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THE THOROUGHLY DISAGGREGATED QUANTITY EQUATION

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ABSTRACT

A calculus called thoroughly disaggregated quantity equation is presented. It apportions each income receiving economic agent the exact amount of currency to perform its role and through this channel all the necessary liquidity for the productive economy is dispensed into circulation. The model utilizes an enhanced mutual credit type of complementary currency and compares it to the narrative of the paradox of monetary profits paying attention to the rigorous assumptions of the latter. The former hinges on the implementation of quantitative control of monetary mass and the restricted environment common to both narratives is shown to be its very enabler. Both narratives are described utilizing stock flow consistent models explained from the perspective of the cash-based accounting. The setup proposed by the enhancements seamlessly isolates mutual credit complementary currency to the realm of the productive exchange and leaves the brunt of the financial exchange to some other currency.

KEYWORDS

degrowth, quantity equation, profit paradox, credit clearing, mutual credit

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1. INTRODUCTION

If there is one thing in the present-day economy that impedes profits, then surely it is not a lack of credit. According to Keen (1995), the economy is following the path of ever riskier behaviour on the side of the businesses and the banks.

In that manner, following the so-called 'great moderation' period of stability, the last global financial crisis struck in 2008. Prior to that, the deregulated banking sector supplied the economy with excessive amounts of credit-induced money. Sobering restraint on the part of businesses alone could not have avoided this ever-riskier behaviour. In the absence of governmental intervention, it is quite clear that the banks themselves producing too much credit actually caused the crisis. The ensuing regulatory, political and media pressure pushed the banking sector in the opposite direction towards restrained credit supply, which could have caused a much more sinister credit crunch and the collapse of the economy had the central banks and governments not intervened in supplementing liquidity through quantitative easing. In other words, the economy with the liquidity supplied by the modern banking sector is not stable and hence the governmental intervention is indispensable (Keen, 1995).

This perspective on the economy, however, is not shared by everyone. Apart from the hardcore proponents of the free market, there are some communities, regions or entire countries where governmental intervention in the monetary field is not considered welcome or of much use. There are countries significantly impeded by corruption where governmental intervention is as much a remedy as it is a disease contributing to the continuation of the corruptive cycle. The other players that cherish independent banking are the economic and administrative initiatives, that strive to stimulate the economy in those underdeveloped regions forgotten by their capitals, and which are not attractive to investors. Many such initiatives seek solutions in community and complementary currencies (CCs), albeit with mixed success. An intrinsically stable banking system is of paramount importance for these players as they either cannot rely on the regulator or do not have many resources to perform such a role.

This paper argues the potential of the self-regulated and self-restrained banking practiced by the CC communities, particularly one kind, which is called mutual credit CC. The paper explains various enhancements meant to improve the acceptance and penetration of the existing mutual credit experiences on the one hand and to contribute some ideas in the search for a better, more resilient and just monetary system on the other.

The idea of a mutual credit CC was popularized by Thomas Greco Jr. in his early books (1990), (1994). Greco refers to E. C. Riegel (1944), (1978), a self-educated author who was the first to propose the use of a currency based on what he called "mutual credit for the national economy". Some authors, such as Lucarelli & Gobbi (2016), perceive mutual credit as a form of credit clearing as proposed by Keynes (Schumacher, 1943) for international exchange, however applied to the domestic economic exchange. Mutual credit is a form of pure credit economy in the sense that: »The nominal liabilities of the financial intermediaries also represent the only exchange media circulating in the system… but does not contain the contentious Wicksellian construct of a natural rate of interest, (Smithin, 1997). It should be noted that in mutual credit any eligible economic agent stands in place of "the financial intermediaries" from the above Smithin's definition. The other property of pure credit economy introduced by Wicksell (1898 (1936, 2007)) appropriated by mutual credit is the use of what is called by Wicksell a "giro system", namely ledger money - money existing in the form of current (sight) deposits only. The distinctive feature of mutual credit which extends the narrow Wicksell's description of pure credit though it does not oppose it is the exclusive use of overdrafts instead of regular loans as the source of credit. In mutual credit the sum of all deposits is at any point in time matched by the sum of all overdrafts.

Riegel (1944), (1978) envisioned mutual credit as a complete replacement for legal tender, which he called political money. Greco (2001) advocated a more stepwise approach, though his vision too was for mutual credit to gradually take over the domain of economic exchange. No doubt numerous legal obstacles exist which prevent these visions from coming true. However, as Kavčič (2016) has shown, the contemporary mutual credit design and implementations lack some important monetary features that inhibit their success and growth. If the benefits of mutual credit are to really be felt in the economy, it must proliferate much more than seen by the present-day implementations and for that purpose it should be able in theory to crowd out legal tender in the realm of productive exchange. To that end, mutual credit must be enhanced substantially. As it will be shown, the crux of the enhancements is quantity control. (Kavčič, 2020, March) introduced an earlier version of what is presented in this paper as the thoroughly disaggregated quantity equation. It is the cornerstone of quantity control. This paper shows that the existing mutual credit theory and implementations flirt with quite a few features instrumental to quantity control, yet these features have not been expressed theoretically or imposed practically in definite terms. One such feature for instance is credit clearing. Thus, Greco (2013) contends that excessive negative balances must be prevented and idle positive balances must be avoided. The full implementation of credit clearing and of the other features is however proposed by the enhancements referenced under the common name Komoko monetary system, abbreviated to KMS and presented in this paper.

