# Overview

on considere une economie constituee de:

- 02 secteurs: rural et urbain

- 02 secteurs urbains: formel et informel

- 02 secteurs informels: avance et retarde

les formes de dualismes considerees sont:

- le dualisme geographique (urbain/rural)

- le dualisme technologique (avancee/retarde)

- le dualisme du marche du travail (formel/informel)

On a donc 04 secteurs $k$ dans lequel sont regroupes les entreprises:

- un secteur rural ($k = 1$)

- un secteur urbain formel ($k = 2$)

- un secteur urbain informel avancee ($k = 3$)

- un secteur urbain informel retardee ($k = 4$)

| | Secteur 1 | Secteur 2 | Secteur 3 | Secteur 4 |

| --- | --- | --- | --- | --- |

| Region | Rural | Urbain | Urbain | Urbain |

| Type de travail | Informel | Formel | Informel | Informel |

| Acces au credit | Non | Oui | Oui | Non |

| Biens produits | Agricoles | Manufacturees | Manufacturees | Intermediaires |

| Technologie | Retardee | Avancee | Avancee | Retardee |

On a egalement 06 categories $z$ de menages:

| Categorie | Secteur | Statut | Description |

|:-:| --- | --- | --- |

| 1 | rural | entrepreneur | paysans |

| 2 | urbain formel | entrepreneur | entrepreneurs formels |

| 3 | urbain informel | entrepreneur | entrepreneurs informels |

| 4 | urbain formel | salaries | salaries formels |

| 5 | urbain informel | salaries | salaries informels |

| 6 | urbain | \*aucun\* | chomeurs |

Une approche en termes d'informalite base sur le concept de degre d'informalite.

On regroupe des les normes qui sont les regles formelles que doivent resspecter une entreprise dans un cadre institutionnel donne. Distinguons alors deux normes:

- les normes du travail (regles formelles regissant la relation salariale)

- les normes de credit (regles formelles regissant l'acces au credit bancaire)

on peut alors segmenter le marche du travail en deux segments:

- le marche du travail formel (ou les participants respectent les normes du travail)

- le marche du travail informel (ou les participants respectent les normes du travail)

on peut egalement segmenter le marche du credit en deux segments:

- le marche du credit formel (ou les participants respectent les normes du credit)

- le marche du credit informel (ou les participants respectent les normes du credit)

les niveaux d'informalite sont alors:

| Niveaux | Respect des normes |

|---| ---|

|Informel (0)| Ne respecte aucune norme|

|Semi-formel (1)| Ne respecte qu'un groupe de normes |

|Formel (2) | Respecte toutes les normes |

si l'on note:

- $n$ le degre d'informalite

- $n^N$ le respect des normes du travail

- $n^L$ le respect des normes du credit

on a:

$$

n = n^N + n^L

$$

Pour l'emploi on peut donc definir une structure de l'emploi comme un repartition des emploi entre le secteur prive et public et le segment formel et informel du marche du travail:

| |Travail Formel|Travail Informel| $\Sigma$ |

|--- | :-: | :-: | :-: |

| Secteur Prive | $N\_{F1}$ | $N\_{F2}$ | $N\_{F}$ |

| Secteur Public | $N\_{G}$ | | $N\_{G}$ |

| $\Sigma$ | $N\_1$ | $N\_2$ | $N$ |

Pour l'informalite on peut egalement definir une repartition des firmes dans un secteur $k$ comme suit:

| |Travail Formel|Travail Informel| $\Sigma$ |

|--- | :-: | :-: | :-: |

|Credit Formel | $Z\_{Fk11}$ | $Z\_{Fk12}$ | $Z\_{Fk1.}$ |

|Credit Informel | $Z\_{Fk21}$ | $Z\_{Fk22}$ | $Z\_{Fk2.}$ |

| $\Sigma$ | $Z\_{Fk.1}$ | $Z\_{Fk.2}$ | $Z\_{Fk}$ |

## Purpose and Patterns

## Entities, State Variables, and Scales

## Process overview and scheduling

# Design Concepts

## Basic Principles

## Emergence

## Adaptation

## Objectives

## Learning

## Prediction

## Sensing

## Interaction

During each period of the simulation agents interact on six types of spaces:

* Regions: all agents interact with neighbors;
* Goods markets: households interact with firms;
* Labor markets: households interact with government and firms;
* Credit market: firms interact with banks;
* Deposit market: households and firms interact with banks;
* Bonds market: government interact with banks and central banks.

