IS THERE A SIMPLE AND GENERAL ECONOMIC MODELLING METHODOLOGY?

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at the Cyprus Economic Society on 21 November 2019

2. The topic is of great relevance because policy questions should be answered on the basis of an economic model.

- **The proposed modelling methodology is explained and illustrated in my books on EUCLIDEAN ECONOMICS.**
- **Progress is not possible without deviation from the norm.**

3. Every modern economy consists of two interrelated subsystems, which operate according to different rules:

- **The first subsystem includes consumers, producers, governments, etc., namely the institutional sectors that are *acceptors but* not *issuers of money*.**
- **The second subsystem is the so called monetary financial sector; it consists of all organizations that are simultaneously *issuers* and *acceptors of money*.**

4. Sectors and countries trade and invest in accordance with written and unwritten laws that govern human behaviour, market exchange and financial relations.

Simulation of current and capital transactions via diverse methods has always been a topic of great interest.

The question is "*Why have the prevalent methods of economic simulation failed in becoming widely accepted and exploited*".

5. Throughout my career I have been interested in the simulation of modern economies. Progress would have been impossible without:

- ***academic knowledge*** **of subjects such as analytic geometry, linear algebra and differential equations;**
- ***professional experience*** **in areas such as financial accounts, national statistics and mathematical software.**

6. In order to build a model that imitates reality, I have adopted the minimum number of premises, which reflect the main principles of *accounting*, *economic*, *mathematical* and *monetary* operations.

The fundamental hypotheses of Euclidean modelling methodology are the following:

Accounting rules

- **Agents are *grouped* under sectors and countries; their transactions are also *classified* by market and currency.**
- **Agents *evaluate* and *compare* economic flows, traded goods and financial stocks via the bank accounting unit.**
- **Transactions are *recorded* as debits and credits and *summarised* by the banking system per time unit.**

Economic rules

- **Agents *maximise* assets and *minimise* liabilities; they also modify outgoings in accordance with incomings and credit policy.**
- **The divisions of *revenue* among sources and the divisions of *outlay* among targets originate from linear homogeneous functions.**
- **The percentages of income sources and expenditure targets *stay constant* within the time unit *but vary* from one year to the next.**

Mathematical rules

- **Income and expenditure are *determined* together *as a vector*.**
- **Quotations are *fixed exogenously* within each time unit; they *adjust according* to the gaps between demanded and supplied amounts from year to year.**
- **The discount rate is the *factor linking* past, present and future.**

Monetary rules

- **Banks issue and accept *liquid securities* at market value.**
- **Banks issue *liquid securities* that other sectors have to accept.**
- **The central bank can intervene regarding yearly increase, sector allocation and annual yield of *liquid securities*.**

11. The fundamental premises determine the exchange network's *modus operandi*

The economic system is based on debits and credits (or assets and liabilities) that give rise to *pairs* of annual flows, market turnovers and present values.

Every Euclidean model consists of *even* number of first-order non-homogeneous linear differential equations with fixed coefficients per time unit.

12. The *endogenous variables* of a Euclidean model are:

- **sector incomes and expenditures,**
- **market sales and purchases, plus**
- **financial assets and liabilities.**

The methodology reproduces the above as pairs of *mathematical functions* and *real numbers*, as *geometric points* or, generally, as *vector spaces*.

