WHAT'S THE ROLE OF Z-SYSTEMS IN THE DIGITAL ERA?

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ABSTRACT

In an article published by *Le Monde* in 1948, the Dominican Father Dominique Dubarle, while writing a review about Norbert Wiener's book on Cybernetics, hypothesized the existence of a machine able to collect information on production and the market in order to support governments in managing the customary machinery of politics. Father Dubarle's *machine à gouverner* is today a reality in many Data Processing Centers (DPC) run by IBM *System z* mainframes. This essay aims to show how DPC can be compared to a small-scale nation and how the digital nation can be similar to a DPC on a larger scale; moreover it shows how DPC's production management model, applied to the digital nation, can solve the problem of generational unemployment, the biggest problem of our digital era.

Keywords: System z, *machine à gouverner*, digital money, digital economy, digital nation.

1. Introduction

In the article *Vers la machine à gouverner* published by *Le Monde* in 1948, the French Dominican Father Domique Dubarle, a Philosophy professor, in the review of Wiener's book *Cybernetics or control and communication in the animal and the machine*, claimed that (see References, note number [1]):

> Can't one imagine a machine to collect this or that type of information, as for example information on production and the market; and then to determine as a function of the average psychology of human beings, and of the quantities which it is possible to measure in a determined instance, what the most probable development of the situation might be? Can't one even conceive a state apparatus covering all systems of political decisions, either under a regime of many states distributed over the earth, or under the apparently much more simple regime of a human government of this planet? At present, nothing prevents our thinking of this. We may dream of the time when the *machine à gouverner* may come to supply — whether for good or evil — the present obvious inadequacy of the brain when the latter is concerned with the customary machinery of politics.

Father Dubarle's idea has nowadays become a reality in Data Processing Centers (DPCs) — the set of people and information technologies that grant the delivery of IT services — in which the mainframe (i.e. the *machine à gouverner*) automatically supervises the production management of IT services by collecting innumerous set of data both inside and outside the DPC. The mainframe synchronizes the work of thousands of people and the access to thousands of devices, in order to follow the plan and to reach the goals established by the DPC's manager.

The *machine à gouverner* has become a reality in the society we live in as well: even if it is in its embryonic state, one can certainly see it at work in the gig economy.

The gig economy is a type of «work organized through online platforms» [2]. In a nutshell, it can be defined as job on demand; food delivery services are an example of this: all one needs is a bike, a smartphone, an account to access the website of the company offering the delivery service and then wait for the algorithm of the app to employ the rider (this is the name of the worker who delivers food to one's house).

Every day we witness the ability to digitally connect among each other companies, consumers and the public administration increase, and nothing can prevent us from thinking that the organization of work using online platforms could not expand from the microeconomic level to the macroeconomic one, fully actualizing Father Dubarle's vision.

If a Data Processing Center behaves like a nation, a nation with a high digital vocation will behave like a Data Processing Center on a larger scale. Therefore, a DPC can not only serve as a laboratory for economic experiments, but as a pure prototype of a digital economy in which one produces goods and services thanks to digital technologies and using digital coins (service unit) as currency, it can also act as referral model for us to foresee how nations with a high digital vocation will evolve.

2. Analogies between a Data Processing Center and the nation

The concept of “scarcity” stands at the base of economic activity. Limited means in relation to a multiplicity of purposes equals a scarcity of resources and, consequently, these resources are to be rationed. Due to the lack of resources, an economic system (like a nation) must face production choices and must decide what, how and for whom to produce.

An informatic system (like a DPC) faces similar production choices: how many hardware resources should one allocate to the online environment and how many to the batch one? How to assign resources to achieve the best cost/performances ratio? Which and to how many users should be served?

An economic system and an informatic system, therefore, have to deal with the same production choices. This is due to the fact that both the production of goods and data processing are, fundamentally, the same process; only the object of production varies: in the case of the economic system it is a «good», in the case of the informatic one it is «datum».

Beside the similarities between the procedure for data processing and the one for the production of goods, there is also a behavioral affinity between informatic agents (management, users and computers) and economic ones (government, households and firms).

DPC’s management and the nation’s institutional bodies (government and Central Bank) have akin goals and policies. The aims of management are to deliver IT services to anyone who requests them, without increasing response times. These aims translate in Service Policies, whose tools are called Performance Management and Capacity Planning, and they get communicated to the mainframe computer that is responsible for their implementation. The goals of the government and of the Central Bank consist in reaching full employment without causing an increase in prices (inflation) — which means to maintain the inflation index under, but near, two per cent. To reach such goals, the institutions use tools typical of Economic policy: Fiscal policy (under the government’s authority) and Monetary policy (under the Central Bank’s authority).

DPC users and households have identical needs that are satisfied by identical means. The user’s need is that to obtain data, an information, or, in a nutshell, to run an electronic transaction, and he satisfies his need with work, meaning by typing on the keyboard the necessary data for the computer to execute the transaction. If the response time (which is defined as the time the system spends to process a transaction) is low, the user is satisfied; on the contrary, the user will be unsatisfied about the service he has received. The need of a household is, on the other hand, the one to consume real goods (food, clothes), and to satisfy that, they offer their work in exchange for a monthly salary. If the wage is high, the household will be satisfied; otherwise, the household will be unsatisfied. Although the needs of the user and the ones of the household may seem different at first glance, they share the same nature. In fact, to process a transaction equals to consume a transaction; if we compare the transaction (the number of executions is easier to measure than the amount of written data) with the good, then the sentence “to run a transaction” is equal to the sentence “to consume a good”. Moreover, although the user’s response time does not seem to be related to the household salary, we observe that the response time is inversely proportional to the service rate: the faster our system responds (so, the higher the service rate is), the lower the response time will be. Therefore, to claim that the user will be satisfied when the response time is low is the same as to say that the user will be satisfied when the service rate is high. The service rate that the consumer gets after his effort corresponds to the salary that the worker receives after his work. Hence, both the user’s satisfaction level and the ones of the household depend on two homologous factors: service rate/salary.

The computers of the DPC (in particular the mainframes managed by the operating system IBM z/OS) and national firms utilize analogous production factors and they adopt a similar production logic. The production factors that the mainframe employs are labor (of the users) and capital (CPU, central storage and disks), whereas the logic that it adopts is the following: if the resource utilization level is low, the system boosts the workload by increasing the number of users that are working (multiprogramming level); if the usage of resources is high though, the system behaves in the opposite way and it diminishes the workload by decreasing the multiprogramming level. As far as firms are concerned, the production factors that they use are, again, labor (of households) and capital (machines, building and computers), and the logic they adopt — said in a nutshell — is the following: if the interest rate is low, the firm will invest more and therefore it will increase the number of workers; if the interest rate is high, the firm will lower its investments and hence reduce the number of workers (this logic has been much simplified; a firm invests not only in respect of a convenient interest rate but also, and especially, in the face of concrete sales perspectives of its products. Furthermore, investments depend not only on the interest rate but also on the income, so on the profit that the firm makes from sales). The logic of any firm is based on the currency interest rate (other than, naturally, on sales expectations), whereas mainframe’s logic rests on the utilization rate of resources. After a careful reflection, we must recognize that, in economics, a tight relation exists between interest rate and utilization rate. When the economy is “pulling” — meaning when we experience a growth in consumption — the productive resources tend towards saturation (it means that the capacity utilization rate increases). A higher resources demand (not only of the machines, but also of the labor force) exerts a certain pressure on the prices. To limit the upward trend of prices, the Central Bank raises the interest rate. Therefore, there is a direct relationship between the consumption of the production capacity and the interest rate. However, what we would like to highlight is that both the interest rate, on which the Central Bank operates, and the utilization rate taken into consideration by the mainframe when decisions are to be made, carry out the same function within the mechanism of regulation of the production process. If we want to simplify, the role of the utilization rate and of the interest rate within the regulation mechanism of the production process can be described as follows: when the utilization rate or the interest rate rises, the employment level diminishes; when the utilization rate or the interest rate decreases, the employment level increases.