### Matching protocols

Following Riccetti et al. (2014), we explicitly model agents' dispersed interactions by assuming that agents on the demand and supply sides of each market interact through a common matching protocol. In each period of the simulation, ‘demand’ agents are allowed to observe the prices or the interest rates charged by a random subset of suppliers (whose size depends on a parameter χ reflecting the degree of imperfect information). Agents' switch from the old partner to the best potential partner selected in this random subset with a probability Prs which is defined, following Delli Gatti et al. (2010a), as a non-linear (decreasing when the price/interest represents a disbursement for the demander, increasing otherwise) function of the percentage difference in their prices pold and pnew. The shape of this function is governed by the ‘intensity of choice’ parameter ε 4 0: higher values of ε 4 0 imply a higher probability of switching.11 In some cases, some suppliers exhaust inventories available for sale, possibly leaving some customers with a positive residual demand. We then allow demand agents to look for other suppliers within the original random subset of potential partners in order to fulfill it. Markets interactions are ‘closed’ when demand agents have fulfilled their demand, when there are no supply agents willing or able to satisfy their demand, or if demanders run out of deposits to pay for demanded goods.

### Economic transactions and financial transfers

Agents' interactions generate several types of economic transactions and financial transfers. As argued before, a clear-cut description of the types of real and financial flows taking place in the model is a key aspect for assessing the accounting and logical consistency of a model. Hence, we classify the flows arising in the model as follows:

Deposit transfers: If agents involved hold their deposits at the same bank, payer's deposit is decreased and receiver's increased. Otherwise, also a reserve transfer for the same amount from the payer's bank to the receiver's bank takes place. The same occurs when an agent decides to move its deposits to a new bank.

Dividends and deposits interests: Firms pay dividends through deposit transfers. Interests on deposits are paid by simply increasing customers' deposits by the required amount. The same occurs for dividends, when the receiver holds a deposit at the paying bank. Otherwise, also a reserve transfer for the dividend amount from the paying bank to the receiver's bank takes place.

Private workers' wages: wages of private workers by firms are paid via a deposit transfer, as explained above.

Public servants' wages and dole: public workers' wages and unemployment benefits give rise to the same type of transfers. The receiver's deposit is increased while reserves are subtracted to the government account at the Central Bank and transferred to the receiver's bank.

Taxes: firms' and households pay taxes using their deposits. Accordingly, the payer's bank transfers reserves for the same amount to the government account at the Central Bank. Banks pay taxes by transferring reserves to the government account at the Central Bank.

Purchases of real goods: transactions in real goods are cleared via a deposit transfer. Contextually, also real goods motivating the transaction are transferred from the seller's to the buyer's asset side.

Purchases of bonds, repayment, and interests: Bonds are a liability for the government and an asset for banks and the Central Bank. Central Bank's purchases increases its liabilities (i.e. reserves, that is legal money) while also increasing the government account at the Central Bank. Interests on bonds are immediately re-distributed to the government. Commercial banks purchases of bonds are cleared via a transfer of reserves from banks to the government current account at the Central Bank. Bonds repayments and bonds interest payments give rise to the opposite flows.

Loans creation, repayment, and interests: Loans and matching deposits are created endogenously and ex-nihilo as explained above. Interest payments and principal repayments (reducing the stock of loans) give rise to the same type of transfers. If borrower's deposit bank coincides with the lending bank, the payment is realized by lowering the borrower's deposit. If the borrower's moved his deposits to another bank, also a corresponding reserves transfer from the borrower's bank to the lending bank takes place.