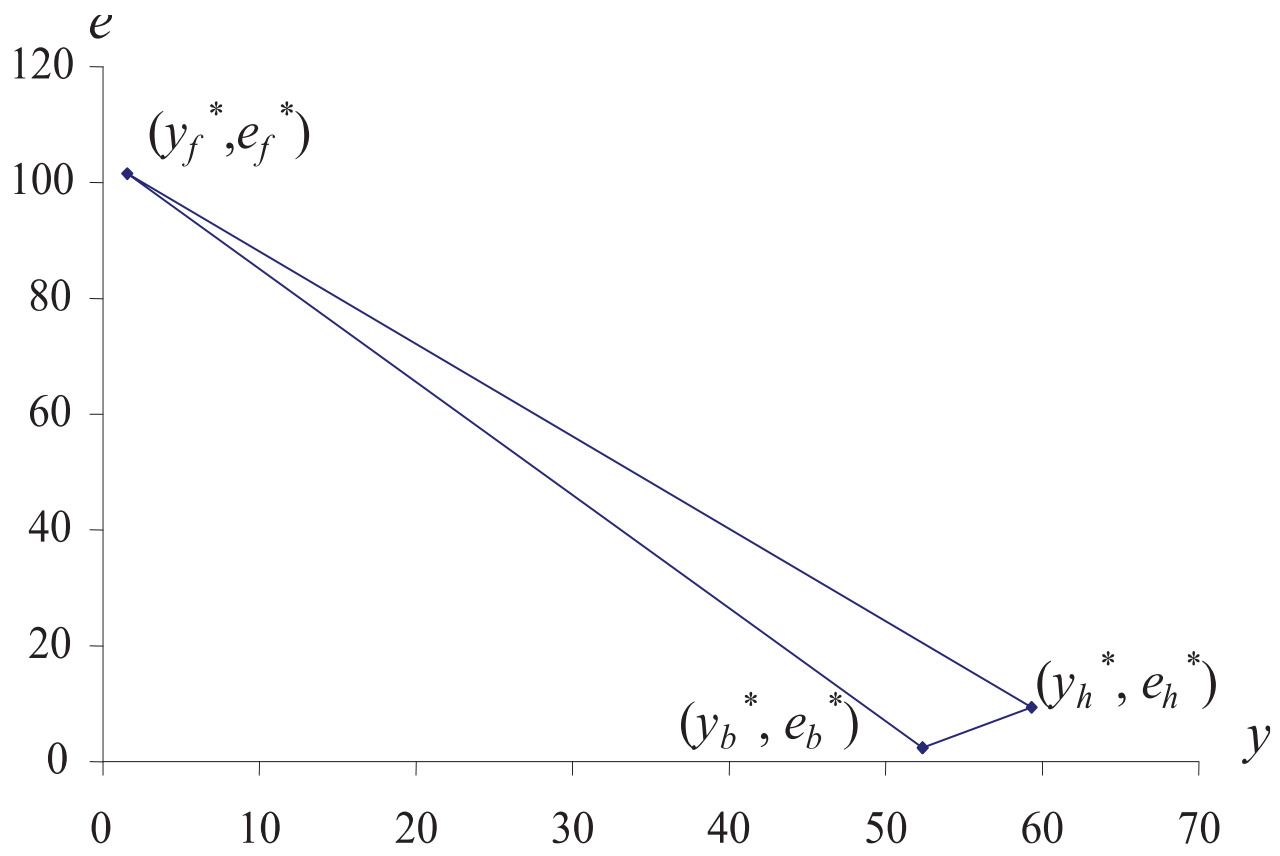
13. The *exogenous factors* of every economy are:

- the *percentages* of revenue derived from and outlay allocated to market goods by each sector;
- the *parameters* of monetary, fiscal and other policies enforced by the authorities;
- the *quantities* of labor, output, liquidity and other available resources;
- the *quotations* of services, products, securities, etc.

14. At the outset, developers and users of a model should agree on the desired level of detail:

- **The *number of equations* is equal to twice the number of sectors times the number of countries.**
- **Exchange networks become *geometrically larger* as sectors and countries are added.**
- **Size does not impede solution and examination of the system by means of *specialised software*.**