3. Application of economics to informatics

3.1 The Data Processing Center from the point of view of production

The analogies we described put the DPC under a new light; it can be seen as a center that "produces services" rather than as a center that "delivers services" (as it is traditionally considered). To deliver is a synonym for to produce, but in the case of delivering a service, the description of the data processing method is based upon mathematical models belonging to the queueing theory, while in the case of producing a service, the same process of data processing rests upon mathematical models belonging to the economic theory.

In order to apply economic models to data processing, it is necessary to establish a correspondence between economic and informatic variables. Such a correspondence is displayed in Tab. A.1, in the Appendix section. This new approach to the analysis of a data processing cycle based on production is called "Economatics"; it is a neologism that describes the approach to computing performance analysis that uses concepts, models and methods of both economics and informatics.

3.2 The aggregate demand and Little's law

In Operational Analysis the service demand D_k is defined as the product between the average number of visits V_k spent to the resource k and the average time of service S_k per request. As a formula: $D_k \equiv V_k S_k$ [3]. In economatics the service demand is substituted by the aggregate demand.

Before illustrating Little's law as aggregate demand, it is necessary to spend a couple of words on this Keynesian economic relationship [4]:

$$\text{Income} = \text{Consumption} + \text{Investment} \qquad (3.1)$$

that, using algebra, can be expressed by the formula:

$$Y=C+I \qquad (3.2)$$

where:

- Y stands for income (GDP – Gross Domestic Product);
- C is the function used to represent consumption, expressed in the equation $C=C_0+cY$, being C_0 the exogenous variable of the consumption (independent by income), c stands for marginal propensity to consume (its complement to unity is the marginal propensity to save s, so: $s=1-c$) and Y is the income;
- I is the investment function, as in the equation $I=f(i)$, being i the interest rate.

In order to make explicit, in 3.2, the variables for the consumption and for the investment — which we consider exogenous and therefore we assume that $I=I_0$ — we get:

$$Y=C_0+cY+I_0 \qquad (3.3)$$

from which, after quick calculations, we get:

$$Y=\frac{1}{1-c} \times (C_0+I_0) \qquad (3.4)$$

this is the economic formula that links income to investment (the ratio $1/(1-c)$, also known as "Keynesian multiplier"). Wanting to make our exhibit clearer, we can implement the following simplifications:

- the consumption function C is described by the equation $C=cY$, (this is due to the fact that C_0, the exogenous component of consumption, does not have a reason to exist within economatics as the user starts to consume in the exact moment he receives a salary);
- the investment function I does not depend on the interest rate i, and is therefore an exogenous variable: consequently we can assume that $I=I_0$ (we stand by the conventional idea that all the variable with zero as subscript are exogenous, so not obtained from the model, but given as an input to the same model).

In the model we are going to build, we will assume that:

- the total income Y equals the sum of all the workers' income: if we indicate with SR (service rate) the income of one worker and with N the number of active workers, then the total income will be $Y=SR \times N$;

- the marginal propensity to save *s* is essentially the same as the response time *R* normalized with respect to the observation time T_0 we have taken as time unit (hence: R/T_0; assuming $T_0=1$, the response time *R* is simply *R* without the time dimension): s≡R;
- the marginal propensity to consume *c* is the complement to unity of the marginal propensity to save *s*, therefore: c≡1-s≡1-R.

After this brief introduction, let's start with the following formula:

$$R=\frac{P_0}{SR} \tag{3.5}$$

The formula 3.5 expresses the following: «the response time *R* is the result of the ratio between the weight (or cost) of the transaction P_0 and the service rate *SR*». In other words, if the weight of the transaction is $P_0=410$ service units and the final user receives a service rate that equals SR=1812 service units per second, then the response time that the user receives is R=0.226 seconds.

In economatic terms, the formula 3.5 states: the propensity to save expressed as dimensionless units *R* is the ratio between the saving expressed in service units P_0 and the nominal wage *SR* of one singular worker expressed in service units. Note to clarify: the weight of the transaction P_0 is comparable to the savings because, as the formula 3.5 declares, this is the result of the multiplication between the income *SR* and the marginal propensity to save *R*. For this reason, part of one worker's income *SR* is made up by consumptions C=c×SR and part is made up by savings P_0 and this can be described by the formula below (assuming that c=1-R):

$$SR=(1-R)\times SR+P_0 \tag{3.6}$$

By multiplying all the factor of the formula 3.6 by the number of users, which are active at the same time N_0, we have as result:

$$N_0\times SR=(1-R)\times N_0\times SR+N_0\times P_0 \tag{3.7}$$

from which, since the total income *Y* of all workers is the result of Y=N×SR and by writing the investment as $I_0=N_0\times P_0$, the formula 3.7 can also be written as:

$$Y = (1-R)\times Y + I_0 \tag{3.8}$$

from which, with quick calculations, we get:

$$Y = \frac{1}{R}\times I_0 \tag{3.9}$$

If we consider that R=s=1-c, and excluding the exogenous variable C_0, it is immediately evident that 3.9 and 3.4 are analogous. First conclusion: we have arrived at the same equations (3.4 e 3.9) starting from different premises (3.2 e 3.5) only by using the correspondence between economic and informatic variables as displayed in Tab. A.1. However, there is a second conclusion to make, to which we will arrive shortly.

In economics, the income *Y* is also the result of the product of the average level of the prices *P* and of the quantity of realized output *Q*; with formulas:

$$Y=P\times Q \tag{3.10}$$

Remembering that in 3.8 we assumed that $N_0\times P_0=I_0$, using the formula 3.10, then 3.9 becomes:

$$P_0\times Q = \frac{1}{R}\times N_0\times P_0 \tag{3.11}$$

By dividing both the parts of 3.11 by P_0, we get:

$$Q = \frac{1}{R}\times N_0 \tag{3.12}$$

The equation 3.12 describes, in real terms, the following concept: the quantity of real product *Q* (GDP) equals the product of the Keynesian multiplier *1/R* and the quantity of real investments N_0. As in economics, investments are a function of the interest rate, so in economatics, investments are a function of the utilization rate. It is possible to generalize 3.12 (substituting the exogenous variable N_0 with the endogenous variable *N*) by adopting the IS–LM economic model (Investment–Saving, Liquidity–Money [5], not discussed in this essay); the result is the following equation of equilibrium (both on the transaction "market" and on the real service unit "market"):

$$Q = \frac{1}{R}\times N \tag{3.13}$$

from which we get:

$$QR=N \tag{3.14}$$

If we explicit the observation period by establishing *Q/T* instead of *Q* and if we consider the response time *R* in its temporal dimension, we get:

$$\frac{Q}{T}\times R=N \tag{3.15}$$

And since Q/T=X (throughput), 3.15 becomes:

$$XR=N \tag{3.16}$$

from which

$$N=XR \tag{3.17}$$

that essentially is Little's law: «The average number of requests in a system is equal to the product of the throughput of that system and the average time spent in that system by a request» [3].