Incidentally, there is one vein of the mainstream economic thought which exploited credit clearing and some other features that stand out within the KMS as the enablers of quantity control. This vein pertains to the paradox of monetary profits. It will be shown in this paper that the rigorous assumptions of the profit paradox (Rochon, 2005) and its solution (Zezza, 2011) coincide with these features of the KMS. From the perspective of the present-day economy these rigorous assumptions are restrictions on the way businesses and individuals perform payments. It will be shown however, that it is worthwhile the effort as the enhanced mutual credit not only can but also must implement these restrictions in order to implement successfully the quantitative control of monetary mass. This is the only possibility for mutual credit to function without the need to lean on legal tender to provide the necessary liquidity. It is shown that both narratives benefit when explained from the perspective of cash-based accounting leading to a straightforward calculus.

The thoroughly disaggregated quantity equation is based in the classical Quantity Theory in the Fisher (1911) formulation. Like the latter also the former is valid in any circumstance and for any monetary system. However, as Werner (1997) has shown, the plain use of the Fisher's equation for the purpose of controlling the monetary mass is worthless. Yet, if the monetary flows are split (disaggregated) between the real and the financial flows, then, according to Werner, the Fisher's formula is useful. Like the Werner's theory, the KMS also proposes the segmentation between the real and the financial flows however not aggregated on the level of the whole economy but "thoroughly disaggregated" on the level of each single economic agent. Special setup implementing unorthodox restrictions is necessary for the thoroughly disaggregated quantity equation to be effective in such a role. Mutual credit CC with the proposed enhancements represents such an environment and from obvious reasons the paper focuses on it. Nevertheless, with the present-day banking system implementing unorthodox measures like negative interest, helicopter money and quantitative easing, it should not be too difficult and preposterous to envisage some cross fertilisation that goes beyond the general descriptive power of the thoroughly disaggregated quantity equation.

The rest of this paper is set out as follows. The second section provides a brief explanation of the background of the profit paradox and the way it is related to the enhanced version of mutual credit. The third section exposes a mutual credit type solution to profit paradox. The fourth section first explains some proposed enhancements to mutual credit theory and practices, such as graded monetary separation of the real and the financial exchange cycles and the inverse maturity of money in existence. Then it deals with a new version of the quantity theory. It explains the calculus that apportions each economic agent separately and the economy as a whole with credit matching its productive needs. The fifth section concludes.

2. THE PARADOX OF MONETARY PROFITS AND MUTUAL CREDIT

"The existence of monetary profits at the macroeconomic (aggregate) level has always been a conundrum for theoreticians of the monetary circuit. If money is created from bank credit, how can we explain profits if firms borrow just enough to cover wages that are simply spent on consumption goods and returned to firms to extinguish their initial debt? Indeed, not only are firms unable to create profits, they also cannot raise sufficient funds to cover the payment of interest. In other words, how can M become M'?" (Rochon, 2005)

In addition to Rochon (2005), a number of authors have proposed solutions to this conundrum even before it was named 'profit paradox'. Parguez (2004) mentions the solutions of Marx and Kalecki before he introduces his own version. In the author's view, Keen was the first to provide satisfactory proof (Solving the Paradox of Monetary Profits, 2011). Keen set up a model consisting of three sectors (workers, firms, banks) using seven types of real transactions to conduct business. Based on this model, he set up a system of differential equations that connect those variables and solved them first by imputing empirical data. He then computed the solution numerically for a steady state. In that way Keen arrives at the proof that profits are possible because, according to him, the stock of money can circulate several times in one year. Keen explains the problem as non-existent:

"...it was not a paradox at all, but a confusion of stocks with flows in previous attempts to understand the monetary circuit of production."

Even though his explanation is spot on, Keen evades the more rigorous conditions of the 'profit paradox' solution, since according to Rochon (2005):"…the story of profits ought to be told within the confines of a single circuit." It is Zezza (2011) who provides a solution to the profit paradox that satisfies the most rigorous conditions:

"Let us consider the simplest possible model of the TMC, namely that of a single production period in a pure credit economy with no government.... We want the circuit to close by the end of the financial cycle, and the only way this can happen is for income to be entirely spent before the circuit ends. This implies that monetary profits realized by both firms must be spent, as well as interest payments received by banks. An assumption underlying Table 8.1, along with the idea that all income is spent, is that firms have perfect foresight on effective demand, so that the whole of production is sold at the current price level." (Zezza, 2011)

It is this rigorous environment that sparks interest. Sciences have a tendency to adopt what could be called the elementary unit of their research where the complexities of their respective fields are put aside as much as possible in order to arrive at some basic truths upon which ever more elaborate interactions and systems are built and which factually represent the main subject matter of the respective science. It seems that the narrative of the profit paradox performs such a basic role for a certain vein of the heterodox macroeconomics.

From the perspective of the mainstream economy, the properties put forward by Zezza (2011) are of course unrealistic. To the mainstream economy the profit paradox proof is of purely theoretical importance if any at all. However, this is not the case with the KMS.