15. The equilibrium vector of an elementary economy called Alpha - with three sectors - on the geometric plane

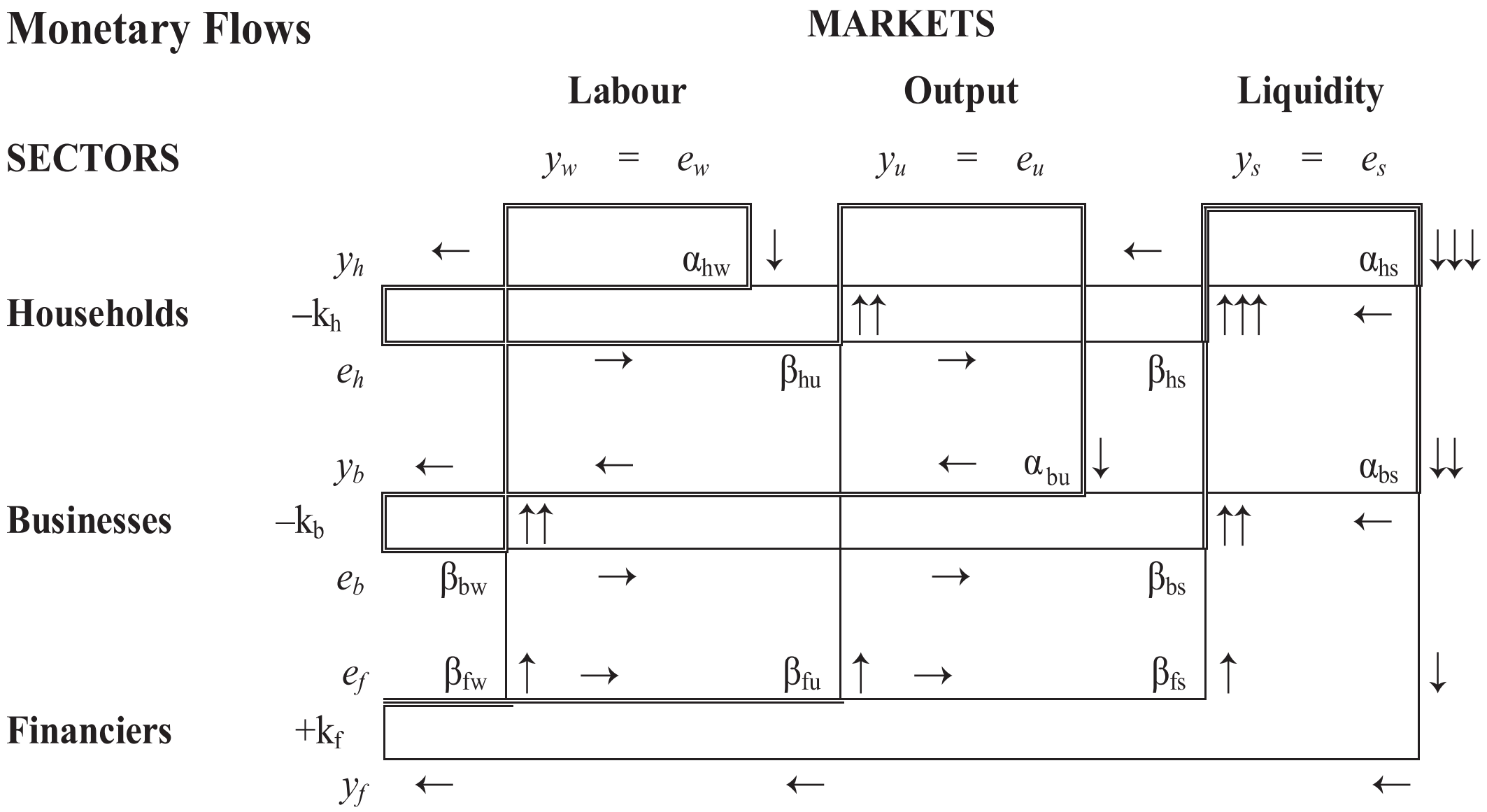


16. Due to their construction rules, Euclidean models allow evaluations, combinations and projections of economies with complementary scientific tools, such as:

- **differential equations and algebraic matrices;**
- **polygons or three-dimensional polyhedrons;**
- **electric, hydraulic and pneumatic circuits, etc.**

Every Euclidean model reproduces the annual transactions recorded and summarized by the banking system. As a result, aggregation problems - that have troubled creators and users of other types of simulations - are precluded.

