# Purpose and Patterns

The proximate purpose of the model is to predict the dynamic effects of labor market reform on employment structure in a dual monetary economy. The ultimate purpose of the model, which will be presented in follow-up work, is to evaluate the effectiveness of employment policies in sub-saharian African economy through their state-dependent effect.

This model was designed by combining a simplified version of the Multi-country Agent-based model of Caiani and all [1] with a simplified two-sector model of dual economy from XXXX. The model of caiani has been used for exploring the effects of alternative wage regimes and suited to our goals to explore similar effects in a new context. To consider this new context, we therefore use two-sector model of XXXX.

We evaluate our model by its ability to reproduce three patterns. The first two are of primary importance because they were observed in extensive laboratory experiments by Loose and Dawidowicz (1994) and appear driven directly by the risk-growth tradeoff (Figure 5.1)...

The labor market context in developing countries As readers of this journal well know the guiding paradigm for the analysis of labor markets in the developed countries is the wage labor market. We picture the typical employee going to the same office, store, or factory day after day and earning a wage or salary that is payable each week or month. As we move down the income scale to middle-income countries and then to low-income countries, other types of work arrangements gain in importance. In the developing countries, steady wage employment of the type found in the developed countries is the exception, not the norm. Workers in poor countries want jobs that are steady and secure, pay well, offer benefits, meet labor standards, and offer social protections — ones that have been called “good jobs.” The problem they face is that there are not enough good jobs for all who want them and are capable of performing them. Here are some of the salient features about labor markets in developing countries. For further details, see Fields (2011)[2]:

* *The unemployment rate in developing countries is lower than it is in developed countries*: Economists and other labor market analysts use the terms “employment” and “unemployment” in accordance with specific definitions prescribed by the International Labour Organisation (ILO). The unemployment rates in the developed economies and the European Union are above average (8.4%) while those in East Asia and South Asia are below average (both 4.4%) (ILO, 2011). The fact that unemployment rates are lower in the developing countries is taken by many as a sign that the unemployment rate is a poor measure of labor market distress.
* *Earnings levels are very low despite long work hours* : In much of Asia, Latin America, and Africa, daily wages are no more than one or two U.S. dollars per day. People are working more often than not, working very long hours. The poor in the developing world are poor despite working long hours.
* *Not only are incomes low but they are also uncertain* : The poor face a “triple whammy”: low incomes when they are working, irregular and unpredictable income flows, and a lack of suitable financial tools (Collins et al., 2009). They respond by managing their money carefully.
* *The composition of employment is very different in developing countries from what it is in developed countries* : As compared with the developed countries, the developing countries have a smaller percentage of people working in offices and factories and a larger percentage working in agriculture. In the developing countries, self-employment, own-account work, and unpaid family work are more important, and paid employment is less important.
* *The great majority of those working in developing countries work in the private sector, not the public sector. A large majority of those who work in the private sector are not registered with the government and therefore do not receive job-related social protections* : Nine out of ten workers in the developing world are in the private sector. In a typical low-income country, some 90% of these workers are excluded from government-run economic security programs.
* *Typically, the better jobs are in wage employment, not self-employment. But within wage employment, the regular wage jobs are better than casual wage jobs* : For these reasons, “everybody” in developing countries wants a regular wage job.
* *The problem the poor face is that not enough regular wage employment is available for all who would like wage jobs and are capable of performing them* : Would-be wage employees could respond to the lack of wage jobs by remaining unemployed and continuing to search. However, few do, for the simple reason that they cannot afford to. They find it better to create their own self-employment opportunities. Banerjee and Duflo (2007, p. 162) write: “Nothing seems more middle class than the fact of having a steady well-paying job. While there are many petty entrepreneurs among the middle class, most of them do not seem to be capitalists in waiting. They run businesses, but for the most part only because they are still relatively poor and every little bit helps. If they could only find the right salaried job, they might be quite content to shut their business down.”
* *Developing country labor markets are usually thought to be segmented* : While definitions differ, the one I prefer has two defining features: first, for workers of any given skill level, some jobs are decidedly better than others; and second, access to the better jobs is rationed in the sense that not all who want those jobs and who are capable of performing them are able to get them. Segmented labor market models will be discussed in depth in Section 3.
* *Not all microenterprise operators and family workers are doing such work involuntarily* : Some could be working as wage employees but choose not to for reasons such as wanting to be their own bosses, trying to make it big on their own, and (especially for women) simultaneously working and fulfilling child-care responsibilities. Surely, some of the selfemployed are doing so by choice, but how a large a percentage they are remains unsettled in the literature.
* *Apart from low earnings levels and lack of social protections, a large number of jobs are downright miserable* : It is this fact that has led the ILO to organize its efforts around the theme of Decent Work and to try to close the Decent Work Deficit.
* *What the developing countries have is an employment problem — that is, poverty among those who work — rather than an unemployment problem* : While more than 200 million people are unemployed, some 1300 million people (i.e., 1.3 billion) belong to the working poor, defined as workers who live in families below the internationally-used two dollar a day poverty line. In other words, 85% of the world's poor are in working families.

# Entities, State Variables, and Scales

The following entities are included in the model: agents representing construction stakeholders (i.e. awarding authorities, engineers, architects and contractors), projects, grid cells (i.e. virtual geographical location) and the global environment representing the construction market (i.e. construction investments and materials available).

## Agents

### Households

Farms are agents that integrate the economic concepts of firms and households. They are characterized by their capital and investment strategy. These variables guide the farms in their investment, production, consumption, and their utility evaluation. We distinguish three types of farms depending on their investment strategy: collaborative farms (represented by value 0), ignorant farms (represented by value 1), and witty farms. Witty farms use expectations, they either follow an adaptive rule (represented by value 2), or a trend-follower rule (represented by value 3). When a witty farm follows an adaptive rule, the value of the adaptive constant can take two values. Similarly, the trend following rule can also take two values. The variables and parameters characterizing these agents are listed in the following tables

Table 1. Household real state variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | s\_U |  | indicator variable of unemployed |
|  | s\_W |  | indicator variable of employee |
|  | s\_WG |  | indicator variable of civil servant |
|  | s\_E |  | indicator variable of entrepreneur |
|  | s\_EB |  | indicator variable of bank owner |
|  | s\_Y |  | sector of production |
|  | n\_W |  | degree of formality of job |
|  | l |  | labour employed |
|  | l\_S |  | labour supply |
|  |  |  |  |