Cash advances creation, repayment, and interests: Cash advances are a loan extended by the Central Bank to commercial banks which is matched by a temporary increase of banks' reserves (a liability for the Central Bank). Conversely, cash advances repayments extinguished the loan while reducing commercial banks' reserve accordingly. Interest payments give rise to the same type of transfer, reducing private banks' reserves. Interests on cash advances are distributed to the government by increasing its deposit account at the Central Bank.

## Stochasticity

## Collectives

## Observation

# Details

## Initialization

we adopted the six-step strategy proposed by Caiani et al. [1]. This strategy involves:

1. creating an aggregate version of the agent-based model
2. constraining it to a real stationary state (SS) associated with a nominal steady growth of prices and wages 
3. numerically solving the constrained model with reasonable values of parameters to obtain initial values of stocks, flows and prices
4. distributing these initial values uniformly across agents created within each sector
5. determining the original amount, outstanding values, age of durable stocks
6. setting the initial network configuration by assigning randomly contractors or suppliers to agents

presenter les matrices de stocks et flux a obtenir

Ce modele s’inspire du modele GROWTH de Godley et Lavoie [2]. Dans ce modele on considere qu’il n’ya pas d’inventaires ou de capital fixe.

On suppose qu’il n’y a pas de changement dans la valeur des fonds propres (on suppose que les marches financiers sont inexistants)

### Computation of initial stocks, flows and prices

We divided the SS system of equations of the aggregated model in four sub-systems or block. Description de la methode de resolution

### Creation of agents, networks and environment

presentation des agents, de la méthode de creation des networks, du placement des agents dans l’environment.

## Input Data

parametres

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Code** | **Description** |
|  | g\_ss | Grow rate of prices and wages in stationary state |
|  | N\_E1 | Number of entrepreneurs in sector 1 |
|  | N\_E2 | Number of entrepreneurs in sector 2 |
|  | N\_E3 | Number of entrepreneurs in sector 3 |
|  | N\_W1 | Number of employees in sector 1 |
|  | N\_W2 | Number of employees in sector 2 |
|  | N\_W3 | Number of employees in sector 3 |
|  | N\_WG | Number of employees in public sector |
|  | N\_U | Number of unemployed |
|  | phi1 | Productivity in sector 1 |
|  | phi2 | Productivity in sector 2 |
|  | phi3 | Productivity in sector 3 |
|  | w1 | Initial wage in sector 1 |
|  | w2 | Initial wage in sector 2 |
|  | w3 | Initial wage in sector 3 |
|  | w\_G | Initial wage in public sector |
|  | w\_min | Minimum wage |
|  | tau | Tax rate |
|  | rho | Dividend policy |
|  | m | Markup rate |
|  | alpha\_b1 | Propension to consume goods 1 in urban region |
|  | alpha\_a2 | Propension to consume goods 2 in rural region |
|  | theta\_W | Desired liquidity share of wage bill |
|  | theta\_E | Initial equity share of banks assets |
|  | theta\_M | Initial bank liquidity ratio |
|  | theta\_Zbar | Reglementary portion of minimum wage dedicated to dole |
|  | r\_D | Interest rate on deposits |
|  | r\_L | Interest rate on loans |
|  | r\_B | Interest rate on bonds |
|  | r\_A | Interest rate on cash advances |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

## Submodels

### Balance sheet (stock consistency)

Table 1. Balance sheet of Dual Monetary Economy

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | Central bank |  |
| HP Money |  |  |  |  |  |  |
| Cash Advances |  |  |  |  |  |  |
| Deposits |  |  |  |  |  |  |
| Bonds |  |  |  |  |  |  |
| Loans |  |  |  |  |  |  |
| Equities |  |  |  |  |  |  |
| Balance |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Transactions Matrix (flow consistency)