If we hypothesize the level of real investment *N* (also called the multiprogramming level) to be constant, the graphic representation of 3.16 is the equilateral hyperbole shown in Fig. 3.1. Little's law curve matches the curve of economics aggregate demand.

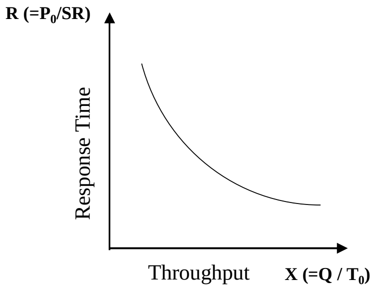

Figure 3.1. Graphic representation of the curve that describes Little's law (the aggregate demand's curve). Source: own creation.

The analytic function shown in Fig. 3.1 is *X=f(R)*; *N* taken as constant. Although the throughput *X* is the dependent variable (and it should therefore be assigned to the vertical axis, the ordinate one) and the response time *R* is the independent variable (and therefore to be assigned to the horizontal axis of abscissas), their place on the Cartesian coordinate system is inverted in order to replicate the exact same position that the independent variable *P*, that describes the price level (on the ordinate axis) and the dependent variable Q, that stands for GDP (on the abscissa axis), assume on the axes of the Cartesian plane. The curve of the aggregate demand corresponds to Thadani's curve [16]: a study, carried out in 1982 by Walter J. Doherty and Arvind J. Thadani of IBM laboratories, demonstrated that the number of transactions that a computer programmer achieves in one hour increases with the diminishing of the system's response time; moreover, it rises significantly when the system's response time goes below one second. In relation to Figure 3.1, in Doherty and Thadani's graphic representation, the position on the Cartesian axes of the throughput *X* and of the response time *R* are inverted (adhering, then, to the correct relation between the independent and the dependent variable according to the conventions in use in scientific literature).

After exploring aggregate demand, we direct our attention to the aggregate supply.

3.3 The aggregate supply and the Response Time law

We look again at the formula at 3.5 and we consider its reciprocal:

$$\frac{1}{R} = \frac{SR}{P_0} \tag{3.18}$$

We observe that the formula SR/P_0 given in 3.18 represents, in economics, the ratio between nominal wage and price level: this ratio is called real wage, or purchasing power of wage, or again marginal productivity of labor. Therefore, *1/R* is the marginal productivity of labor (or the purchasing power of wage). With this insight in mind, 3.13 acquires a new meaning. Considering: *Q* as the output, *1/R* as the marginal productivity of labor and *N* as the number of active workers (instead of real investments), after we substitute *Q* with Q/T_0 and this ratio with the throughput *X*, the equation 3.13 becomes:

$$X = \frac{1}{R} \times N \tag{3.19}$$

that represents, from the aggregate supply point of view, the production function displayed in Fig. 3.2.

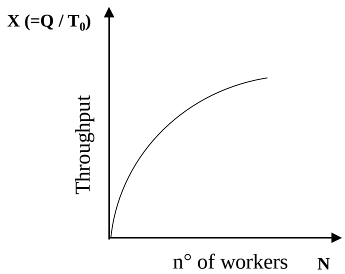

Figure 3.2. Graphic representation of the production function. Source: own creation.

In summary: whereas from the aggregate demand point of view we considered:

- *Q*: real GDP;
- *R*: marginal propensity to save;
- *N*: real investments;

when discussing the aggregate supply we considered:

- *Q*: quantity of product;
- *1/R*: marginal productivity of labor;
- *N*: number of active workers.

The number of active workers *N* (multiprogramming level) is given by the subtraction between the total number of users who are connected to the system L_{tot} and the number of user who are connected to the system but not active (idle) L_{out}:

$$N = L_{tot} - L_{out} \tag{3.20}$$

By inserting 3.20 in 3.19 we get as result:

$$X = \frac{1}{R} L_{tot} - \frac{1}{R} L_{out} \tag{3.21}$$

If we want to express the function *R* explicitly in terms of *X*, then 3.21 becomes:

$$R = \frac{1}{X} L_{tot} - \frac{1}{X} L_{out} \tag{3.22}$$

If we consider the subtrahend of 3.22 as the "lost production", due to the inactivity of the idle workers, and we make it equal to the user think time Z_0, i.e.:

$$Z_0 = \frac{1}{X} \times L_{out} \tag{3.23}$$

by inserting formula 3.23 in formula 3.22, the latter can be re-written as shown:

$$R = \frac{1}{X} L_{tot} - Z_0 \tag{3.24}$$

Which is the well-known response time formula whose graph, obtained thanks to the Mean Value Analysis technique, is represented in Fig. 3.3.

Whereas the aggregate demand curve expresses the throughput *X* in terms of the response time *R* (as a formula: X=f(R), and therefore as function of the price level *P* because R=f(P)), the curve of the aggregate supply expresses the response time *R* (i.e. the price level P, or even better, the reciprocal of the purchasing power of wage) in terms of the throughput *X* (as a formula: R=f(X)).

It is remarkable and of particular interest to observe that the causal relationships between the throughput *X* and the response time *R* in the functions of both aggregate demand and supply of economatics are clearly explicit, instead the causal relationships between the price level *P* and the wage level *Y* in the aggregate demand and supply curves are not so clearly expressed in economics, with the exception of Blanchard [15], who claims that:

- «the aggregate demand relation captures the effect of the price level on output. It is derived from the equilibrium conditions in the goods and financial markets» (and the equation Y=f(P) is correctly formulated as well);
- «the aggregate supply relation captures the effects of output on the price level. It is derived from the behaviour of wages and prices» (and the equation P=f(Y) is correctly formulated as well).

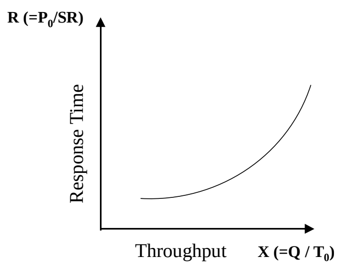

Figure 3.3. Graph of the curve representing the Response Time law (aggregate supply curve). Source: own creation.

3.4 The aggregate demand and supply model: the interaction between Little's law and the Response Time law

Now we will describe a new approach to analyze the processing performances, recurring to the interaction between Little's law and the Response Time law: we will analyze such interaction in the same way in which, in economics, one analyzes the interaction between aggregate demand and aggregate supply (Fig. 3.4).

