Simulation parameters

## Environmental parameters

elasticity of substitution between factors	$\alpha$	0.5
number of individuals in the developed country	$L_t^k$	1080
number of individuals in the developing country	$L_t^{k'}$	450
number of firms in the developed country	$F_t^k$	225
number of firms in the developing country	$F_t^{k'}$	90
standard deviation of the wages distribution	$\xi$	0.8
standard deviation of the capital remunerations distribution	$\varsigma$	0.8
share of the world average wage (giving the migration cost)	$\omega$	1.0
share of the world average capital remuneration (giving the FDI cost)	$z$	0.5
% of firms allowed to make FDI	$x$	0.1

# Simulation parameters

## Individual's parameters

home preference effect	$\beta$	0.3
network effect	$\gamma$	0.3
wage differential effect	$\lambda$	0.2
risk aversion effect	$\delta$	0.2
risk aversion appreciation/depreciation index	$\Delta_r$	0.1
size of the Moore neighbourhood (1 = 8, 2 = 24, 3=48 surrounding cells)	$m$	2
radius of the area in which the individual is able to create a link	$\Omega$	2
weight of a relationship at its creation		1
depreciation of a relationship over time	$d$	0.5

# Simulation parameters

## Firm's parameters

capital remuneration differential effect	$\eta$	0.3
foreign presence effect	$\nu$	0.2
network of firms effect	$\iota$	0.3
wage differential effect	$\tau$	0.2