Table 2. Transactions matrix of Dual Monetary Economy

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Consumption |  |  |  |  |  |  |
| Wages |  |  |  |  |  |  |
| Transfers |  |  |  |  |  |  |
| Taxes |  |  |  |  |  |  |
| Interests on advances |  |  |  |  |  |  |
| Interests on bonds |  |  |  |  |  |  |
| Interests on loans |  |  |  |  |  |  |
| Interests on deposits |  |  |  |  |  |  |
| Entrepreneurial profits |  |  |  |  |  |  |
| Central Bank profits |  |  |  |  |  |  |
| Change in advances |  |  |  |  |  |  |
| Change in bonds |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in loans |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
| Change in equities |  |  |  |  |  |  |
| Loan defaults |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Primary sector initial state (steady state)

The first block contains the equations which refer to firms of the primary sector.

let x be the variation and y the rate, such that:





In the equations, letters in bold type indicate the dependent variables of the system. All other variables and parameter values are set exogenously to characterize numerically the SS. The first block is a system of ten equations in ten unknowns referring to capital firms and, indirectly, to banks, as far as loans and deposits in the capital sector balance sheet are concerned. Eq. (A.1) states that workers employed in the capital sector Nk should be equal to the real output of capital firms yk divided by labor productivity μN. Prices of capital goods pk (Eq. (A.3)) are a markup muk over unit (variable) costs, which are equal to wages W over labor productivity (Eq. (A.2)). Capital firms want to hold an amount of deposits Dk equal to a fraction sigma of wages paid to workers (Eq. (A.4)). Since we have stationary state in real terms, capital firms' real output is exactly equal to replacement investment realized by consumption firms' ic in order to replace obsolete capital. This in turn is equal to total real capital k over real capital duration κ (Eq. (A.5). Real capital inventories (Eq. (A.6)) are constant and equal to a share ν of real output (i.e. sales). Profits of capital firms are revenues from sales plus interests on previous period deposits, plus the variation of nominal inventories (evaluated at their unit costs of production uck), minus wages and interests paid on the previous-period stock of loans (Eq. (A.7)). Notice that past period values of nominal variables will be equal to the current value divided by ð1 þ gSSÞ, gSS being the exogenously imposed SS nominal rate of growth. A fraction τk of profits goes to pay taxes (Eq. (A.8)), while a share ρk of remaining net profits is distributed as dividends to households (Eq. (A.9)). Finally, for accounting reasons the variation of loans (Eq. (A.10)) should be equal to the sum of the variation in the nominal value of inventories and the variation of deposits, minus retained earnings (see the KA column for the capital sector in the Transaction Flow Matrix presented in Appendix A)



























### Secondary sector initial state (steady state)

The second block of equations refers to consumption firms. Workers employed in the consumption sector are computed by dividing output for labor productivity in the consumption sector (Eq. (A.11)). By definition, labor productivity in the case of a technology which employs labor and capital fixed coefficients is equal to the product of capital productivity μk and the fixed capital-labor ratio lK. Prices are a markup muc over unit variable costs (Eq. (A.15)), defined as wages paid to workers over output (Eq. (A.12)). Unit costs are computed as overall production costs, including the financial amortization of capital, divided by output (Eq. (A.13)). Since we are in a real stationary state and given the assumption that capital lasts for κ periods, consumption firms invest in each period to buy an amount of k=κ capital goods in order to replace the batch of obsolete capital (purchased κ periods ahead) thus keeping the total stock of capital k constant. Since we further assume a linear financial amortization of capital, consumption firms register an amortization cost equal to a share 1=κ of the disbursement originally incurred to buy each batch of capital. This disbursement was equal to k κ pk ð1 þ gSSÞt for each batch purchased t 1⁄4 1; ...; κ periods ahead. Therefore amortization costs are equal to pkk κ2 Pj 1⁄4 1 κ1 ð1 þ gSSÞj. Following the same reasoning, we can determine the nominal value of the stock of capital held by consumption firms Kc as expressed by Eq. (A.14). Consumption firms want to hold a share σ of wages as deposits (Eq. (A.16)). Output is given by the stock of capital multiplied by the rate of capacity utilization u and by the productivity of capital (Eq. (A.17)). Real inventories are a share of real sales, which in the SS are equal to output (Eq. (A.18)). Profits in the case of consumption good producers differ from those of capital firms, as they also include the amortization cost of previously purchased capital batches (Eq. (A.19)). Taxes and dividends are then defined as in the case of capital good producers (Eqs. (A.20) and (A.21)). The variation of loans granted to consumption firms can be obtained by exploiting the capital account identity (see column KA for the consumption sector in the Transaction Flow Matrix presented in Appendix A) for the consumption sector. The difference with respect to the correspondent equation for capital firms is the inclusion of the investment and amortization flows (Eq. (A.22)):