The aggregate demand curve, or AD curve, (which represents Little's law) intersects the aggregate supply curve, or AS curve, (which represents the Response Time law) in point *E* where the system has its equilibrium. Here we read the following values (see Tab A.2 in the Appendix):

- the response time is the same as the target one: $R=R_0=0.226$ seconds (since the current response time *R* equals the target response time R_0 previously established by the DPC management, the production system is in equilibrium);
- the average transaction cost (the average price level) is $P_0=410$ service units;
- the real throughput per time unit $T_0=1$ second (real GDP) is $Q_t=24.91$ transactions;
- the nominal throughput (nominal income) is $Y=P_0\times Q_t=10{,}213$ service units;
- the velocity of circulation of money *M* is equal to V=5.64
- the multiprogramming level (or employment level, corresponding to the velocity of circulation of money *M*) is N=V=5.64;
- the nominal service rate (nominal income *W*)

equals SR=1812 service units in relation to the time unit T_0=1 second (therefore, the nominal income: Y=N×SR=10,220 service units);

- the service unit stock given per time unit T_0=1 second (money stock M_1) is M=1812 service units (the money stock M_1 coincides with the nominal income W because the operating system can serve only one person at a time).

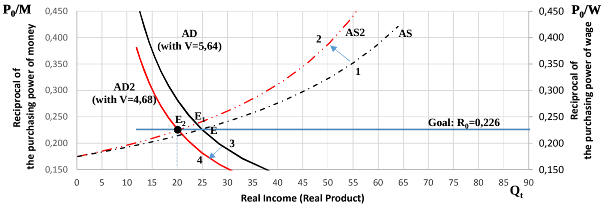

Figure 3.4. Interaction between the curve representing Little's law (corresponding to the economics' aggregate demand curve AD) and the curve representing the Response Time law (corresponding to the economics' aggregate supply curve AS). Source: Tab. A.2 (the aim of R_0=0.200 for 80 percent of the transactions, as specified in WLM parameters, has been substituted in the graph with the actual response time R=0.226. The two AD and AS curves have been calculated thanks to the Mean Value Analysis technique, applied to a closed model with 265 TSO users).

We assume that the average weight of the transactions varies between P_0=410 service units and P_0=510 service units (price shock): the aggregate supply curve will then move to the left, from AS to AS2, whereas the aggregate demand curve will remain unvaried because the velocity of circulation of money V (multiprogramming level) stays unvaried. The intersection point between AS2 and AD moves from E to E_1; here both the real product Q_t (as the real money balances M/P_0 decrease) and the real wage W/P_0 diminish (the response time $R=W/P_0$ rises above the set limit to 0.226 seconds). One must observe that when the price levels P_0 increases, the AD curve does not move (its variation is determined only by variations in the velocity of circulation of money V). The point E_1 is not an equilibrium point because forces that tend to bring the response time to its goal level of R_0=0.226 seconds act on it. Since the nominal wage (or service rate) of 1812 service units, due to increasing of the price level, is insufficient to lower the response time to 0.226 seconds, the operating system (or, more precisely, its component named WLM — Workload Manager) must increase the circulating money supply M_1 and such an increase flows into the nominal wages W (i.e. SR); at the same time, if the monetary base M_2 remains constant (the engine's SU/SEC do not vary), the rising of the money supply M_1 will increase the interest rate (i.e. the utilization rate of resources, of the CPU in particular) which, on its turn, will reduce the investments I and, consequently, the employment N. But N corresponds to the velocity of money V: therefore, the diminishing of N means the diminishing of V (from 5.64 to 4.68) and such a reduction pushes the aggregate demand curve to the left, from AD to AD2. E_2 is the new equilibrium point. With the decrease in the number of workers N (MPL) from 5.64 to 4.68 one has the following effects:

- the Gross Domestic Product (real GDP) lowers: it goes from 24.91 to 20.05 transactions (per second);
- the nominal income (nominal GDP) remains unchanged: $Y=P_0×Q_t$=510×20.05=10,225 service unit.

The graph in Fig. 3.4, which illustrates the interaction between the AD and AS curves representing, respectively, Little's law and the Response Time law, differs slightly from the economic graph, which illustrates the interaction between aggregate demand and aggregate supply. In fact, in the latter graph, on the ordinate axis we find the price level P and not the multiplicative inverse of the purchasing power of money P/M or the reciprocal of the purchasing power of wage P/SR. However, the graph in Fig 3.4 clearly illustrates the relationship among the real product Q, the employment N (through the velocity of circulation of money V≡N) and the real wage rate (or purchasing power of wage SR/P), fully complying with the observation of the economist Franco Modigliani who, when integrating the labor market in the Hicks' IS-LM model, literally stated: «It is now time to consider the role of the second part of the system in the determination of equilibrium [… the role of] the forces that determine the real variables of the system: physical output, employment, real wage rate» [6]. The model of Fig. 3.4 portrays exactly the real variables of the system that Modigliani described.

4. Application of informatics to economics

4.1 Economics tested in a laboratory with the Data Processing Center

To learn about the current state of the art of economic laboratory experimentations, we quote the thoughts of two well-known economists:

> Like astronomers studying the evolution of stars or biologists studying the evolution of species, macroeconomists cannot conduct controlled experiments in a laboratory. Instead, they must make use of the data that history provides them with. Macroeconomists observe that economies differ from one another and that they change over time. These observations provide both the motivation for developing macroeconomic theories and the data for testing them (Mankiw) [7].

> As an economist, the euro experiment has been fascinating. Economists don't get to do laboratory

> experiments. We have to test our ideas with experiments that nature — or politics — throws up (Stiglitz) [10].

Almost every day the system engineers of a Data Processing Center perform economic “experiments”. They do not really economic experiment but, in substance, they do operate as if they were performing economic experiments.

Let us suppose that the DPC’s management aims to ensure that 80% of TSO transactions will be completed within 0.2 seconds (200 milliseconds). The goal of the management must be communicated to the mainframe, which already has its own goal: to maximize the throughput, to ensure the DPC management to get the best return on investment; but it has to reach this goal compatibly with the one established by the management, i.e. to complete 80% of transactions within 0.2 seconds. In order to tell the mainframe its goals, the system engineers use the WLM (Workload Manager) interface. Once the objectives have been received, the operating system regulates the multiprogramming level (MPL) during the data processing so to grant users the correct service rate needed to get a response time of 0.2 seconds.

By analyzing the reports, the performance specialists check whether the goals have been achieved; otherwise they evaluate whether to better calibrate some of the system’s parameters (e.g. workload priority or others — tuning-specific activities), or whether to move resources (e.g. disks) from low priority workloads to high priority workloads (performance management activities), or if to expand the processing capacity by adding CPU, more storage, or more disks (capacity planning activities). Performance management and capacity planning activities correspond, respectively, to Fiscal and Monetary Policy. The activities that the performance specialists carry out do not always produce results in line with expectations. Therefore, it will be necessary to rethink the hypotheses, to re-adjust the parameters, to repeat the measurements and so on. Essentially, we are looking at real "experiments" on the field. Using correspondence Tables between informatic and economic variables (such as Tab A.1 and Tab. A.2), one can perform economic experiments in a lab, in a controlled way, while having the freedom to vary, according to one’s wishes, the informatic/economic variables in order to assess the impact on production processes (the numerical values written in Tab. A.2 are the result of a “macroeconomics experiment”, i.e. of the tuning activity of the Data Processing Center where 265 programmers, who use TSO, work).