Table 2. Household nominal state variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | Variable | **Domain** | **Description** |
|  | E |  | equities |
|  | E\_star |  | equities desired |
|  | D |  | deposits |
|  | D\_star |  | deposits desired |
|  | M |  | cash |
|  | V |  | net worth |
|  | Z |  | doles received |
|  | W |  | wage received |
|  | w\_D |  | reservation wage |
|  | C\_star |  | desired consumption |
|  | C1 |  | consumption of goods 1 |
|  | C2 |  | consumption of goods 2 |
|  | iota\_D |  | deposits interests |
|  | Pi\_d |  | dividends received |

### Firms

Farms are agents that integrate the economic concepts of firms and households. They are characterized by their capital and investment strategy. These variables guide the farms in their investment, production, consumption, and their utility evaluation. We distinguish three types of farms depending on their investment strategy: collaborative farms (represented by value 0), ignorant farms (represented by value 1), and witty farms. Witty farms use expectations, they either follow an adaptive rule (represented by value 2), or a trend-follower rule (represented by value 3). When a witty farm follows an adaptive rule, the value of the adaptive constant can take two values. Similarly, the trend following rule can also take two values. The variables and parameters characterizing these agents are listed in the following tables

Table 3. Firm status variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | s\_Y |  | sector of production |
|  | n\_W |  | degree of formality on labor market |
|  | n\_T |  | degree of formality on credit market |
|  |  |  |  |

Table 4. Firm real stock and flow variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | N\_J |  | number of vacant job opened |
|  | l |  | labour employed |
|  | l\_D |  | labour demand |
|  | y |  | production |
|  | y\_inv |  | production unsold (inventories) |
|  | y\_star |  | production desired |
|  |  |  |  |
|  |  |  |  |

Table 5. Firm nominal stock and flow variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | E |  | equities |
|  | L |  | loans |
|  | L\_D |  | credit demand |
|  | L\_def |  | loan default |
|  | D |  | deposits |
|  | M |  | cash |
|  | V |  | net worth |
|  | W |  | wage bill |
|  | Q |  | nominal sales |
|  | iota\_D |  | deposits interests |
|  | iota\_L |  | loans interests |
|  | Pi |  | profit |
|  | Pi\_d |  | dividends |
|  | T |  | taxes payed |

Table 6. Firm price variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | w |  | wage offered |
|  | p\_Y |  | price offered |
|  | r\_L |  | loans interest rate |
|  |  |  |  |

Table 7. Firm parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | delta |  | adjustment parameter |
|  | theta\_y |  | desired proportion of inventories |
|  | upsilon\_F |  | elasticity of wage adjustment probability |
|  | phi |  | productivity |
|  |  |  |  |
|  |  |  |  |

### Banks

Farms are agents that integrate the economic concepts of firms and households. They are characterized by their capital and investment strategy. These variables guide the farms in their investment, production, consumption, and their utility evaluation. We distinguish three types of farms depending on their investment strategy: collaborative farms (represented by value 0), ignorant farms (represented by value 1), and witty farms. Witty farms use expectations, they either follow an adaptive rule (represented by value 2), or a trend-follower rule (represented by value 3). When a witty farm follows an adaptive rule, the value of the adaptive constant can take two values. Similarly, the trend following rule can also take two values. The variables and parameters characterizing these agents are listed in the following tables

Table 8. Bank state variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | E |  | equities |
|  | L |  | loans granted |
|  | L\_def |  | loan default |
|  | D |  | deposits |
|  | M |  | reserves |
|  | B |  | bonds |
|  | A |  | cash advances |
|  | V |  | net worth |
|  | iota\_D |  | deposits interests |
|  | iota\_L |  | loans interests |
|  | iota\_B |  | bonds interests |
|  | iota\_A |  | advances interests |
|  | Pi |  | profit |
|  | Pi\_d |  | dividends |
|  | T |  | taxes payed |

Table 9. Bank parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | delta |  | adjustment parameter |
|  | theta\_Ebar |  | minimum capital ratio |
|  | theta\_Rbar |  | minimum liquidity ratio |
|  | beta\_L |  | elasticity of interest rate to leverage ratio |
|  | gamma\_L |  | elasticity of loan probability to leverage ratio |
|  |  |  |  |
|  |  |  |  |

### Government

Farms are agents that integrate the economic concepts of firms and households. They are characterized by their capital and investment strategy. These variables guide the farms in their investment, production, consumption, and their utility evaluation. We distinguish three types of farms depending on their investment strategy: collaborative farms (represented by value 0), ignorant farms (represented by value 1), and witty farms. Witty farms use expectations, they either follow an adaptive rule (represented by value 2), or a trend-follower rule (represented by value 3). When a witty farm follows an adaptive rule, the value of the adaptive constant can take two values. Similarly, the trend following rule can also take two values. The variables and parameters characterizing these agents are listed in the following tables

Table 10. Government state variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | M |  | reserves |
|  | B |  | bonds sold |
|  | B\_S |  | bonds supply |
|  | iota\_B |  | bonds interests |
|  | Pi |  | profit |
|  | T |  | taxes payed |
|  | Z |  | doles payed |
|  | W |  | wages payed |
|  | w |  | wage offered |
|  |  |  |  |

### Central Bank

Farms are agents that integrate the economic concepts of firms and households. They are characterized by their capital and investment strategy. These variables guide the farms in their investment, production, consumption, and their utility evaluation. We distinguish three types of farms depending on their investment strategy: collaborative farms (represented by value 0), ignorant farms (represented by value 1), and witty farms. Witty farms use expectations, they either follow an adaptive rule (represented by value 2), or a trend-follower rule (represented by value 3). When a witty farm follows an adaptive rule, the value of the adaptive constant can take two values. Similarly, the trend following rule can also take two values. The variables and parameters characterizing these agents are listed in the following tables

Table 11. Central Bank state variables

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Variable** | **Domain** | **Description** |
|  | M |  | reserves |
|  | B |  | bonds |
|  | A |  | cash advances |
|  | iota\_B |  | bonds interests |
|  | iota\_A |  | advances interests |
|  | Pi |  | profit |

## Spaces

### Economy

cells are the lowest-level habitat entities; habitat variation within a cell is not represented (except via cell variables such as the fraction of the cell providing velocity shelter). Each cell represents a two-dimensional polygon in the horizontal plane. Most habitat characteristics are represented as cell state variables (Table 3). Because there are many cells, static cell variables are treated as state variables instead of parameters.