### Banks sector initial state (steady state)

The third block of equations encompasses the relations referring to the households and banking sectors, plus those related to the public sector which is composed of the general government and the central bank.

Profits by banks are the sum of interests on the previous period outstanding stock of loans, plus interests paid by the government on the stock of bonds held by banks, minus interests paid on deposits of households and firms (Eq. (A.22)).48 Banks pay taxes (Eq. (A.32)) and distribute a share of net-profits to households (Eq. (A.33)). Banks' net worth is defined as the difference between assets, that is loans, bonds, and reserves, and liabilities, which are represented by customers' deposits (Eq. (A.34)). Given the structure of the economy banks reserves (Eq. (A.35)) are exactly equal to central bank's holdings of government bonds (see the Balance Sheet Matrix of the economy presented in the Appendix A), which are defined as the a residual (Eq. (A.36)).

the third refers to banks and the public sector (government and central bank).





















### Households initial state (steady state)

Total employment is given by the sum of workers hired by the consumption, capital, and public sectors (Eq. (A.23)). Households' income is composed of wages, interests on deposits, dividends and the tax-exent dole ωW that unemployed workers receive from the government. Dividends are distributed by firms and bank to households at the end of the period, after households have consumed and firms and banks have paid taxes. Therefore, we assume that dividends from period t 1 enter in the (behavioral) definition of the gross income of households of period t (although they have already increased the amount of deposits held by households in period t 1, see equation ...). Net income is then defined by Eq. (A.24), whereas taxes paid by households are given by Eq. (A.25). Real consumption is a function of real net income and the real net-wealth inherited from the previous period (Eq. (A.26)). Given the stationary state condition real consumption is exactly equal to the amount of goods produced by consumption firms (Eq. (A.27)). Nominal consumption is obtained by multiplying real consumption for the price of consumption good (Eq. (A.28)). The variation of households' net worth obviously depends on the difference between net-income, as defined above, and consumption. However, since the definition of net income given above includes a the flow of dividends paid at the end of the previous period (thus already increasing households' net worth), while neglecting current period dividends, we respectively subtract and add them in the equation to get the right dynamics for households' net worth (Eq. (A.29)). Households' net wealth takes the form of banks' deposits (Eq. (A.30)):

urban households:





















### Public sector initial state (steady state)

The variation of government debt is given by the difference between government outlays for wages of public servants, unemployment benefits and interests on past period public debt, and government revenues from taxes and central bank's profits (Eq. (A.37)). This latter are just represented by interest on bonds held by the central bank, which are promptly returned to the government (Eq. (A.38)):

















**References**

1. Caiani, Alessandro, Antoine Godin, Eugenio Caverzasi, Mauro Gallegati, Stephen Kinsella, and Joseph E. Stiglitz. 2016. Agent based-stock flow consistent macroeconomics: Towards a benchmark model. *Journal of Economic Dynamics & Control*: 375–408.

2. Godley, Wynne, and Marc Lavoie. 2007. *Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth*. Vol. 86. Palgrave Macmillan.