From the ideological and practical reasons, the success or failure of the KMS hinges on getting rid of the complexity in line with the restrictions used by Zezza (2011) even more than meets the eye. In addition to the aforementioned:

1. Single production period (production cycle),
2. pure credit economy with no government,
3. balanced flow of incomes and outlays of each and every agent within the period of interest,
4. total destruction of money at the end of the period,

there are a few less conspicuous restrictions which were nevertheless used in (Zezza, 2011) and are indispensable in the KMS:

5. set quantity of the initial financing (money mass) that satisfies the needs of the whole economy,
6. no proper store of value function of money,
7. the division of the real and the financial flows,
8. the only and final means of payment,
9. a closed system,

and one approach which introduces some elementary clarity in otherwise complex explanations:

10. cash based accounting.

Speaking about the ideological reasons, the KMS fully embraces the basic tenets of the mutual credit theory and movement. Within it there is an obvious aversion to the mainstream banking practices among which interests and access to credit are probably ranking the highest. Thus Greco (1990) equates the contemporary interest with usury and considers the existing monetary system which gives the bankers a practical monopoly over the issuance of money the root cause of many ills that torment the modern world like poverty, financial instability and even the environmental problems. Mutual credit CCs have emerged and evolved to the present day with this ideological background.

Speaking about the practical reasons, mutual credit never gained the momentum envisaged by Greco in his works. Many mutual credit implementations sparked into existence and eventually disappeared many still work and develop. What they have in common is that none of them ever prevailed as the principal means of exchange to its member base. Even the most prominent mutual credit implementations exhibit miniscule turnovers compared to legal tender.

From the available schoolbook tools of central banks for regulating the money mass and inflation mutual credit only has its version of "printing" money at its disposal. Due to the complexities of the modern financialized economies central banks have since long abandoned targeting money supply and reverted to targeting interest rates. However, what can be perceived by the mainstream economy as a limitation to a fully blown economic life is actually a prerequisite for the KMS to facilitate it, as the restricted possibilities of economic agents maintain the simplicity necessary for the success of the quantitative control of the monetary mass. Thus, the KMS type of mutual credit and the profit paradox narrative somehow converge towards utilizing a thoroughly restrictive model of economy. However, from obvious reasons their paths diverge after that. Whereas the profit paradox narrative is destined to be confined to its sandbox environment, the KMS purports to construct a thoroughly controllable, yet fully blown economic eco system.

The implementation and the role of some of the restrictions are explained within the KMS based example solution of the profit paradox in the succeeding section 3 and their role in a fully blown real life implementation can be inferred from that. Some restrictions are explained further on by describing their implementation and role in a hypothetical mutual credit based real economy. For the sake of completeness and due to a limited paper space, the remaining restrictions and the cash-based accounting approach are explained separately in Appendix B.

3. THE MUTUAL CREDIT SOLUTION TO THE PARADOX OF MONETARY PROFITS

The structure of this case roughly follows Zezza (ibid), who used the neo-Kaleckian approach for a solution to the 'profit paradox', according to the taxonomy proposed by Parguez (2004). Minor changes are introduced that adjust the model to the rules of a theoretical version of mutual credit proposed by Kavcic (2020, March). The method of Zezza's proof, though correct for the particular configuration, is however criticized (see Appendix A) for the lack of generality and an improved method is introduced instead.

Following Zezza's "The simplest consistent monetary circuit" (ibid), the business sector is represented by two firms producing consumption goods (labelled 'Firm A' and 'Firm B'). However, the logical sequence of events in the model does not strictly follow the order propounded by the 'Theory of the Monetary Circuit' (TMC) and used by Zezza (ibid). According to Zezza (ibid):

> *At the heart of the TMC is the notion, shared by Godley, that production requires time, and that costs of production have to be paid before receipts from sales can be obtained. Monetary wages must therefore be paid in advance, and this requires firms to have enough liquidity before production occurs.*

In reality wages are not paid in advance. Employees only get their paycheques after working for an employer for the whole pay period. In Europe, running a monthly payroll is the norm. Considering the limitations of our model pure credit economy, at the outset there are no deposits and loans, no money at all, and people would starve for almost a month. If life is about to continue normally in the model economy, people should consume before getting their paycheques. This is normal in everyday life, because people use their credit cards exactly for that purpose.

Table 1 Transactions and money holdings at different stages of the financial cycle for the mutual credit example

No.	Transaction	Date	Households		Firm A		Firm B		Bank Cash		Bank Loans		Househ	Firm A	Firm B	Bank Ca	Bank Lo
			D	C	D	C	D	C	D	C	D	C	balance	balance	balance	balance	balance
1	Opening balance	1. 1. 2021											0	0	0	0	0
2	Weekly shopping	8. 1. 2021	76			38		38					-76	38	38	0	0
6	Weekly shopping	15. 1. 2021	60			30		30					-136	68	68	0	0
4	Firm A pays out dividends for the previous period	16. 1. 2021		40	40								-96	28	68	0	0
5	Firm B pays out dividends for the previous period	16. 1. 2021		40			40						-56	28	28	0	0
7	Weekly shopping	22. 1. 2021	60			30		30					-116	58	58	0	0
8	Weekly shopping	29. 1. 2021	60			30		30					-176	88	88	0	0
11	Households spend the remaining part of their income	29. 1. 2021	20			10		10					-196	98	98	0	0
9	Salaries firm A	29. 1. 2021		100	100								-96	-2	98	0	0
10	Salaries firm B	29. 1. 2021		100			100						4	-2	-2	0	0
12	Households pay for interest	31. 1. 2021	24							24			-20	-2	-2	24	0
2	Bank pays interest for previous month deposits to both firms	1. 2. 2021				2		2	4				-20	0	0	20	0
13	Dividends bank	1. 2. 2021		20					20				0	0	0	0	0

Table 1 shows the transactions and the account balance of each economic agent at different stages of the financial cycle. Following Zezza (ibid) the circuit should close by the end of the financial cycle, and the only way this can happen is for income to be entirely spent before the circuit ends. This implies that the monetary profits realized by both firms must be spent, as well as the interest payments received by banks.