### Goods market

cells are the lowest-level habitat entities; habitat variation within a cell is not represented (except via cell variables such as the fraction of the cell providing velocity shelter). Each cell represents a two-dimensional polygon in the horizontal plane. Most habitat characteristics are represented as cell state variables (Table 3). Because there are many cells, static cell variables are treated as state variables instead of parameters.

### Labor market

cells are the lowest-level habitat entities; habitat variation within a cell is not represented (except via cell variables such as the fraction of the cell providing velocity shelter). Each cell represents a two-dimensional polygon in the horizontal plane. Most habitat characteristics are represented as cell state variables (Table 3). Because there are many cells, static cell variables are treated as state variables instead of parameters.

### Credit market

cells are the lowest-level habitat entities; habitat variation within a cell is not represented (except via cell variables such as the fraction of the cell providing velocity shelter). Each cell represents a two-dimensional polygon in the horizontal plane. Most habitat characteristics are represented as cell state variables (Table 3). Because there are many cells, static cell variables are treated as state variables instead of parameters.

### Deposit market

cells are the lowest-level habitat entities; habitat variation within a cell is not represented (except via cell variables such as the fraction of the cell providing velocity shelter). Each cell represents a two-dimensional polygon in the horizontal plane. Most habitat characteristics are represented as cell state variables (Table 3). Because there are many cells, static cell variables are treated as state variables instead of parameters.

### Bonds market

cells are the lowest-level habitat entities; habitat variation within a cell is not represented (except via cell variables such as the fraction of the cell providing velocity shelter). Each cell represents a two-dimensional polygon in the horizontal plane. Most habitat characteristics are represented as cell state variables (Table 3). Because there are many cells, static cell variables are treated as state variables instead of parameters.

## Temporal and spatial scale

In our model, the temporal scale is set as days because project duration is often counted in working days. A tick in this ABM means a day. The new projects are also announced by project owners (e.g., the government, commercial entities, etc.) every day... This model sets the simulation time as 3 years because the duration of most projects in the small construction design field range from 2 weeks to 1 year, and simulating 3 years can properly encompass the typical operations of a small projectbased organization.

Scales. The model’s spatial extent is a square of 200 ×200 square cells, each 5 m × 5 m in size; hence, the total area is 100 ha. This relatively fine resolution was chosen so the model can represent the effects of the small patches of trees and other habitat types that typify Jamaican coffee farms. The model’s space is represented as bounded, not toroidal: birds at one edge of the space cannot jump to cells on the opposite edge.

# Process overview and scheduling

We conclude this section dedicated to agents’ behaviors by sketching out the sequence of events taking place during each round of the simulation:

1. **Production planning** : firms determine their desired production, their labor demand, the price of their output and the wage offered.
2. **Loans and cash advances**: firms interact with banks on the credit market and possibly receive loans. Banks possibly ask cash advances to the Central Bank to satisfy the mandatory liquidity ratio.
3. **Labor market matching** : Firms interact with workers on the labor market.
4. **Wages, dividends and taxes payments**: Workers are paid. Dividends generated in the previous period are distributed to equity holders, summing up to their current income. Taxes are paid (on past period profits and current period households’ income). Firms and banks update their net worth and shareholders’ equity after dividends and tax payment.
5. **Public expenditures** **and policies** : Governments calculate revenues from taxes, determine the level of public spending and the tax rate for the next period, repay bonds plus interests to bond holders, and determine the quantity of bonds to be issued.
6. **Bonds purchases** : Bonds are put on the bond market where commercial banks buy it. The possible residual part is purchased by national Central Banks.
7. **Good production and consumption** : After having paid taxes and received the tax-exempt monetary transfer from the government, households compute their demand for consumption goods and interact with firms on the correspondent good markets.
8. **Interests and loans repayments** : Deposits repayment, Loans repaymnts and cash advances repayments.
9. **Entry-exit** : Firms and banks compute their profits. Defaulted firms and banks exit the market. Household equity investment takes place and, if enough financial resources are collected, new firms and banks are created.

# Design Concepts

## Basic Principles

At the system level, this model addresses a well-known management problem of agricultural and ecological systems: how does land use, including both the amounts of different land uses and their spatial arrangement, affect both agricultural production and wildlife conservation? For example, are these two goals best met by separating intensive agriculture from natural reserves or by conducting agriculture in ways that also support wildlife? Such questions are especially interesting and complex when wildlife provides services such as pest control to agriculture, as in this model. In its bird foraging submodel (Section 2.3.7.1, below), this model poses a classic problem of optimal foraging theory: how should an individual decide whether to stay and feed in its current location and when to move on to another location? There is extensive literature on this problem, much of it based on the influential “marginal value theorem” of Charnov (1976). However, here this problem is posed in a more complex and realistic context than typically addressed in the foraging theory literature, especially because this is a population model with multiple birds depleting and competing for food. We provide insight into this problem by contrasting four alternative theories for this decision by how well they reproduce a variety observed patterns (Section 3).

## Emergence

The model’s primary results—pest insect infestation rates in two types of coffee production—and intermediate results such as bird abundance and spatial distributions of birds emerge from the amount and spatial distribution of the six habitat types, the seasonal abundance of pest insects, the number of birds, and the foraging behavior of birds. Of the nine characteristic patterns used to design and test the model, patterns 3, 4, 5, 7, and 8 especially emerge from bird foraging behavior and habitat characteristics. These patterns are believed driven by the same mechanisms that produce the primary results, so these patterns must also be emergent to make them useful for testing the model’s suitability for its primary purpose. Patterns 1, 2, 6, and 9 are at least partially imposed by model rules and parameters. These four patterns are direct outcomes of lower level processes, especially related to the pest insect’s life cycle, from which other patterns emerge; making these patterns emerge from lower-level mechanisms would make the model much more complex and was determined unnecessary for its purpose.

## Adaptation

The model households have one adaptive behavior: deciding whether or not to move to another location and, if so, selecting a new location. The decision of whether to move is modeled as direct objective seeking: a household moves if its objective measure (Objectives, below) is below a “tolerance threshold”. This approach can be considered a type of satisficing—making a decision to achieve an acceptable level of the objective instead of maximizing it. The tolerance threshold is a model parameter named %-similar-wanted. When a household does decide to move, it selects a new location from those not currently occupied using a stochastic process described below (the “move” submodel).