Laboratory economics experiments with a Data Processing Center have no cost: a DPC equipped with mainframes and managed by IBM z/OS can perform economic experiments without having to buy any additional hardware or software. Every DPC already has specialized people, meaning system engineers, the performance manager, and the capacity planner: during the reading of RMF reports, it will be sufficient to use the table indicating the correspondence between the informatic and the economic variables described in this essay (Tab. A.1 and Tab. A.2). With regards to economic knowledge, central banks can already count on experts in economics, in addition to the DPC with a mainframe, who could work with IT personnel to lead the economic experiments to explore new monetary policies or to investigate economic theories such as the Quantity Theory of Money that is, still today, a debated topic among economists (Monetarists against Keynesians).

4.2 The Quantity Theory of Money: Fisher’s equation of exchange derived from informatics

In economics, there is a relationship that binds the amount of money, prices and transactions together. This relation is called "equation of exchange" and is connected to the name of the American economist Irving Fisher:

$$M \times V = P \times T \tag{4.1}$$

M is the total amount of money, *V* is its velocity, *P* is the average price level and *T* is the transactions’ volume (i.e. the number of times in which, in a year, a good or a service is exchanged for money).

4.1 is, by definition, a true equation, because it derives directly from the definition of “transactions velocity of money”:

$$V \equiv \frac{P \times T}{M} \tag{4.2}$$

For example, one can suppose that 100 loaves of bread are sold in a given year at €1.00 per loaf. The total number of euro exchanged is P×T=€1.00/loaf per 100 loaves/year=€100/year. Let us suppose, again, that the total amount of money available in the economy amounts to 25 euro. Therefore, the velocity of circulation of money is V=(100 euro/anno)/(25 euro)=4 times per year.

The number of transactions T is difficult to assess, for this reason, in order to analyze the role of money in the economic system, economists usually resort to a slightly different version of the equation of exchange, replacing the number of transactions *T* with the aggregate production *Y* [7]:

$$M \times V = P \times Y \tag{4.3}$$

in which *M* stands for the total amount of money, *V* is the income velocity of circulation of money, *P* is the average price level and *Y* is the aggregate production (real GDP). The income velocity of circulation of money measures the number of times in which, on average, each banknote enters in an individual's income over a given period of time. Economists call the M/P ratio "real money balance";

it measures the purchasing power of the currency. Resuming the previous example, if an economic system only produces bread, if the amount of money is equal to 25 euro and if the price of a loaf is 1 euro, then the real money balances correspond to 25 loaves; this means that, at the current price, the stock of money available in the economy is able to buy 25 loaves.

If we introduce further hypotheses in 4.3, the equation of exchange turns into a theory of the effect of money on an economic system, otherwise called "Quantity Theory of Money". Hypothesis number 1: the velocity *V* is constant. This means that changes in the money supply *M* produce proportional changes in nominal GDP (P×Y). Hypothesis number 2: the variation of the aggregate production *Y* depends on the growth of production factors and on the technological progress; these can therefore be considered as constants. It means that nominal GDP's variations cause changes in the general price level. Conclusion: the growth of the money supply determines the rate of inflation (however, this did not occur in the Eurozone despite the quantitative easing, the program wanting to purchase government bonds and European bonds, issued by regions and local authorities and carried out by the ECB for a value of 60 billion euro per month, which started in March 2015 and ended in January 2019, with the aim of bringing the inflation rate of the Eurozone below, but close, to 2 percent).

After this brief but necessary economic premise, we illustrate the Quantity Theory of Money from the point of view of economatics.

In economatics, the equation of exchanges is the following::

$$M \times V = P \times Q \qquad (4.4)$$

in which *M* is the total amount of money (or total amount of service units), *V* is its velocity, *P* is the average price level (or average transactions weight) and *Q* is the transactions volume (i.e. the number of electronic transactions run in one hour, or even in one second, against the usage of service units).

Unlike economics, the economatic equation of exchange does not derive from an identity (from the definition of the velocity of circulation of money), but it comes from the IS–LM model that describes the concurrent equilibrium in the transactions "market" and in the service unit "market" (besides describing, in mathematical terms, the behavior of the System Resources Manager — SRM). However, there is a different way to get 4.4, less orthodox but extremely simpler, which we want to illustrate here. By considering Little's law as written in 3.17 (which represents the aggregate demand curve) and the expression that gives us the value of the response time *R* (we omit the zero subscript of the quantity P_0 and consider the price level *P* generically):

$$N = XR \qquad R = \frac{P}{SR} \qquad (4.5)$$

By substituting the second expression given in 4.5 inside the first formula and multiplying both the terms of the resulting equation by *SR*, we get:

$$SR \times N = P \times X \qquad (4.6)$$

The variable *SR* is the user's nominal wage (measured in service units) and corresponds to the circulating money M_1 delivered by the operating system (let us remember that the system serves one user at a time, with a speed that is a billion times greater than the man's reaction time, which is of the order of a few seconds; therefore one has the impression that the system serves thousands of users simultaneously). If we indicate generically with *M* the variable M_1, then $SR=M_1=M$. Moreover, in place of the throughput $X=Q/T_0$ we simply consider the number of transactions *Q*, performed in the unit of time (assuming $T_0=1$), and therefore X=Q. Making the necessary substitutions, 4.6 becomes:

$$M \times N = P \times Q \qquad (4.7)$$

The variables *M*, *P* and *Q* in 4.7 are the very same of the expression in 4.1 (*M*, *P* and *T* respectively): therefore, we can assume that N≡V, so the multiprogramming level *N* corresponds to the transactions velocity of money indicated by *V*:

$$M \times V = P \times Q \qquad (4.8)$$

We derived Fisher's equation of exchange using Little's law. Let's see what 4.8 tells us:

- in the hypothesis that the velocity of money *V* and that the amount of transactions *Q* were constant (as in economics), since the aim is to grant a previously decided response time, i.e. to guarantee the stability of the purchasing power 1/R=SR/P, the rising of the price level *P* leads to a growth of the circulating money *M*;
- said growth of circulating money *M* has an effect on the salaries *SR*, that will increase, to guarantee the stability of purchasing power (SR/P);
- the circulating money *M* can grow only in the light of an increase in the monetary base as well, here called M_2 (deposits plus circulating money), because, if M_2 does not grow, the interest rate *i* will rise (note: in economatics the interest rate *i* is the result of the difference between the utilization rate of current resources and the utilization rate of target resources: $i=u_{current} - u_{target}$; therefore, if *M* rises but M_2 remains constant, the value of $u_{current}$ will be higher than

the one of u_{target} and, consequently, *i* will increase) and this will lead to a decrease in investments *I*, in employment *N* and therefore in the velocity of money *V* (which, as stated in the first hypothesis, must remain constant);

- M_2 can grow only if the capital (CPU) can too, as service units are closely linked to the capital. If the capital can't grow, then M_2 remains constant; the increase of the variable *M* will cause the investment rate to rise, the investments will diminish, as will employment and the velocity of money: the results will be a reduction of the amount of production *Q*.

4.3 A new economic equation derived from informatics

The fact that the response time *R* is showing here as marginal propensity to save *s* on the aggregate demand's side, and also as marginal productivity of labor 1/R (or real wage *w*) on the aggregate supply's side, leads us to an interesting consideration: since R=s and 1/R=w, with respect to the identity R≡R, then R=1/(1/R) and we can get the following economatic expression s=1/w that combines demand and supply in one formula (Fig. 4.1).