Zezza (ibid) continues his discussion explaining the social accounting matrix (SAM) and the flow of funds table pertaining to the model. Based on these tables, Zezza presents the basic accounting identities contained in the two and then, using some symbolic algebra, arrives at the final result in the form of equation:

$$\Pi = - \Delta D$$

where Π represents profits and ΔD represent the remaining deposits. Zezza interprets this final equation in the sense that the households' demand for new deposits should be zero if firms are supposed to pay back the initial loan plus interest and conversely, if "households increase their end-of-period stock of deposits, firms will have a positive end-of-period debt with the banking sector". These two assertions are spot on, however quite misleading if taken as emanating from the equation presented as implied by Zezza. Interpreting $\prod = - \Delta D$ to mean that firms must report non-negative profits to be able to pay back interest is wrong (explained in Appendix A).

What transpires from the analysis of Zezza's solution in Appendix A is the fact that Zezza unwittingly presupposed the profit paradox solution by the introduction of the "financial period" as part of the initial setup conditions. With other words, in the described environment, the profits are guaranteed.

The mutual credit solution subsumes the essence of Zezza's financial period and thus it is shown that it also can guarantee profits. This shifts the following narrative of the mutual credit example from the trivial task of proving the existence of profits to the task of calculating the necessary monetary mass.

In the mutual credit example economy, the necessary monetary mass is calculated already. It is shown in Table 1 in the columns displaying the account balances of the respective agents throughout the course of the financial period. The money needed to do the business equals the maximum value of the overdraft displayed with the minus sign in the balance column. We see that households need $196 and both firms need $2 each. The underlying assumption of the KMS is that the primary principle of the economic prosperity is the repetition of the financial cycle of each economic agent potentially adjusted for the collective growth (de-growth) decisions and individual forecasts that diverge from it. So, in this example, the $196 and $2 would be calculated based on the previous period and assigned as overdraft facilities with the adequate limits to the respective agents at the beginning of the current period.

Table 2 Transactions-flow matrix with example data of the model

		(1)	(2)	(3)	(4)	(5)	(6)
		House-holds	Firms		Bank		Total
			Current	Capital	Current	Capital	
	Transactions						
(A)	Consumption	-276	276				0
(B)	Investment		0	0			0
(C)	Wages	200	-200				0
(D)	Profits	100	-80	0	-20	0	0
(E)	Interest on deposits		4		-4		0
(F)	Interest on loans	-24			24		0
	Flow of funds						
(G)	Net lending NL	0	0	0	0	0	0
(H)	ΔD deposits						0
(I)	ΔL loans						0
(J)	ΔE equity						0

For the sake of completeness, Table 2 displays transactions-flow matrix in the Nikiforos & Zezza (2017) format with the data values pertaining to the logical sequence of events shown in Table 1. The profits of the firms amount to $80 and are all distributed via dividends to the household sector which spreads its income between consumption and paying interest to the bank. All money is destroyed at the end. What is also informative about data in Table 2 is that it doesn't indicate in any way the amounts of money that each agent needed in order to complete the cycle. This is because the transactions-flow matrix displays aggregate flows over the period whilst the liquidity needed is determined by the peak requirement within the period.

This model proves that the overdrafts provided based on the expected wages can supply almost the entire money mass necessary to run mutual credit-based production inclusive profits. A very small part of the initial financing is provided via overdrafts to the firms. Taken from the risk aversion perspective the latter is an equivalent of loans in regular banking.

The overall velocity of money in this example mutual credit model is 1,54 for the period. However, the profits in this model don't hinge on the velocity to be greater than one implying that the money is reused – the feature essential to the solution of Keen (2011). The reason why the velocity isn't kept at one in this mutual credit model is because the author purported to simulate a realistic situation not just from the monetary perspective but also from the risk aversion perspective. A variant of the mutual credit model can be demonstrated featuring positive profits with the overall velocity of money equal to 1.

The bottom line is that a mutual credit economy working under the rigorous assumptions of the 'profit paradox' gets enough liquidity and can flourish. Now the question arises how the beneficial properties of the restricted example environment can be transferred to a real-life situation.

4. THE KMS AND THE QUANTITY THEORY

What is hidden in the rigorous conditions of the 'profit paradox' and its solution is the implicit adoption of the quantity theory of money. The gist of the 'profit paradox' is in showing that a set amount of money provided as initial credit can or cannot finance production and profits in one single period. Proving that it can does not mean it always would. For instance, in the present-day real economy there is no force that would push a miser to spend all his income. Mutual credit theory and implementations, like some other alternative currency initiatives in the past, flirt with the idea of negative interest (demurrage) and unsurprisingly, so do the present day central and commercial banks. However, demurrage is no solution to the challenge of quantitative control set forth in front of the KMS. Demurrage is a second-degree controlling mechanism – it changes interest to regulate money flow. Nobody knows how much more money will be spent for each additional percent of negative interest. This controlling mechanism requires feedback, introduces lags and potential instability. The other disadvantage not irrelevant in the ever more ecologically aware society is the potential buying spree that would ensue following some psychological threshold not unseen in the past periods when money was losing its value too rapidly.