## Objectives

Investors rate business alternatives by an objective measure (utility measure, in economics) that represents their expected future wealth at the end of a time horizon (T, a number of future years) if they buy and operate the business. This expected future wealth is a function of the investor’s current wealth and the profit and failure risk offered by the patch: U = (W + TP) (1 – F)T where U is the expected utility for the patch, W is the investor’s current wealth, P is the annual profit of the patch, and F is the probability per year of the business failing. The term (W + TP) estimates investor wealth at the end of the time horizon if no failures occur. The term (1 – F)T is the probability of not having a failure over the time horizon; it reduces utility more as failure risk increases. (Economists might expect to use a utility measure such as present value that includes a discount rate to reduce the value of future profit. We ignore discounting to keep this model simple.)

## Learning

Learning is not implemented

## Prediction

The utility measure estimates utility over a time horizon by using the explicit prediction that profit P and failure risk F will remain constant over the time horizon. This assumption is accurate in this model because the patches’ P and F values are static.

## Sensing

Model trout are assumed able to sense habitat conditions and select habitat from among cells within a radius that increases with their size. Specifically, a trout can sense and potentially move to all cells whose centroids are less than sensing-distance from the centroid of the trout’s current cell; the value of sensing-distance is equal to bLa where L is the trout’s current length (cm) and a and b are model parameters with standard values of 50 and 2.0. Therefore, sensing is a mechanism for positive feedback of growth: trout that grow more rapidly can sense and potentially occupy a wider range of habitat, which may allow them to grow more rapidly (or, should they choose, to use safer habitat).

## 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.

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.

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 (see section 3.2.3.1)
* Dividends and Profits transfers (see section 3.2.3.2)
* Wages and dole (see section 3.2.3.3)
* Taxes payment (see section 3.2.3.4)
* Purchases of real goods (see section 3.2.3.5)
* Purchases of bonds, repayment, and interests (see section 3.2.3.6)
* Loans creation, repayment, and interests (see section 3.2.3.7)
* Cash advances creation and repayment (see section 3.2.3.8)
* Equities investments and reimbursements (see section 3.2.3.9)

## Stochasticity

Stochasticity is used in initializing the model (Initialization, below) to create irregular clumps of each habitat type; this stochastic process allows creation of multiple landscapes that have the same over-all habitat characteristics (e.g., area of each habitat type, number and mean size of habitat clumps), which are used as replicates in analysis of model responses to habitat availability scenarios. Stochasticity is also used in initialization to assign each bird a home cell, and to impose variability among cells in coffee pest infestation rates (see the “pest infestation rate” submodel, below). During a simulation, the main uses of stochasticity are to (1) avoid a feeding hierarchy by randomizing the order in which birds execute their foraging trait each foraging time step, and (2) decide whether birds die if they did not make their daily intake requirement (see the “mortality” submodel, below). In bird foraging, several cells may offer exactly the same, highest, food intake rate; in such cases, the bird chooses one of these cells randomly.

## Collectives

The model includes no collectives.

## Observation

The location (spawning area) and genome of each individual are recorded every generation. The changes in the genetic structure are assessed through the global, within-subnetwork (upstream or downstream to the dam) and paired (between two subpopulations) Fst index (Weir and Cockerham, 1984, Weir, 1996) before and after the addition of the dam. Global Fst is the component of the genetic variation due to differences among all subpopulations. Within-subnetwork Fst is the component of the genetic variation due to differences among the subpopulations within each subnetwork. The pairwise Fst is the inter-population level genetic variation between two subpopulations. The Fst is estimated as FFFFFF = ∑ σσPPvv 2 gg vv=1 ∑ σσPPvv 2 gg vv=1 +∑ σσGGvv 2 gg vv=1 (1) where σPv2 is the variance between subpopulations and σ2Gv is the variance within subpopulations for the locus v. The σ2Gv is estimated as the mean square for within populations (MSG) σσGGvv 2 = MMMMMM = 1 ∑ii(nnii−1) ∑ nniippAAii�1 − ppAAii� ii (2) where pAi is the frequency of the allele A of the locus v in the ith subpopulation, and ni is its subpopulation size. The σ2Pv is estimated as σσPPvv 2 =1 nncc (MMMMMM − MMMMMM) (3) where MSP is the mean square for between populations and nc is composed by the average sample sizes and their variance. Then, the nc is estimated as nncc = 1 (rr−1) (∑ nnii rr ii=1 − ∑ii nnii2 ∑ii nnii ) (4) where r is the number of populations and ni is the population size of the population i. The MSP is estimated as MMMMMM = 1 rr−1 ∑ii nnii (ppAAii − ppAA)2 (5) S

# Initialization

We adopted the six-step strategy proposed by Caiani et al. [3]. First, the procedure have to define the initial values of the different types of stocks and flows held by each sector, so that they respect Copeland's quadruple entry principle (see section 3.2.1 for details on these stocks and flows). Second, aggregates stocks should then be distributed across agents within each specific sector, thus characterizing their overall balance sheet. As described in the previous sections, agents balance sheets are sometimes characterized by the presence of multiple stocks of the same type, which differ in terms of quantity, age, maturity, prices, and liability and asset counterparts. In our model, this is the case for loans in firms' and banks' balance sheets, and capital goods in consumption firms' balance sheets (see Sections 3.2 and 3.1.4). The third task thus consists in finding a strategy to characterize each specific stock in these collections and assign it to agents who hold it as an asset or a liability.