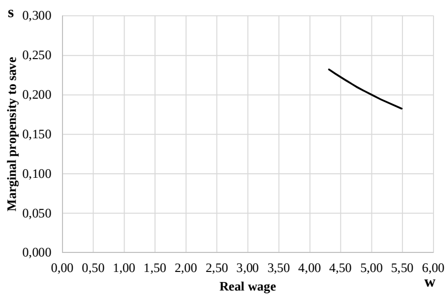

Figure 4.1. The curve shows an inverse relationship between the real wage *w* (or purchasing power of wage, or marginal productivity of labor) and the marginal propensity to save *s*. The price level P_0 does not influence the position or the shape of the curve. Source: own creation.

The curve of Fig. 4.1 graphically expresses this concept: «as the real wage increases, the propensity to save decreases and, vice versa, as the real wage decreases, the propensity to save increases».

In other words, if you earn less you tend to save more. This does not mean that you save more money, but that you are more restrained in consuming. The statement seems reasonable and was formulated for the first time in [8] and published in [9] following the very same mathematical procedure reported in this article. If the economatic equation s=1/w (represented graphically in Fig. 4.1) were to prove valid in economics too, then we would have discovered a new economic equation.

5. Applications of economatics to real economy: employment, product, purchasing power

5.1 Dual-currency circulation

Dual-currency circulates in the Data Processing Center, although the Center is not aware of it: the euro — that the management and users use for exchanges with the world outside the DPC (production and consumption of goods) and managed by the bank — and the service unit — that users use for exchanges inside the DPC (production and consumption of transactions) which is controlled by the DPC's management. Let us analyze how digital currency is used within the DPC.

A mainframe equipped with a cpu, which is able to deliver 70 million of service units per hour (70 MSU) costs approximately 727,273 euro (the amount given is real and it already factors in the real storage, the disk pool, the software and all that is necessary to deliver IT services according to the service levels established by DPC's management). Consequently, the conversion rate between euro and service unit (SU) is: 727,273:70,000,000=0.0104 (€/SU). In other words, 100 SU equal 1 €. The above mentioned "70 million service units per hour" is due to the fact that we are considering production periods with a time interval of one hour each, in which, in order to meet the throughput and response time goals, 70 million service units are just enough.

Referring to the values shown in Tab. A.2, we assume that a DPC's computer programmer receives from the mainframe a digital salary of 1812 SU per second and that he produces (and consumes at the same time) a certain amount of transactions lasting 3 CPU seconds in total, during the whole eight-hour-long workday (one must not be surprised if one consumes "only" 3 CPU seconds: 3 CPU seconds of a very powerful CPU constitutes a big amount, especially for activities that are only performed at video terminal). The computer programmer's digital salary is therefore 1812×3=5436 SU. Considering that a month has 22 working days, the monthly digital wage of the worker must be 119,592 SU net and it is all spent for the consumption of transactions. If we convert the monthly wage from SU to euro, we have as a result: 11,592SU×0.0104€/SU=1244 euro net. Lastly, considering that one year has 12 working months (we do not count one month of vacation), the net annual income of the computer programmer is 1244×12=14,928 euro (we consider the "net annual income" because the nation's production time is usually of one year).

Now we calculate the velocity of circulation of money.

The mainframe computer we are taking into account is an IBM 2097-713 with 13 processors, but the partition we are analyzing, and from which we have obtained the values reported in Tab. A.2, is equipped with 2 processors. Having 2 processors, the system supplies 44,692.7 service units per second per processor. To simplify, we consider only one processor whose speed is 44,692.7 service units per second: the currency stock, made by both deposited and circulating money, is of 44,692 SU. Again, we will consider a time span of 1 second. Since every user receives, in a second, a wage that amounts to 1812 SU, the system–firm must ask the artificial bank for an amount of money corresponding to 1812 SU (we remind the reader that the system pays one user at a time). Differently said, the amount of money that the artificial bank must release in the market is M=1812 SU (i.e. the circulating money M_1). Since in 1 second 24,91 transactions are being made, each with an average weight of 410 SU (see Tab. A.2), the wealth produced in 1 second is Y=P×Q=10,213 SU. According to the equation 4.8, the velocity of circulation of money is given by: V=(P×Q)/M, which means that V=10,213/1812 from which one calculates V=5.64. This value corresponds, as we also highlighted in paragraph 4.2, to the number of user/workers *N*, i.e. to the multiprogramming level.

If an additional programmer is hired, the digital wage of each programmer will decrease (due to the law of diminishing returns) and consequently, the respective wage in euro will decrease as well. Hence, given a specific price level, if one wishes to preserve the purchasing power, in the case we took as example, one must hire no more than 265 computer programmers. It follows that employment can grow only in the light of a growth of capital. For the capital to expand, it is necessary that not all the income is consumed but that part of it is being saved to run investments (and therefore to enlarge the money stock).

Summing up what we have just said: the amount of physical capital available has a precise monetary value that (in our model) is distributed as income to the workers. The income is partially spent for the consumptions and partially saved up. The part of income that has been saved up allows one to make investments, which, in turn, allow growing one's capital, that permits the growth of the employment's level.

The employment then is related to the amount of available resources: therefore, only by linking currency and the amount of real resources it is possible to obtain an equilibrated growth (with this term we mean that the capital gradually expands as the population grows, maintaining the purchasing power constant). Flowingly, the amount of currency must be increased only in face of a rise in the amount of available resources. The creation of money through the interests mechanism (the one that banks use) ensures that an amount of money exceeding the amount of resources will tempt the consumer in wanting to consume more than what can be produced: this will cause the prices to go up. The price is the mean through which the rationing of resources takes place. Hence, if the rationing of resources does not happen *ex ante*, before the production (by correctly balancing the amount of currency and the available resources), it happens *ex post*, after the production (due to the prices rising).

Instead of the word "savings" (which is equivalent to "deferred consumption over time") in our example we should have used the more correct expression "unavailable labor income" (which is the part of the income subtracted from the total income as a result of the application of income taxes): it's exactly this unavailable labor income which, in our model, turns into capital (factor of production); and since this unavailable income derives from the taxes demanded by the State, the capital becomes property of the State (so, property of all of us).

As the salary is the compensation for the work of the employee, the profit is the compensation for the work of the entrepreneur. In our model for the management of digital money, profit is treated as salary: even a part of the entrepreneur's profit is withdrawn, through taxes, to generate new capital. The capital, therefore, is formed by levying part of the wage and part of the profit through taxes.

In this model, digital currency is not subject to interest: savings, loans, deposits, mortgages are not subject and do not give rise to interest. This does not mean that the interest rate is meaningless, on the contrary. In our model, the interest rate is an important regulator of the use of resources (and therefore of the product), of the employment and of the purchasing power.

The digital currency of the State, as the service unit of *System z*, is scriptural money and it has no costs. It is similar to the scriptural money of the bank (or bank money) with the following important differences from bank money:

- it does not generate new currency by exploiting interests;
- it is connected to the value of real resources (capital): so it can rise or diminish only as the amount of capital varies (if the capital rises then the money will increase too).

The digital currency of the Sate will produce the benefits listed here:

- it will make the national economy stable (as it will not be influenced by speculative bubbles or by financial crises);
- it will generate higher incomes for the State (since the transactions are centralized and tracked, tax evasion will simply not be possible).