Assigning adequate overdraft limits to its members is the primary instrument at hand for the KMS monetary authority to control the amount of money in circulation and consequently prices, stable exchange and output. This method is direct and thus does not hinge on feedbacks, does not introduce lags and is intrinsically stable. In addition to that it can be implemented in growth and de-growth scenarios. It does however require a set of restrictions to be implemented. Conveniently for the author, these restrictions are a subset of those already identified as common to the profit paradox.

The goal of the KMS is to guarantee that, within the period of interest, agents, by buying new goods and paying for services, discharge the amount of money into circulation that matches the available output of new goods and services which is more than just implying the existence of market equilibrium. It means creating it.

In everyday life, money can buy everything that is on the market. This includes services and newly produced goods on the one side, and old capital and durable goods on the other. According to the conditions of the 'profit paradox' and in line with the KMS theory, money in hand should only buy newly produced goods (and services). There is little room for this money to buy old capital and durable goods, if any, but surely the supply of money in hand is no match for the potentially unlimited supply of old capital goods that are the essence of, for example, the stock market. And conversely, money in hand should not remain unused in accounts on the one side while leaving a pile of new unsold goods on the other. Supply must match demand. To that end the KMS introduces its enhancements explained below under the three titles:

- Monetary separation of the exchange cycles.
- The mandatory currency circulation.
- The thoroughly disaggregated quantity equation and the forecast-based calculation of overdraft limits.

4.1. Monetary separation of the exchange cycles

The KMS model has built-in mechanisms aimed at suppressing financial transactions and speculation. It basically goes along the line of thought already expressed by Keynes (1930) who recommended various monetary policies to a Currency Authority contingent upon the needs of what he called Industrial circulation and Financial circulation, respectively. His division of currency circulation between Industrial circulation and Financial circulation coincides fairly closely with the division of exchange between the exchange of new goods and services and old capital and durable goods as used in this paper. To this end, the KMS proposes a monetary separation graded into three levels.

- The first level consists solely of the real transactions representing the exchange of services and new goods. The other two levels consist solely of the financial transactions. The real exchange categorized here as the first level is meant to be thoroughly financed by the KMS overdraft facilities wherever and whenever necessary. The KMS model describes the KMS acting as a kind of community bank which provides, via overdrafts, working capital to the economic agents based on their productive needs. All the KMS currency in circulation stems from such an act.
- The second level consists of the financial transactions which are supported by the KMS. Some of these financial transactions represent the KMS's mechanism of saving – a financial transaction which collects money from the investors (i.e. account owners, not the KMS) that is meant to be spent shortly after (in the same period). When the money collected is spent on new goods and services this represents a real transaction belonging to level 1. Thus, the large scale investment is made possible in the KMS. When money is used for any other purpose like for instance to give allowances to family members or to purchase a used car this is a financial transaction belonging to level 2. There is no restriction on the kind of financial transaction that can be performed with the KMS. However, as will be explained further on, the KMS money has an expiry date which pushes it towards consumption in real exchange and hence such financial transactions have a very limited space. They do not encroach upon the liquidity needed for the real transactions as from the perspective of the real exchange the money involved in financial transactions of

level 2 is doing a moonshine job and in the morning, it is fresh and even more eager to perform the real purchases.

- The third level consists of the brunt of the exchange of old capital goods, a kind of which is taking place for instance at stock exchanges. This kind of exchange needs its own liquidity and is meant to be supported by the other currency. An exchange facility between the KMS currency and the other currency is foreseen in the model that would function much like the known crypto exchanges. For a more elaborate explanation of the exchange facility see Appendix B, topic "Closed system".

The KMS currency can be spent on the real or the financial transactions without limits. Nevertheless, the part of the financial circulation supported by the KMS is controlled and treated differently than the real circulation. To that end the last publication, (Kavčič, 2020, March) proposes the following setup. Physical and legal persons are supposed to have their accounts split into two partitions, one dubbed the "real" account, and one dubbed the "financial" account. The financial transactions end up on the financial account, the real transactions end up on the real account.

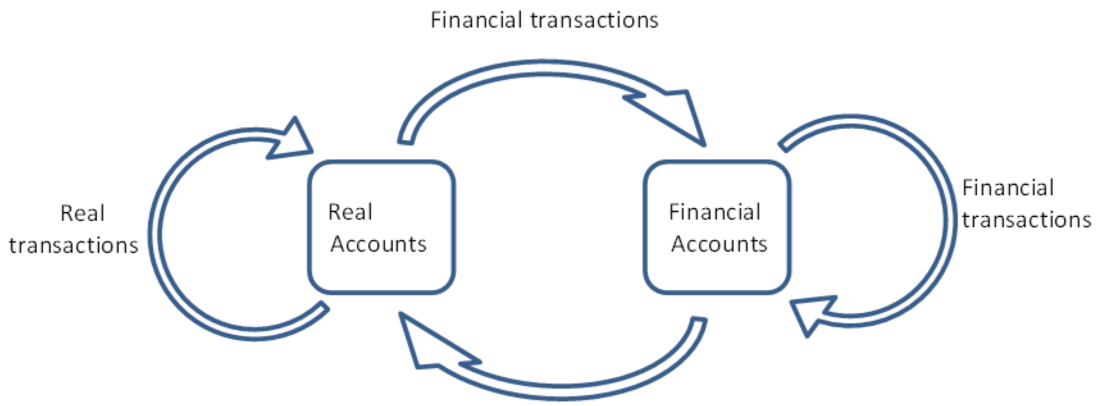

Figure 1: The real and the financial accounts and transactions

The structure of the real and the financial accounts is just the framework. Based on that, the control of the financial transactions is effectively achieved by the workings of the other two distinctive features of the KMS i.e. by the mandatory currency circulation and by the forecast-based calculation of overdraft limits.