Monetary Flows



18. The economic system is dynamic in the sense that whenever an exogenous factor is altered the endogenous variables adjust unevenly and with delay.

We conclude that policy issues are best studied as problems involving dynamic control of interdependent flows and stocks.

Econometric, VAR, DSGE and similar models are built neither as vector spaces nor as closed dynamic systems. Hence, they leave inexplicable gaps and open questions.

19. Every Euclidean model yields the economy's *equilibrium* vectors, *stability* conditions and *control* limits as functions of the exogenous factors.

Monetary, fiscal and other policy parameters are the main but not the only tools via which the related sector *flows*, market *sales* and financial *stocks* may be regulated.

20. Specialized software allows academics, bankers and officials to test the effects of diverse combinations of exogenous factors, including policy parameters, on sector flows, market sales, present values, etc.

World-wide co-existence implies that countries – wishing to maximise gross turnovers and minimise quotation pressures – should coordinate monetary, fiscal and other policies via a global Euclidean model.

ALFA: Percentages of Income Demand and Expenditure Supply

	Consumers		Producers		Bankers		Turnover
	Source	*Destination*	*Source*	*Destination*	*Source*	*Destination*	
Household Labour							Services
Receipts from	88.9%			83.3%			46.6%
Payments for						50.0%	
Business Output							Products
Receipts from			85.7%				39.8%
Payments for		87.5%				36.2%	
Financial Liquidity							Securities
Receipts from	11.1%		14.3%		100%		13.8%
Payments for		12.5%		16.7%		13.8%	
Share of Monetary Increment	$^1/_2 \cdot k_f$		$^1/_2 \cdot k_f$		\$1.0 billion = k_f		

22. Quotations (p) and quantities (q) of market goods

Market Good	Average Quotation	Available Quantity
Labor / Year **w**	p_w = \$470.90	$q_w = 10^6$ years
Output / Piece **u**	p_u = \$0.38	$q_u = 10^9$ pieces
Security / Unit **s**	p_s = \$13.60	$q_s = 10^7$ units

The annual yield on financial securities is 7.3% = 1/13.60

23. The model of Alpha comprises six differential equations with constant behaviour coefficients within the unit of time

$$dy_h/dt = -y_h - (1/7)\cdot y_b + (5/6)\cdot e_b + (^{2023}/_{3168})\cdot e_f$$

$$de_h/dt = y_h - k_h - e_h$$

$$dy_b/dt = -(1/9)\cdot y_h + (7/8)\cdot e_h - y_b + (1/2)\cdot e_f$$

$$de_b/dt = y_b - k_b - e_b$$

$$dy_f/dt = (1/8)\cdot e_h + (1/6)\cdot e_b - y_f$$

$$de_f/dt = y_f + k_f - e_f$$

	ECONOMY ALPHA	TRADED GOODS						
	Three Sectors and Three Goods	**Labor Services**		**Output Products**		**Liquid Securities**		**Annual Flow**
	Households - Consumers	**Supply**	**Demand**	**Supply**	**Demand**	**Supply**	**Demand**	
1	Income Sources x10^3	$527 484				$65 936		$593 420
2	Expenditure Destinations x10^3				$81 743		$ 11 677	$93 420
3	+ Surplus or New Deposits x 10^3							$500 000
	Businesses - Producers							
4	Income Sources x10^3			$448 800		$74 800		$523 600
5	Expenditure Destinations x10^3		$19 667				$3 933	$23 600
6	+ Surplus or New Deposits x 10^3							$500 000
	Banking Organizations							
7	Income Sources x10^3					$15 610		$15 610
8	Expenditure Destinations x10^3		$507 817		$367 057		$140 736	$1 015 610
9	Deficit or New Loans x 10^3							–$1 000 000