For this sake, we adopted the following six-step strategy:

1. We derive an aggregate version of the model.
2. We constrain the aggregate model to be in a real stationary state associated with a nominal steady growth equal to gss. This imply that while all real quantities are constant, all prices and wages are growing at the same rate gss.19
3. We numerically solve the constrained model by setting exogenously reasonable values for the parameters for which some empirical information is available (e.g. unemployment rate, mark-ups, interest rates, and income and profit tax rates) or that we want to control (e.g. technological coefficients, number of agents in each sector, distribution of workers across sectors, loans and capital durations). We then obtain the initial values for each stock and flow variable of the aggregate steady state, as well as the values of some behavioral parameters, which are hence compatible with the steady/stationary state (e.g. the propensity to consume out of income, target capacity utilization and profit rates, initial capital and liquidity targets for banks).
4. We distribute each sector's aggregate values uniformly across agents' in that sector. In this way we derive the total value of each type of stock held by agents (e.g. households' and firms' deposits, total outstanding loans and real capital for each firm, total loans, and reserves and bonds for individual banks) and agents' past values to be used for expectations (e.g. past sales, past wages, and past profits).
5. To determine the original amount, outstanding values, age of durable stocks we assume that, in each of the periods before the simulation starts, firms have obtained a loan and consumption firms have also acquired new capital batches to replace old capital and maintain their productive capacity. We further assume that the real value (i.e. corrected for inflation) of each of these loans and capital batches was constant. Knowing the constant inflation rate gss and the amortization schedules for capital goods and loans, we can then derive the outstanding value for each of these stocks, so that the sum of these values is exactly equal to the amount determined in the previous step.
6. In order to set the initial network configuration, we randomly assign a previous period supplier (required for the matching mechanism) to each demand agent on each market, ensuring that each supplier has the same number of customers. Similarly, we assign to households' and firms' deposits, and to firms' loans a randomly selected bank, so that each bank has the same number (and amount) of deposits and loans with the same number of agents.

The procedure20 just explained generates an important symmetry condition on agents' initial characteristics: that is, we start from a situation of perfect homogeneity between agents in order to limit as much as possible any possible bias embedded in asymmetric initial conditions, and we let heterogeneity emerge as a consequence of cumulative effects triggered by the stochastic factors embedded in agents' adaptive rules. Furthermore, by setting initial values based on SS stock-flow norms, we aim to achieve the threefold objective of limiting our arbitrariness in defining agents' initial endowments, restricting the number of free behavioral parameters in the simulation, and find a criterion to set the values of several others.

parametres

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Code** | **Description** |
|  | g\_o | 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\_W1 | Number of employees in sector 1 |
|  | N\_W2 | Number of employees in sector 2 |
|  | N\_WG | Number of employees in public sector |
|  | N\_U | Number of unemployed |
|  | phi1 | Productivity in sector 1 |
|  | phi2 | Productivity in sector 2 |
|  | w1 | Initial wage in sector 1 |
|  | w2 | Initial wage in sector 2 |
|  | 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 |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# Input Data

No input data is used.

# Submodels

## Stock-Flow consistent matrices

The model deployed here is an adaptation GROWTH de Godley et Lavoie [4]. describes a growing economy which does not spontaneously find a steady state even in the long run, but which requires active management of fiscal and monetary policy if full employment without inflation is to be achieved. Its main new features are as follows. As the model describes a growing economy, firms now undertake fixed investment and their pricing mark-up is endogenous, depending on the rate at which dividends are paid and the proportion of investment that firms wish to finance through retained earnings. Second, firms now issue stock market shares – equities.1 Third, there is now a distinction between unit costs and normal unit costs, the former being actual labour costs per unit produced. When production is above normal, actual unit costs will be lower than normal unit costs, which depend on trend productivity. It will now be assumed that households as well as firms borrow from banks, and that the gross flow of new personal loans (before repayments) is exogenously determined as a proportion of disposable income.2 As a result, consumption will depend on net lending as well as real disposable income and wealth. Finally banks will have to face the fact that some corporate borrowers default on their loans. As a result, banks retain part of their profits, accumulating own funds that allow them to absorb capital losses while fulfilling regulation obligations related to capital adequacy ratios. The loan rate will once more be determined endogenously as a mark-up on the deposit rate. As in any growth model, some of the most crucial equations are those determining how growth arises. First, we assume an exogenous – unexplained trend rate of growth in labour productivity, while the potential labour force is assumed to be constant. Second, we initially assume that real pure government expenditure (excluding interest payments) – grows at a constant rate, initially the same rate at which labour productivity is growing. Third, we assume that the rate of accumulation of fixed capital is a function of the rate of capacity utilisation and of the real rate of interest. The rate of growth of fixed capital is thus an endogenous variable, which adjusts to the growth rate of pure government expenditures.

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

### Balance sheet

As always, we start the description of the model with its balance sheet and transactions-flow matrices to which we add a revaluation matrix. provides the balance-sheet of the model, which we shall call Model GROWTH. The economy is again divided into five sections – households, firms, banks, a central bank and a government, each of which has distinct functions and objectives. The household column has three new features. First, households are now indebted to banks. Second, they now hold stock market equities (or shares) issued by firms, e shares each valued at price pe. The third new feature of this column is the term OF which describes the own funds of banks the value of their equity. It is assumed that whereas production firms are corporations valued by the stock market, banks are privately held companies, which do not issue stocks. As a result, the net worth of these banks belongs to the private owners of the banks, and must appear as part of the net wealth of households. It may be useful to recall some accounting issues which were discussed at the beginning of Chapter 2. The description of the Firms column here corresponds with that in Table 2.2 where the net worth of firms is defined as the difference between all their assets and all their liabilities including the market value of equities. As a consequence the net worth of firms Vf can be either positive or negative. By contrast, the Banks column corresponds to the one in Table 2.3 where the net worth of banks is calculated as the difference between all assets and liabilities, excluding equities (since we assumed away their existence!). This is the own funds of banks, or their equity capital. For the bank to be solvent, this net worth must be positive. However these own funds of the bank, OFb, belong to the owners of the banks, and for this reason, while they enter with a negative sign in the balance sheet of the banks they also enter with a plus sign in the balance sheet of households. The other components of the balance sheet have already been introduced in previous models. Firms own both kinds of tangible asset needed for production – inventories and fixed capital.

Table 12. Balance sheet of Dual Monetary Economy

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

### Transactions Matrix

We now move to a new matrix, the revaluation matrix, given by Table 11.2 which was also discussed in Chapter 2. In previous models, the revaluation matrix comprised only one entry, the capital gains or capital losses on holdings of long-term bonds. In the GROWTH model, four components may be revalued. Besides bonds, stock market equities are also liable to capital gains and losses. Third, banks accumulate own funds, but these funds belong to the owners of the banks, so that they are treated as a liability of the banks. From the standpoint of the bank owners, since this is a closed rather than a publicly owned corporation, the own funds accumulated by the bank during a period are treated as a capital gain. From a Haig–Simons point of view, the bank’s own funds are part of the wealth of household owners, because if the bank were to be liquidated, their owners would be left with the bank capital the own funds of the bank. Finally, the fourth line of the matrix shows an automatic revaluation of the value of firms’ fixed capital, arising from price inflation.