State digital currency is the alternative to the idea of a flexible euro advanced by the American economist Joseph Stiglitz (according to Stiglitz, a flexible euro should be of electronic nature: every nation would have its own euro with the advantage of being able to levy taxes easier and having more flexible exchange rates [10]). The State's digital currency, with regards to Stiglitz's flexible euro, has the advantage of being able to be used within short times, because, since it exists on a national level (just like the digital currency provided for digital restaurant vouchers), it will not be examined or be in need of approval by the nations who belong to the so called Eurozone. Digital currency is completely equivalent to virtual currency (it exists only in a computer storage) and, in this form, it is also the same as cryptocurrency. About cryptocurrency, the European Central Bank (ECB) affirms: «Virtual currency schemes, such as Bitcoin, are not full forms of money as usually defined in economic literature, nor are virtual currencies money or currency from a legal perspective. Nevertheless, VCS [*Virtual Currency Schemes* — Author's note] can/may substitute banknotes and coins, scriptural money and e-money in certain payment situations» [11]. From the words of the ECB, it is clear that any private community could issue ("could mine") and use its own cryptocurrency; therefore, the State can too. However, unlike cryptocurrency which requires electricity — and a lot of it — in order to be "mined" (that is, extracted, created), the State's digital currency linked to the capital (with the participation of the State), being scriptural — like bank money —, is much cheaper.

5.2 The solution to the problem of generational unemployment

Nations are investing more and more in automation and digital disintermediation, becoming more and more similar to Data Processing Centers. They must face the problem of digital unemployment (caused by internet's digital disintermediation, by the substitution of a man with another type of man; for example, with regards to the phenomenon of home banking, the bank employee gets replaced by the client of the bank, now e-employee), besides that of Ricardian unemployment (or technological unemployment, caused by the replacement of labor with capital, of men with machines; for example the supermarket employee can be replaced by the client or "virtual employee" in occasions such as the self-checkout), besides, again, Keynesian unemployment (due to a lack of demand leading to a reduction of the number of workers — firms cut down on employees when they don't sell their products because the unemployed or low-wage workers do not consume or consume very little). Automation, disintermediation and lack of consumption demand are the causes of the biggest problem of our digital era, generational unemployment, which is the unemployment of an entire generation, the one that is now thirty years old.

In the era of automation and disintermediation, which countermeasures must we adopt to face the three kinds of unemployment: Digital, Ricardian and Keynesian? Some suggest to apply a robot tax and some suggest a "base income", otherwise called "guaranteed income" (this topic, which is very current in Italy, is addressed in the paragraph "Revisiting the basic income" in the book *The second machine age* written by Brynjolfsson and McAfee, two researchers of the Massachusetts Institute of Technology (MIT) [12]). Economatics suggests to focus on labor income, instead of on the basic income. Let us explain why.

Both the basic income and the labor income have an influence on consumption, but they act on them in a different way. In economics, the function of consumption is $C=C_0+cY$ in which C_0 is the autonomous consumption (independent by income), Y is the income and c stands for marginal propensity to consume (we have already explained this in paragraph 3.2 about equation number 3.2).

But what are those "autonomous consumptions"? Here is a definition:

> […] autonomous consumptions [are] the consumptions financed by consumer loans. When we buy a vehicle or a house appliance in installments, a bank has indeed paid for us in advance, crediting newly created money in the seller's account, money that we will give the bank back, with interests. Similarly, purchasing a house with a mortgage, even if deceptively classified in national accounting as an investment expense, is a kind of autonomous consumption, actually, it is the most powerful kind as the American, Irish and Spanish real estate bubbles demonstrated; the very same that have preceded and then ignited the financial crisis of 2008 [Author's translation] [13].

The basic income which the State supplies, despite not coming from labor, will generate consumption through autonomous consumption ($C=C_0$). On the other hand, economatics (as we said before), suggests to focus on labor income Y, that is in the variable cY, and not on the basic income (which influences the variable C_0), because in economatics, unlike economics, the function of consumption is expressed by $C=cY$ in which C_0, the variable about the autonomous consumption, is missing. This is due to the fact that the user starts to consume in the moment he starts producing, so in the moment he receives an income. Hence, economatics can work only with consumptions from labor incomes.

We observe that, to consume, households need an income; to produce and assign an income, firms need people to consume (this circular causality is recurrent in economic analysis, especially in macroeconomics). The basic income, one must admit it, could solve the *impasse*: it will give a fresh start to consumptions, which will stimulate production, which will enable firms to create workplaces, which will give households an income, and this will increase consumptions, that will again boost production, which will increase employment (but the latter is not really to be taken for granted: firms could resort to already existing employees whose work capacity is not at saturation and, therefore, employment will not grow).

One could act in a different way though. We must observe again that the circular causality of consumptions–employment–consumptions obliges employment to rely on consumptions (as the basic income will do). However, the very same circle wants consumptions to be dependent on employment; this labor-based approach is what characterizes economatics.

The very same result that the basic income will have on consumptions, with even bigger effects, could be obtained by balancing the incoming and outcoming labor fluxes. In fact, if the consumption demand is stagnant or insufficient (as it is the case in many countries nowadays, Italy included), it can be stimulated by promoting the early-exit of long-term workers (the ones close to retirement, to be clear) in order to welcome the young ones who are looking for a job. These very same young workers are the ones who could push consumptions further, especially the consumption of those kind of goods (like a house, furniture, household appliances) that long-term workers do not need because they already bought them. Moreover, young generations, the so-called "digital natives" (the ones born after 1985, the year of mass diffusion of PCs and of the first Windows operating systems) are the best kind of workforce to build the digital future of the firms and of the nation.

Both the basic income and the anticipated retirement of long-term workers affect the State budget: if there were no new incomes, both reforms must be sponsored with the public deficit or with resources to be found by cutting other expenditures (pensions — first and foremost —, public health care, debt's interests rates — the latter to be implemented by reducing the public deficit — which are the biggest expenditures of the State).

Looking back at Keynes' equation in 3.1 and adding public spending and foreign trade to it, the global demand consists of: consumption demand (households' expenditures on goods), investment demand (expenditure by firms on new capital goods), demand stemming from government purchases (public spending) and foreign demand for exports. To solve the unemployment problem, global demand must be increased ("bringing about higher rates of overall economic growth" [12]). To increase global demand, it is necessary to act on some regulatory mechanisms. Let's take a look at them.

To promote exports, it is necessary to reduce the exchange rate, but this regulatory mechanism is blocked, since with the single currency, the euro, European States have no longer the control of the exchange rate at national level, and exports to other continents are conditioned by the same exchange rate choices on which the individual nations of the euro area have little (if any) influence.

To promote public spending, the same must be financed with the public debt, but this regulatory mechanism is blocked, since the Eurozone States have signed a Stability and Growth Pact (which means: compliance with budgetary constraints and of debt. The deficit of a nation — in which the expenditure is higher than the revenues — must not exceed 3% of the GDP, and the public debt must remain below 60% of the GDP). This means that the European Union obliges Eurozone States to regulate public spending and public debt.