4.2. The mandatory currency circulation

The KMS model proposes two mechanisms that push currency into circulation: the mandatory periodical clearing of the real business accounts and the inverse maturity of deposits on all other accounts. The real business accounts are mandated to clear at least once in a period, so all the currency is pushed into circulation. The period referenced here is called the mandatory clearing period set by the KMS and is supposed to last between 3-6 months. For businesses that have their turnover period longer than the mandatory clearing period there is a special provision explained in Kavčič (2020, March). The turnover period of a business is a period of time in which the account's balance curve repeats its pattern. This notion of turnover period is in special cases an equivalent of the definition used by Marx (1867) and Keen (2011): »a time lag between outlaying M and earning M+«. In general, however it is not. For a detailed description of the clearing period see Appendix B, section "Single production period (production cycle)".

The rest of the accounts keep records of the inverse maturity of deposits i.e. credit entries. It means that each credit entry in any of these accounts has a maturity date attached to it signaling when the credit entry will become due to be charged with progressive negative interest. The maturity of a credit entry is calculated depending on the type of the account (household/business, real/financial). The maturity of a credit entry is determined at the time of the transaction and thereafter it does not change (Kavčič, 2020, March). In general, the maturity of credit entries in the KMS is less and up to the duration of the mandatory clearing period. These two mechanisms push currency into circulation with the pace that exactly matches the production. Thus, within one mandatory clearing period the amount of money discharged to various recipients like employees, rentiers, subcontractors and vendors as payment for goods and services is awaiting and must purchase the amount of goods that are entering the market and services that are available. That is how the market equilibrium is created within the KMS.

Since the KMS currency is of limited duration, it is not exactly suitable to perform the store of value function. It is expected that this function of money would be performed by the other currency.

4.3. The thoroughly disaggregated quantity equation and the forecast-based calculation of overdraft limits

Werner (1997) developed his own version of the quantity equation which he named 'The quantity theory of disaggregated credit'. It shows that there are two separate flows of money needed in the economy, one that captures the real transactions (those that are part of GDP) and another that captures the financial transactions (not part of GDP). In the KMS the quantity equation capturing the real transactions must be calculated for each and every economic agent as the basis of the respective overdraft limit that is granted. The underlying assumption of this calculation is that the primary principle of the economic prosperity is the repetition of the production cycle of each and every economic agent potentially adjusted for the collective growth (de-growth) decisions and individual forecasts that diverge from it.

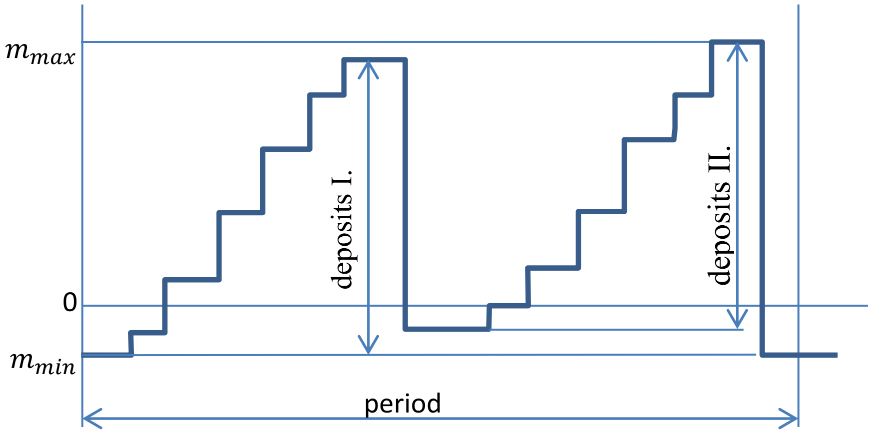

Figure 2: Quasi-real balance curve of an account for a period and the relevant variables

The calculation is based in the quantity equation (Fisher, 1911):

$$MV = PQ \tag{1}$$

where M represents the money stock, and V is the average turnover velocity of money, PQ equals the value of transactions (the sum of all prices times the quantities transacted).

The calculation of the thoroughly disaggregated quantity equation starts with equation (2), a reordered version of the quantity equation (1), where to replaces PQ, and m_max - m_min replaces M, v ≡ V.

$$v = \frac{to}{m_{max} - m_{min}} \tag{2}$$

where:

v velocity of money

to period turnover, calculated as a sum of all real deposits within a period (to = deposits I. + deposits II.)

m_{max} the maximum quasi-real balance of both accounts (the 'real' and the 'financial' account) within a period

m_{min} the minimum quasi-real balance of both accounts (the 'real' and the 'financial' account) within a period

Firms have different turnover periods, which determine the revolving cycle of money inflows and outflows and thus the quantity of money that a firm needs and gets. The quasi-real balance of both accounts is artificially calculated cumulative time function derived at by adding up the real transactions from both accounts (the 'real' + the 'financial') however stripped of purchases of newly produced fixed assets. The omission of fixed assets purchases is due to the fact that equation (2) is meant to be used in the calculation of the holder's overdraft limit and will be explained in the following text. Period turnover means period revenue for businesses and period income for households. This calculation works when the beginning balance is equal or greater than the ending balance, when not, a slightly different calculation of velocity is necessary. In the opposite case, when the beginning balance is smaller than ending balance then to - period turnover from equation (2) should be calculated as a sum of all real outlays within a period. The explanation and the proof are presented in (Kavčič, 2020, September).