10	**Aggregate Demand** x10^3	$ 527 484	$ 448 800	$ 156 346	$1 132 630
11	**Aggregate Supply** x10^3	$ 527 484	$ 448 800	$ 156 346	$1 132 630

12	**Gross Turnover** x10^3	**$ 527 484**	**$ 448 800**	**$ 156 346**	**$ 1 132 630**
		A	***B***	***C***	***D***

25. In addition to Alpha’s annual flows and market turnovers, the Table shows that:

- **total incomings and outgoings amounted to $1.13 billion, respectively;**
- **revenues and outlays differ by the sector’s share in the monetary increment.**

26. Annual expenditures ρ on services *w*, products *u* and securities *s* are linear functions of the increase k and the allocation κ of liquidity:

$$\rho_w = (8/_{1771763}) \cdot (59560+114523 \cdot \kappa_h) \cdot k_f$$
$$\rho_u = (6/_{1771763}) \cdot (184085-103109 \cdot \kappa_h) \cdot k_f$$
$$\rho_s = (2/_{1771763}) \cdot (115061+46891 \cdot \kappa_h) \cdot k_f$$

Dividing the gross sales of services (ρ_w), **products** (ρ_u) **and securities** (ρ_s) **by the average salary** (p_w), **price** (p_u) **and value** (p_s), **respectively, we find that Alpha demands 1.1 mil. years of labor, 1.2 mil. pieces of output and 1.1 mil. units of liquidity per annum.**

27. The gaps between demanded and supplied quantities (q) are functions of credit parameters (k, κ) and market quotations (p)

$$\{\rho_w^{*}/\,p_w\} - q_w^{\#} = \{(8/_{1771763}) \cdot (59560+114523 \cdot \kappa_h) \cdot k_f / p_w\} - q_w^{\#}$$

$$\{\rho_u^{*}/\,p_u\} - q_u^{\#} = \{(6/_{1771763}) \cdot (184085-103109 \cdot \kappa_h) \cdot k_f / p_u\} - q_u^{\#}$$

$$\{\rho_s^{*}/\,p_s\} - q_s^{\#} = \{(2/_{1771763}) \cdot (115061+46891 \cdot \kappa_h) \cdot k_f / p_s\} - q_s^{\#}$$

The model and the data reveal deficits of 120,000 years of labor, 181,000 pieces of output and 149,000 units of liquidity, which must be eliminated to contain inflation.

28. The gaps between demanded and supplied amounts comprise a linear equation system. Solving the system for the *credit policy vector* (k, κ and p_s), we find that all shortages are eliminated when the monetary authority:

- ***restricts*** **the bank balance-sheet increment *to* $870 million *from* $1 billion;**
- ***raises*** **the household share of new loans & deposits *to* 53% *from* 50% of the total, or**
- ***reduces*** **the business share of new loans & deposits *to* 47% *from* 50% of the total;**
- ***decreases*** **the average yield of liquid securities *to* 6.5% *from* 7.3% per annum.**

29. A world-wide economic model can generate the combinations of national policy measures that minimize quantity gaps and quotation pressures in all sectors, countries and zones simultaneously.

Endogenous variables can also be expressed as animated images in order to facilitate dialogue among officials, employers, employees and other stakeholders regarding tools, targets and outcomes.

30. Without a Euclidean economic model monetary, fiscal and other authorities:

- ***fail to estimate*** **the policy parameters that eliminate quantity gaps and quotation pressures;**
- ***ignore that*** **targets and tools are subject to strict static, dynamic and controllability limits;**
- ***rely on*** **presumed flexibility of quotations to bridge quantity shortages and surpluses.**