To promote the firms' demand for investment goods, the interest rate must be reduced, but this regulatory mechanism is blocked, since, with the single currency, there is no control of the interest rate at the national level. It is true that currently the interest rate is low (equal to 0.00%: this is the ECB rate, the rate that European banks have to pay when they borrow money from the ECB — source: https://www.euribor.it/tasso-bce/ of 16 July 2018), but, despite the low interest rate that commercial banks, in turn, are willing to apply to customers, investments (and consequently employment) are struggling to take off.

To promote the households' demand for consumer goods, taxes must be reduced (in this case direct taxes: this way, households have more money to spend on consumer goods). This regulatory mechanism is blocked, since minor taxes and equal public expenditure generate a deficit and a public debt and this goes against the Stability and Growth Pact.

The era which we live in is characterized by deflation and unemployment (some will say that inflation is moving towards the desired 2% target, a sign that there is a recovery, even if weak, and that, on the employment front, we are moving on with structural reforms, i.e. with interventions on the labor market and pension's management system). Since unemployment and deflation are at the basis of the current problems (in Italy the unemployment rate was 11.2% in 2017, corresponding to 2.9 million unemployed people [14]), Keynes has, again, the answer to fight these two problems *at the same time*, by stimulating global demand. However, nowadays times are different from the times which Keynes lived in: the solutions advanced by Keynes to solve the problem of unemployment in 1929 (one of these is the socialization of investments, which means that investments are made by the State instead of by firms) must be adapted to our digital age.

The solution could be the following: to balance the flow of the labor force entering and leaving firms. For example, this is the mechanism that the economatic system uses to regulate consumptions, production, employment and income, by alternating various users on the job (in technical terminology one talks about swap–out and swap–in): a user stops working (he has been swapped–out) and at the same time another user starts (he has now been swapped–in). The solution should be found by matching the labor force flows with pensions, whose delivery should be endogenous, so it should happen without the State's intervention. One must underline that to offer incentives to firms so that they hire more workers is not going to give results, because firms, due to the lack of demand, can't foresee their products being sold and, therefore, they are not inclined to hire new employees (or, if so, just for the short time in which those incentives are still given out).

Our era bears the digital footprint: therefore the answer to stimulate employment hides in the digital world. Since economy is based on exchange and exchanges use money as a medium, the adoption of the State-issued digital currency, managed by the State (we talked about it in paragraph 5.1) and circulating in parallel with the currency managed by the bank, is the solution to the problem of current generational unemployment.

6. Conclusions

Empirical observation and mathematical models demonstrate that the Data Processing Center is equivalent to a nation; it is a small-scale model of a nation and could therefore serve as a laboratory for economic experiments with similar conditions to those of the real world.

Similarly, a digital nation is equivalent to the Data Processing Center, it is its reproduction on a larger scale and, therefore, the production model adopted by the DPC based on the use of digital currency, can also be applied to the digital nation.

Digital nations, like DPCs, will develop automation and disintermediation more and more, and these will have an impact on employment.

To mitigate their impact on employment, the State could use a State-issued digital currency that is not subject to interest, that is linked to real resources (capital, land and labor), which is managed by the State and used for exchanges within the nation, which will be circulating with the euro; the latter would instead be managed by the bank and would be used for exchanges with the outside world.

Dual-currency circulation will make the national economy stable, not exposed to speculative bubbles and financial crises; it will allow implementing the necessary measures to favor consumption, to stimulate investments, to develop employment, to facilitate generational turnover without weighing on the State budget. Finally, these measures will be in accordance with the Stability and Growth Pact, to which the countries of the euro area adhere.

7. Appendix

Table A.1. Correspondence between economic and informatic variables.

ECONOMICS	Mathematical variable	INFORMATICS
Production period (1 year)	T_0	Data Processing period (1 hour)
Real good	-	Transaction
Stock of exogenous money (deposits + circulating)	M_2	Stock of service unit (speed of processor)
Amount of money offered (endogenous)	M_0	Service rate (SR)
Global Domestic Product (real GDP)	Q	Throughput (the informatic variable is $X \equiv Q/T$. If T=1 second, then X=Q)
Price of goods	P_0	Weight of transaction
Nominal wage	W	Service rate (it coincides with M_0 because the system serves one user at time): $W \equiv SR$
Marginal propensity to save	s	Response time ($R=P_0/SR$)
Marginal propensity to consume	c=1-s	1-R
Real wage (=nominal wage/price level=purchasing power)	$w=W/P_0$	Reciprocal of response time (1/R)
Labor force	L_0	Users connected to the system (working + "idle")
Employee	N	Multiprogramming level (MPL)
Amount of circulating money (endogenous)	M_1	Global service rate ($M_1=N \times SR$)
Velocity of money circulation	V	Multiprogramming level (MPL): $V \equiv N$
Real interest rate	r	Difference between the current utilization rate and the target utilization rate: $r=u_{current}-u_{target}$

Table A.2. Values reported by RMF concerning a real case.

Economic variable	RMF variable	mathematical variable	Value
Production period	INTERVAL	T_0	000.49.59 (hhh.mm.ss)
Stock of money (deposits + circulating)	SU/SEC	M_2	44.692,7
Amount of money offered	TRX SERV (CPU only)	M_0	1812
Labor force	TSO AVE	L_0	265
Employee	Transactions AVG	N	5.64
Real GDP	Transactions END/S	Q	24.91
Nominal wage	TRX SERV (CPU only)	SR	1812
Nominal GDP	Not given	$Y=N \times SR$	5.64×1812= 10,219
Amount of circulating money	Not given	$M_1=Y$	10,219
Velocity of circulation of money	Transactions AVG	$V \equiv N$	5.64
Price level	Not given	$P_0=Y/Q$	10,219/24.91 =410
Marginal propensity to save	Goal Response Time	R_0	0.200
	Actual Response Time	$R= P_0/SR$	0.226
Marginal propensity to consume	Not given	c=1-s=1-R	0.774
Nominal interest rate	APPL% CP	$i=M_1/M_2$	23.54 ($util_{current}$. Include CP overhead)
Real interest rate	Not given	$r=util_{current}-util_{target}$	0

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	Claudio Maria Perfetto started working in 1979 as an application programmer (CICS Assembler macro level and CICS COBOL command level). After two years he became a system programmer — dealing with the generation and maintenance of mainframe operating systems (MVS/370, MVS/SP, MVS/ESA, MVS/XA, OS/VS1, DOS/VSE, VM) — and a specialist in performance management and capacity planning. From 1987 to 2006 he worked for Pirelli and Olivetti as a specialist in information technology (generation of MVS/XA and OS/390 operating systems, service level management, tuning, capacity planning). From 2006 to 2010 he worked in a company owned by Deutsche Telekom as Business Continuity Manager with the aim of designing and maintaining the Business Continuity Plan to be used in cases of disastrous events (such as floods and earthquakes) which cause the unavailability of essential resources for running the business (buildings, personnel, ICT, electricity, documentation). Since 2011 he has been working as an IT consultant in the field database administration — DBA — (he also implemented a mainframe statistics portal on z/OS, based on IBM http server and HTML–REXX–DB2 interfaces). During his professional career, he observed that data processing is very similar to the production of goods, and this led him to investigate more deeply the laws at the basis of data processing and of economic processes. He developed a synthesis between economics and informatics, which he calls “Economatics”, thanks to which it is possible to run laboratory experiments in economics in conditions close to those of the real world and to find solutions to economic problems, including generational unemployment (the unemployment that concerns an entire generation).