Table 13. 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 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Table 11.3 describes net transactions between all five sectors in some given period of time, measured at current prices. Start with the first seven items in the top half of the second column, written in bold characters. This list is the national income identity comprising the major expenditure categories (government expenditure, personal consumption and investment) and flows of factor income (wages and profits). Every item in this column is a transaction with another sector or with a different part of the same sector (e.g. when firms buy investment goods from other firms or profits are retained in the business), so a new column, the capital account column has been created to record these capital transactions.

The columns describing the government and central bank are no different from those of Table 10.2. Indeed, every entry in the top half of the matrix has already been encountered in previous chapters and is self-explanatory, except for two unusual features relating to national income accounting conventions. First, in the row called ‘financing cost of inventories’, in column 2, the loan rate of interest multiplied by the opening stock of inventories has been substituted for conventional stock appreciation (or IVA). Second, interest payments by firms, other than with respect to loans for the finance of inventories, are included in line seven as a component of distributed profits. The reasons for making these entries have already been explained in detail in Chapter 8, where we dealt with various possible definitions of profits, and the distinction between the requirements of business and national accounts. Banks and producing firms distribute dividends to their owners (FDb and FDf ), and keep part of their profits undistributed, in the form of retained earnings (FUb and FUf ).

The bottom of the first half of the Table describes the various interest payments on deposits, bills, bonds and personal loans. The latter is a new entry. It is assumed that households obtain personal loans from banks (Lh) on which they make interest payments. These payments carry a negative sign, since they are a use of funds, being subtracted from the personal income of households.

The lower part of the transactions-flow matrix describes the flow-of-funds. Checking the first column, that of households, there are two new items. Besides acquiring cash balances, money deposits, bills and bonds, households purchase stock market shares newly issued ( e). In addition, when households increase their borrowing, they have a new source of funds in the form of personal bank loans. The other new entry is ‘Loan defaults’ (NPL) which describe non-performing loans. It is assumed that a certain proportion of loans made to firms turn bad. The new loans ( Lf ) that firms obtain as residual finance for changes in inventories and fixed investment will be reduced by the amount of defaulted loans. These non-performing loans will also appear in the capital account of banks.

## Initial steady state relations

We divided the SS system of equations of the aggregated model in four sub-systems or block. As explained in Section 4 our procedure is based on the imposition of a real stationary state coupled with a nominal steady state growth (i.e. inflation) at the macroeconomic level. More precisely, we first declare a set of exogenous parameters, aggregate variables, and stock-flow norms that we fix at reasonable values (see Section A.4). Then we employ the accounting identities and the steady state (SS hereafter) conditions to find a numerical solution to the system. For tractability and explanatory reasons we divided the SS system of equations in three sub-systems: the first block contains the equations which refer to capital good producers (Section A.1), the second presents the set of equations related to consumption firms (Section A.2), and the third (Section A.3) refers to households, banks and the public sector (government and central bank). Once the first block of the system is solved, its solution are employed to solve the second subsystem, whose solutions in turn are used to solve the third one.

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





### Firms sector initial state

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

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)

















Specifique au entreprises du secteur 1















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

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

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

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)):

















## Economic transactions

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.

### Deposits transfers and interests

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.

Household make deposits

Table 14. Accounting of deposits made by households

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Firm make deposits

Table 15. Accounting of deposits made by firms

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Household withdraw deposits

Table 16. Accounting of deposit withdrawals by households

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Firm withdraw deposits

Table 17. Accounting of deposit withdrawals by firms

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

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.

Bank pay interests to household

Table 18.Accounting of payments of interests on households deposits

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Interests on deposits |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Bank pay interests to firm

Table 19.Accounting of payments of interests on firm deposits

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Interests on deposits |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Profits distribution

Firms pay dividends through deposit transfers.

Firm pay dividends to households

Table 20. Accounting of dividend payment by firms

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Entrepreneurial profits |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Bank pay dividends to households

Table 21. Accounting of dividend payment by households

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Entrepreneurial profits |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Central bank transfer profits to Government

Table 22. Accounting of profit transfers by Central bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Central Bank profits |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Wages and doles

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.

Firm pay wage to households

Table 23. Accounting of wage payment by firms

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Wages |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Government pay wage to households

Table 24. Accounting of wage payment by Government

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Wages |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Government pay doles to households

Table 25. Accounting of doles payments

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Transfers |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Taxes payments

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.

Household pay taxes

Table 26. Accounting of taxes payment by households

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Taxes |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Firm pay taxes

Table 27. Accounting of taxes payment by firms

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Taxes |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Bank pay taxes

Table 28. Accounting of taxes payment by banks

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Taxes |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### 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.

Household consume goods using only cash

Table 29. Accounting of goods purchases

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Consumption |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Purchases and repayments of bonds

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.

bank buy bonds

Table 30. Accounting of bonds purchases by banks

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in bonds |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

central bank buy bonds

Table 31. Accounting of bonds purchases by Central Bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in bonds |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Government repay bank bonds

Table 32. Accounting of bonds repayments to banks

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Interests on bonds |  |  |  |  |  |  |
| Change in bonds |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Government repay central bank bonds

Table 33. Accounting of bonds repayments to Central bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Interests on bonds |  |  |  |  |  |  |
| Change in bonds |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

bank transfer bonds to central bank

Table 34. Accounting of bonds tranfers between banks and Central Bank

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in bonds |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Loans creation and repayments

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.