The KMS considers all four variables from the above equation as slowly changing and characteristic of each account. When calculating the account's overdraft limit for the coming period, the KMS carries over the value of the money velocity and the value of the maximum quasi-real balance from the previous period. The value of the turnover in the current period is forecasted, however, it is supposed to only change by a small amount in comparison to the previous period. This change mainly depends on the growth (de-growth) rate determined by the KMS community, although there is also room for the KMS to follow the individual forecasts. To calculate an account's overdraft limit for the coming period, the equation (2) is reordered, and one new summand is added:

$$m_{min}(1) = -\frac{to(1)}{v(0)} + m_{max}(0) - \mathrm{NCO}(0) \qquad (3)$$

where:

$m_{min}(1)$ if the value is negative then $|m_{min}(1)|$ means the absolute value of the overdraft limit for the coming period; if the calculated value is zero or positive then the account does not need an overdraft

$to(1)$ forecasted turnover of an account in the coming period

$v(0)$ money velocity of an account in the previous period

$m_{max}(0)$ the maximum quasi-real balance of the holder's accounts for the previous period

$NCO(0)$ calculated net cash generated by the account holder operating activities for the previous period (for the calculation see Appendix C). This summand is supposed to be included only when positive. If NCO(0) is negative, then it should be ignored or taken only partially as decided by the KMS contingent upon the general liquidity situation.

Fixed assets cannot be included in the overdraft limit calculation, as the inclusion would cause the KMS to finance fixed assets purchases by a corresponding increase in the overdraft limit (i.e. decrease of m_min (1) according to the calculation method). Compared to working capital, fixed assets have substantially longer periods of return and financing them introduces much higher risks. However, in the aggregate, the exclusion of fixed assets in the overdraft limit calculation of each economic agent would deprive the economy of the initial financing up to the value of all fixed assets produced in the period. The approach used in the KMS model is that in order to compensate for this omission, additional initial financing needs to be provided to the economic agents and to that end the NCO(0) summand is included in (3). For the disclosure of the "compensation calculation" and the "compensation proof" see Appendix C.

This additional financing could then be used by agents to pay instalments that come due or to invest before they earn within the period. Thus, they dispense into circulation additional money which may in the aggregate compensate for the missing liquidity. It may however not, as economic agents act prudently, and they probably shun investing before earning. To that end, the KMS calculates the aggregate overdraft that needs to be exploited for the forecasted total turnover. In case that this isn't exploited, the KMS can then implement various means in order to fill the gap. One possibility is to exclude completely or partially the negative NCOs from the equation (3) as already indicated.

For the aggregate overdraft calculation, the equivalent of equation (3) can simply be aggregated across all account holders to reach the version of the quantity equation valid for the economy.

The liquidity of a KMS-based economy is thus achieved when the following rule is satisfied:

$$\sum m_{min}(1) \leq \sum -\frac{to(1)}{v(0)} + \sum m_{max}(0) - \sum \mathrm{NCO}(0) \qquad (4)$$

An alternative method leading to the same results is disclosed in Appendix D.

5. CONCLUSION

The broad narrative of the profit paradox and its solutions were used to explain the role and the importance of the restricted economic environment for the purpose of monetary control in mutual credit implementations. The paper has shown that the rigorous constraints of the profit paradox imply quantitative control of money mass. Two more recent solutions to the profit paradox were analysed in more detail. It was shown that the solution of Keen (2011) hinges on using the velocity of money greater than one which in some way evades the ideal of the restricted environment. Zezza's (2011) solution lies in defining the financial cycle in place of the production cycle. An improved version of the latter approach was also used by the mutual credit solution to the profit paradox explained in this paper. Using transaction-flows matrices it was demonstrated that the mutual credit model can produce profits even in the most restricted economic environment imposed by the very narrow boundaries of the profit paradox which implies that from the pure macroeconomic perspective mutual credit could crowd out legal tender.

The conditions that make quantity control possible within the example environment of the profit paradox proof were migrated into the real-life environment of the mutual credit based monetary system by some enhancements introduced to the latter. The enhancements appear in the form of firm rules where there were just recommendations and as exact formulas where there were just vague guidelines published or implemented in the existing mutual credit theory and practice respectively. The enhancements pertain to three innovative methods presented in this paper: monetary separation of the exchange circles, the forecast-based calculation of overdraft limits facilitated by the thoroughly disaggregated quantity equation and the mandatory currency circulation.

The consequence of these innovations is that the currency loses its store of value function. This function must be assumed by some other currency. Thus, the liquidity preference is taken out of the equation and hence it stops playing its destabilising role. This leads us to entering an economy where according to Say's rule supply creates its own demand.