31. According to the relevant theory, the equilibrium vector of a dynamic system can be *externally controlled* when it is:

i) unique, ii) stable and iii) right-handed,

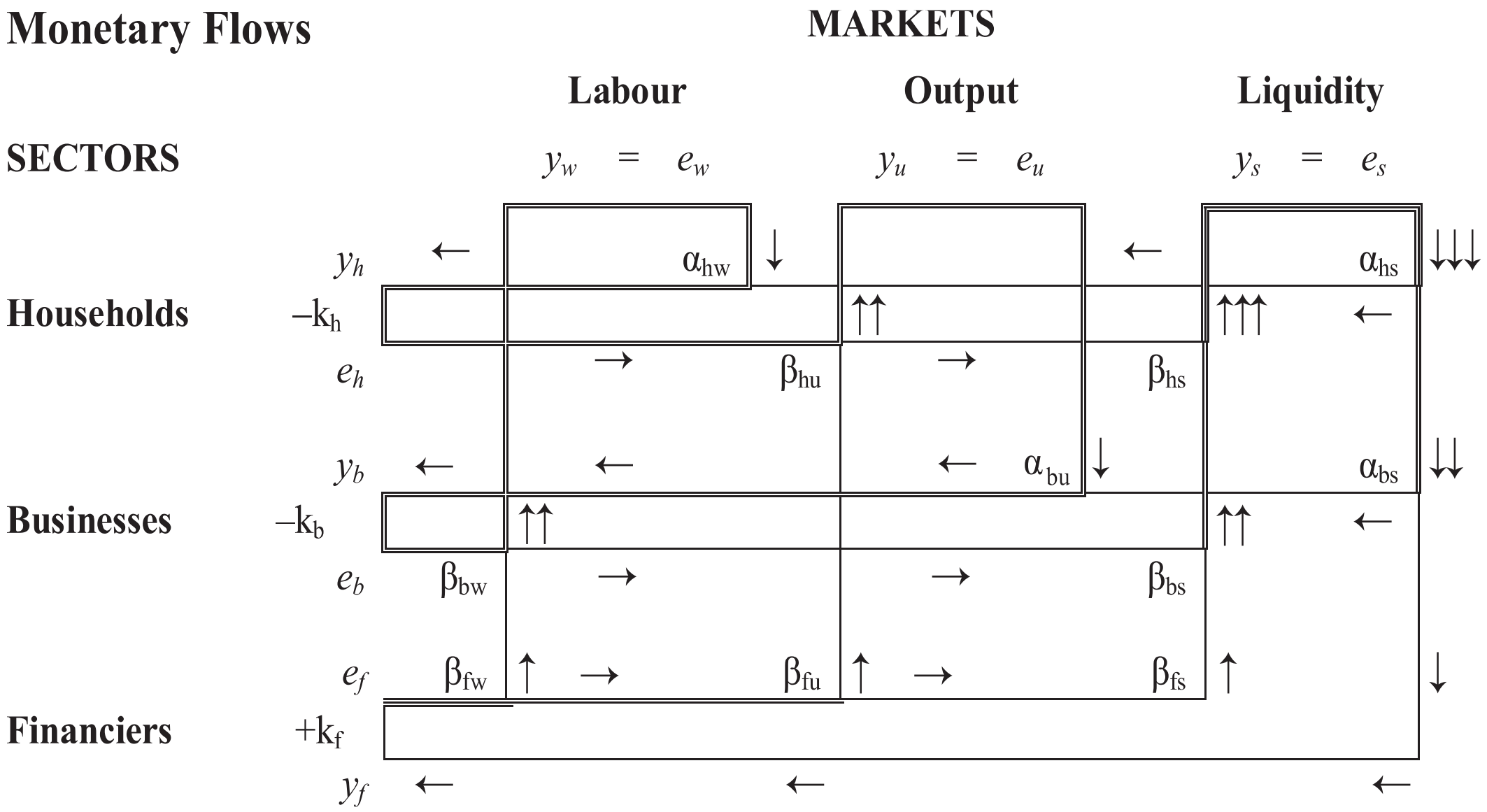
i.e., it consists of flows having the same sign or turning in the same direction.

32. In models such as ours, *uniqueness* and *stability* of equilibrium depend on the Routh-Hurwitz determinants being greater than zero.