Bank give loans to firm

Table 35. Accounting of loans

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in loans |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Firm reimburse loans to bank (capital + interests)

Table 36. Accounting of loans repayments

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Interests on loans |  |  |  |  |  |  |
| Change in loans |  |  |  |  |  |  |
| Change in deposits |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

bank make default loans

Table 37. Accounting of default loans

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in loans |  |  |  |  |  |  |
| Loan defaults |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Cash advances creation and repayments

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.

when central bank give cash advance

Table 38. Accounting of cash advances

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in advances |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

bank repay cash advance

Table 39. Accounting of cash advance repayments

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Interests on advances |  |  |  |  |  |  |
| Change in advances |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

### Equities investment and reimbursements

household invest in firm equities (firm entry)

Table 40. Accounting of investments on firm equities

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in equities |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

household invest in bank equities (bank entry)

Table 41. Accounting of investments on bank equities

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in equities |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

firm close by transferring residual money

Table 42. Accounting of reimbursements of firm equities

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Households | Firms | Banks | Government | C. bank |  |
| Entrepreneurial profits |  |  |  |  |  |  |
| Change in HP Money |  |  |  |  |  |  |
| Change in equities |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

## Household behaviors

## Firm behaviors

### Production planning

Firms’ production plans depend on their sales expectations and the level of inventories inherited from the past. Furthermore, we assume that firms desire to hold a level of inventories invit equal to a given share h of expected sales, as a buffer against unexpected demand swings (Steindl, 1952) and possibly to avoid frustrating customers with supply constraints (Lavoie, 1992). We indicate by qit the (real) output produced by firm i in period t, by q^it the quantities sold, by pit their selling price, by qiet firm’s (real) sales expectations, and by qittot 1⁄4 qit þ invit the total amount of goods available for sales, equal to current production plus inventories. Prices and sales expectations are revised adaptively from period to period according to the following scheme:







Equation (12) states that if past sales exceeded expectations, firms adaptively increase both sales expectations and their selling price. By increasing prices they aim to increase their profit margin. When instead past sales were below their expected value and no supply constraint was binding [equation (13)], both expectations and prices are revised downwardly. By reducing prices firms aim to make their output more attractive to consumers, thereby improving their sales performance. Finally, when firms’ past sales were below expectations due to the presence of a supply constraint [i.e., despite firms had exhausted all their available supply, see equation (14)], firms postpone any revision of prices and expectations to the next periods. Prices have a lower bound represented by unit costs of production, that is, pit wit /it , where /it is firm’s i current level of labor productivity.

Function de production



The demand for labor can be obtained by dividing planned output for the firm’s labor productivity level: liDt 1⁄4 qiDt =/it. However, if firms have not enough funds to pay wages (witliDt ), labor demand is reduced accordingly. Firms’ labor demand can be also frustrated by other factors, for example, if the economy is already at full employment or if the salary offered is too low to cover vacant positions. Since production depends on the quantity of labor actually employed, which can differ from demanded quantities for the reasons explained above, also actual output may be lower than originally planned. The salary wit offered by firm i changes according to the difference between labor demanded li;Dt 1 and labor actually employed in the previous period li;t 1. If the firm was not able to cover all vacant positions, i.e., labor employed 10 A. Caiani et al. Downloaded from https://academic.oup.com/icc/advance-article-abstract/doi/10.1093/icc/dty016/4964718 by Kaohsiu



The salary wit offered by firm i changes according to the difference between labor demanded li;Dt 1 and labor actually employed in the previous period li;t 1. If the firm was not able to cover all vacant positions, i.e., labor employed was below labor demanded, it increases the salary so to attract workers. When all vacant positions were covered, firms consider the possibility to reduce wage so to increase their profit margins. The lower the unemployment, the lower is the probability of such a revision, since reducing wages increases the risk of ending up being labor constrained.







### Credit demand

Firms’ production and R&D investment can be financed using both internal funds accumulated through time (Dit) and external funding in the form of loans asked to domestic and foreign banks (Lit). Following a wellestablished assumption in AB modeling, inspired by the “Pecking Order Theory of Finance” (Myers, 1984), firms in the model resort to external financing after internal funding possibilities have been exhausted, since the cost of external finance is usually higher due to market imperfections and information asymmetries. Accordingly, the demand for loans by firms can be expressed as:



However, given the cost of external finance the demand for loans is positive only if the expected revenues generated by employing these funds are greater than the cost of financing.9 Firms are financially constrained if the amount of credit received (Lit) is lower than demanded (see Section 2.1.3): Lit LiDt . This happens when banks have already exhausted the total amount of loans they were willing to supply in a given period or if none of them is willing to provide credit to the firm, if it is perceived as too risky (see Section 2.1.3). Yet, firms can try to fulfill their financing needs asking credit to different banks. When financially constrained, firms prioritize production over R&D. For simplicity reasons, in this first version of the model, loans are assumed to be granted and repaid within the same period, similarly to the monetary circuit theory (Graziani, 2003).10

### job destruction and creation

Workers in excess, when present, are randomly sampled from the pool of firm employees and fired. We also assume a positive employee turnover, expressed as a share θ of firm's employees.



### Profit computation

As for households, also firms randomly choose their deposit bank, receiving an interest rdt on the amounts deposited. Profits are then computed as the sum of revenues from sales (pitqit), interests received on deposits held at banks (rdtDit), and the nominal variation of inventories DINVit11, minus labor expenditure for production (witlit) and R&D activities(R&Dit), and credit costs (ritLit):











### Tax payment

If we omit the variation of inventories from equation (24), we obtain a measure of the net operating cash flows generated by the firm, which we indicate by pit. When pit > 0, firms pay taxes (Tipt) and distribute dividends (Divipt) to equity holders, expressed as a share q of their residual net cash inflow. Since profits are generated at the end of period t—when public spending, tax payments on income of households, and consumption have already taken place—taxes on profits generated in period t are paid in period t þ 1. Accordingly, also dividends generated in period t are paid to equity holders in period t þ 1.



### Dividends payment

If we omit the variation of inventories from equation (24), we obtain a measure of the net operating cash flows generated by the firm, which we indicate by pit. When pit > 0, firms pay taxes (Tipt) and distribute dividends (Divipt) to equity holders, expressed as a share q of their residual net cash inflow. Since profits are generated at the end of period t—when public spending, tax payments on income of households, and consumption have already taken place—taxes on profits generated in period t are paid in period t þ 1. Accordingly, also dividends generated in period t are paid to equity holders in period t þ 1. Dividends are distributed to equity holders proportionally to their participation share.



### networth update

Retained net profits increase firms’ net worth: Ai;tþ1 1⁄4 Ait þ pit Tp it Divp it: (27) Since firms belong to households who originally invested in their creation, as Ai;tþ1 increases also equity holders’ participations are increased accordingly.



## Bank behaviors

### Credit supply

In addition, banks endogenously create means of payment by providing credit to firms. As it happens in reality, every new loan granted by a bank, which is an asset for it, is immediately balanced by the creation of a matching liability in the form of a deposit for the borrower, both being created ex nihilo. This implies that banks’ credit supply is not constrained by the amount of deposits already in circulation nor by the amount of reserves they hold. However, we assume that to avoid taking excessive risks, the maximum amount of credit that banks are willing to supply in any given period is a multiple l1 of their equity Azt:



For each firm that is a client, the bank calculates the probability  of satisfying its loan demand. Furthermore, banks also discriminate borrowers by applying different interest rates . The probability and the interest rate charged  are, respectively, a decreasing and increasing function of the borrowers’ target leverage, computed as the ratio between their demand for loans () and their worth () :





### Cash advances demand

Banks are subject to minimal reserve requirements, expressed as a share  of their deposits:



Reserves are held at the national Central Bank and yield no interest rate. Whenever reserves RzMt are below the minimum level, banks apply to the Central Bank lending facility, asking cash advances (LzCBt) to restore the mandated liquidity ratio. National Central Banks accommodate these requests, receiving the discount rate rt on funds lent to banks.



### Bonds purchases

If instead banks have reserves in excess with respect to the mandatory level, these can be invested in the purchase of bonds (BzDt) issued by any member country k, which bring an interest rate rbkt computed following equation (45). In each period of the simulation, all the bond tranches issued by governments of the Monetary Union (Section 2.1.5) are piled up and shuffled. Then, commercial banks enter the bond market in a random order and go through this pile, having a probability of purchasing each tranche which depends on the riskiness associated to the country and defined as:



### Profit computation

Therefore banks’ profits (pzt) are equal to:











### Tax payment

When profits are positive (pzt > 0), banks pay taxes (Tipt) and distribute to equity holders a share q of net profits (Divzpt). As for firms, dividends are distributed among investors proportionally to the share of the bank’s equity they own.



### Dividends payment

When profits are positive (pzt > 0), banks pay taxes (Tipt) and distribute to equity holders a share q of net profits (Divzpt). As for firms, dividends are distributed among investors proportionally to the share of the bank’s equity they own.



### Net worth update

Retained profits after taxes then increase banks’ net worth: Az;tþ1 1⁄4 Azt þ pzt Tp zt Divp zt: (35) As Az;tþ1 varies, also households’ participation in the bank, and thus households’ net worth, is revised accordingly.



### Failure

Banks default when their net-worth turns negative. Defaults by banks instead do not directly affect households and firms, as the government totally bears the loss by issuing additional bonds to reimburse depositors (Section 2.1.5). However, in this way banks’ failures affect public debt dynamics. In addition, banks’ failures may eventually cause a reduction of the total credit supply in the economy. Finally, even before causing a default, negative profits of firms and banks prevent them from paying dividends and decrease their equity, thereby affecting the net worth of equity holders.

## Government behaviors

## Central Bank behaviors

# Liste des tableaux

[Table 1. Household real state variables 5](#_Toc210661564)

[Table 2. Household nominal state variables 5](#_Toc210661565)

[Table 3. Firm real state variables 7](#_Toc210661566)

[Table 4. Firm nominal state variables 7](#_Toc210661567)

[Table 5. Bank state variables 9](#_Toc210661568)

[Table 6. Government state variables 10](#_Toc210661569)

[Table 7. Central Bank state variables 11](#_Toc210661570)

[Table 8. Balance sheet of Dual Monetary Economy 18](#_Toc210661571)

[Table 9. Transactions matrix of Dual Monetary Economy 19](#_Toc210661572)

[Table 10. Accounting of deposits made by households 27](#_Toc210661573)

[Table 11. Accounting of deposits made by firms 27](#_Toc210661574)

[Table 12. Accounting of deposit withdrawals by households 27](#_Toc210661575)

[Table 13. Accounting of deposit withdrawals by firms 27](#_Toc210661576)

[Table 14.Accounting of payments of interests on households deposits 28](#_Toc210661577)

[Table 15.Accounting of payments of interests on firm deposits 28](#_Toc210661578)

[Table 16. Accounting of dividend payment by firms 28](#_Toc210661579)

[Table 17. Accounting of dividend payment by households 28](#_Toc210661580)

[Table 18. Accounting of profit transfers by Central bank 29](#_Toc210661581)

[Table 19. Accounting of wage payment by firms 29](#_Toc210661582)

[Table 20. Accounting of wage payment by Government 29](#_Toc210661583)

[Table 21. Accounting of doles payments 30](#_Toc210661584)

[Table 22. Accounting of taxes payment by households 30](#_Toc210661585)

[Table 23. Accounting of taxes payment by firms 30](#_Toc210661586)

[Table 24. Accounting of taxes payment by banks 30](#_Toc210661587)

[Table 25. Accounting of goods purchases 31](#_Toc210661588)

[Table 26. Accounting of bonds purchases by banks 31](#_Toc210661589)

[Table 27. Accounting of bonds purchases by Central Bank 32](#_Toc210661590)

[Table 28. Accounting of bonds repayments to banks 32](#_Toc210661591)

[Table 29. Accounting of bonds repayments to Central bank 32](#_Toc210661592)

[Table 30. Accounting of bonds tranfers between banks and Central Bank 32](#_Toc210661593)

[Table 31. Accounting of loans 33](#_Toc210661594)

[Table 32. Accounting of loans repayments 33](#_Toc210661595)

[Table 33. Accounting of default loans 33](#_Toc210661596)

[Table 34. Accounting of cash advances 34](#_Toc210661597)

[Table 35. Accounting of cash advance repayments 34](#_Toc210661598)

[Table 36. Accounting of investments on firm equities 34](#_Toc210661599)

[Table 37. Accounting of investments on bank equities 35](#_Toc210661600)

[Table 38. Accounting of reimbursements of firm equities 35](#_Toc210661601)

# References

1. Caiani, Alessandro, Ermanno Catullo, and Mauro Gallegati. 2019. The effects of alternative wage regimes in a monetary union: A multi-country agent based-stock flow consistent model. *Journal of Economic Behavior & Organization* 162: 389–416. https://doi.org/10.1016/j.jebo.2018.12.023.

2. Fields, Gary S. 2011. Labor market analysis for developing countries. *Labour Economics* 18: S16–S22. https://doi.org/10.1016/j.labeco.2011.09.005.

3. 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.

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

5. Dawid, Herbert, and Domenico Delli Gatti. 2018. Agent-Based Macroeconomics. In *Handbook of Computational Economics*, 4:63–156. Elsevier. https://doi.org/10.1016/bs.hescom.2018.02.006.