Economy Alpha has a *unique* and *stable* equilibrium as long as banks allocate:

- **maximum 87% of *operating expenses* to financial liabilities;**
- **minimum 13% of *operating expenses* to services and products.**

Monetary Flows



34. Regarding *controllability*, receipts and payments should be treated as a system of inequalities, which can be solved for the division of credit that yields positive sector flows.

Alpha's incomings and outgoings have positive signs or turn counterclockwise as long as:

- **consumer loans range between 46% and 72% of the total;**
- **producer loans range between 28% and 54% of the total.**

Outside the above credit shares, Alpha becomes uncontrollable.

35. Arguably, every exchange network is a system of interdependent flows and stocks. Economic issues - concerning sectors, markets, countries and zones - should be studied and solved in this framework.

Econometric, VAR, DSGE and other models are neither vector spaces nor closed dynamic systems. They are not useful for policy formation because their equilibrium, stability and controllability properties are undefinable.

	ECONOMY ALPHA	TRADED GOODS						
	Three Sectors and Three Goods	**Labor Services**		**Output Products**		**Liquid Securities**		**Annual Flow**
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37. The Table indicates that the monetary sector:

- **earned $11.7 mil. *from* households, $3.9 mil. *from* businesses plus $140.7 mil. *from* banks as interest and dividend on securities;**

- **spent $65.9 mil. *for* labor services, $74.8 mil. *for* output products plus $15.6 mil. *for* interest and dividend on securities.**

Discounting annual receipts and payments at the rate of 6.5%, we confirm that the present values of bank flows were $2.4 bil., respectively.

38. Per time unit, banks engage in current operations and capital transactions.

- **Monetary financial balance-sheet expansion in Alpha is $1.0 billion or close to 42% per annum.**
- **Alpha suffers from shortages of services, products and securities due to excess supply of liquidity.**

39. Banks are trusted as long as they receive and pay interest and dividend without fail.

- **The steady state becomes fragile when households, businesses, etc., allocate insufficient percentages of their annual expenditures to their financial liabilities.**
- **This was among a number of disastrous developments in Cyprus, Greece, Italy, Portugal, and Spain during the years preceding the financial crises of 2007 - 2015.**

The 12 premises of Euclidean methodology apply equally to national and global models.

- **Trade, investment and payments among countries require *additional hypotheses*, mainly as regards the ways in which current and capital transactions are estimated and realized.**
- **The *most important* addition is that sectors and countries conduct their affairs without money illusion; they evaluate flows, goods and stocks in international monetary units.**

41. From 2007 to 2015 successive blunders regarding expansion, allocation and pricing of loans and deposits, increased demand, enlarged deficits and accelerated inflation, especially in southern members of the EU.

- **When monetary balance-sheets were brought under control, incomes and expenditures dropped sharply in Cyprus, Greece, Italy, Portugal and Spain.**
- **Banking organizations that issued deposits and accepted loans at unreasonable annual amounts, sector distributions or interest rates were burdened with losses.**

42. All Euclidean simulations are built on the same simple and general framework. In comparison, econometric, VAR, DSGE and other models are *sui generis* constructs.

The 12 essential hypotheses - assisted by computer technology - enable economic, accounting and mathematical analysis and synthesis of issues concerning institutional sectors, traded goods, sovereign countries and currency zones.

43. My books provide numerous examples and applications.

Among other topics, I have investigated:

- **Stabilization of sector flows, market sales and balance sheets;**
- **Convergence of countries wishing to adopt a common currency;**
- **Division of gains and losses resulting from trade liberalisation;**
- **Economic history and growth by means of automated projections;**
- **Advantages and disadvantages of monetary, fiscal and other policies;**
- **Flow and stock effects of interest and exchange rates world wide.**

44. Despite methodological innovations, my findings are in harmony with economic theory, accounting practice and mathematical science.

Universities, governments, banks and others should further develop and refine Euclidean models because they are very promising.

Without deviation from the norm, progress is not possible.