The result is a new form of mutual credit which purports to be more responsive to the economic needs of the member base on the one hand and more resilient and stable on the other. For the member base it means that the eco systems built around mutual credit implementations could safely offer various financial services and products without concern that the basic tenets of mutual credit CC would be breached. The firm rules and the exact equations of the thoroughly disaggregated quantity equation presented in this paper translate into the resilience and stability of the underlying currency system, which means that the administrators could comfortably manage each implementation towards success and growth.

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APPENDIX A

Critique of Zezza (Godley and Graziani: Stock-flow Consistent Monetary Circuits, 2011), Page 159:

"When production is complete firms can sell the output, and as they recover liquidity from sales, they can pay the interest to banks, which in turn can use this liquidity to purchase goods or equities from firms. If effective demand is equal to output, at the end of the whole (financial) period, firms have received back the entire amount of money they own to the banks, including interest, and the value of their profits will equal the value of investment."

What Zezza states here is only possible if distributed profits (=dividends) are taken out of the equations and thus "the value of their profits" mentioned by Zezza should be actually red as "the value of their undistributed profits of the period" and again this can only hold true if the investment mentioned by Zezza is fully self-financed implying that there is no net lending on the capital account. The first condition is implicitly worked out by Zezza on page 160:

»If firms' profits are used to purchase consumption goods there will be a simultaneous payment and receipt for the firms sector as a whole, and cancel out in ex post balance sheets.«

Zezza is right in his observation that distributed profits have no bearing on the final ability of firms to pay interest to banks however he should have used proper terms in his text.

Page 163: Zezza presents the equation $\prod = - \Delta D$ as the final result of the manipulation of symbolic algebra expressions, starting with the basic accounting identities from social accounting matrices and flow of funds tables. Zezza interprets this final equation in the sense that the households' demand for new deposits should be zero if firms are supposed to pay back the initial loan plus interest and conversely, if "households increase their end-of-period stock of deposits, firms will have a positive end-of-period debt with the banking sector". These two assertions are spot on in their own right however quite misleading if taken as emanating from the equation presented as implied by Zezza. Interpreting $\prod = - \Delta D$ to mean that firms must report non-negative profits to be able to pay back interest is wrong. Even if $\prod$ would stand for undistributed profits only, the above implication is still wrong. Firms can have negative undistributed profits and are still able to pay back interest for example if they disinvest by selling equity. And vice versa, firms can have positive undistributed profits and are not able to pay back interest if they fail to acquire enough cash or its equivalents in spite of otherwise profitable operations like for instance if they would sell their goods but fail to collect money for that. In the books of the firm, it would imply funds in the form of accounts receivable on the one hand and the invoice for interest as expense on the other. In the books of the bank the invoice for interest would be entered in the accounts receivable against revenue. This situation is not quite in sync with the example environment put forward by Zezza where the two firms produce consumer goods only and everything clears. The situation somehow excludes funds in the form of accounts receivable and accounts payable since transactions with the households are supposed to be in the form of cash and its equivalents (sight deposits) only.

Using social matrices and the flow of funds tables as the basis for his reasoning Zezza introduces some ambiguity as these instruments are designed to use statistics gathered also from individual businesses' accounting data which is predominantly accrual based. In spite of that, Zezza's assumptions are consistent with cash-based accounting in place of accrual-based accounting. However, the condition implied by Zezza that that firms must report non-negative profits to be able to pay back interest is wrong even in case of cash-based accounting as the arithmetic's in the transaction matrix doesn't differ from the accrual-based example.

Using Godley's transaction tables or social accounting matrices (SAM) to explain some macroeconomic truth by aggregating the data of individual agents requires some caution. Above all, the author must differentiate between gross and net items where the role of the differentiator is played essentially by depreciation. In Zezza's paper this is not clear. Zezza is using the term profit marked with Π, though it can be discerned from the context of Zezza's example that this relates to undistributed profits only. Zezza is unclear about depreciation. Only if the depreciation is zero, there would be no difference between gross and net figures. Otherwise, the field in the business column should contain gross operating margin, as the investment is calculated gross in the example.

The biggest surprise in the analysis of Zezza's solution however lays in its opening setup. To solve the profit paradox, Zezza introduces what he calls "a financial period" which is in his words defined as: "(The financial period) starts when a loan is made and money is created and ends when the loan is paid back and the money is destroyed.". Taking into account the fact that money must be destroyed at the end, it is practically impossible for the firm not pay its obligations of any kind, be it wages or interest. A firm may even make a loss but would still possess enough cash to settle the instalment by selling equity through shares or by borrowing either from households or from the bank. With other words in the opening setup Zezza presupposes the solution. However, this is not an error. It is just the solution that is hidden in the very definition of the financial period. The rest of Zezza's paper is not superfluous though, but it should be read as an interesting explanation.

APPENDIX B

Descriptions of the remaining restrictions

Single production period (production cycle)

It is obvious that this "just one circuit requirement" pertains to the theoretical profit paradox example economy only and that it is unattainable in any kind of real economy. The latter is characterized almost exactly by the opposite requirement i.e. superimposition and repetition of many circuits. The existing definition of circuit coming from Graziani makes it impossible to consolidate or compare the two i.e. the example environment of the profit paradox and the real economy. Graziani considers the circuit to start with the moment credit is granted and to be closed when all the goods were sold, money returned to the bank and destroyed. Graziani does not discuss a possibility of a partial return. For instance, when Zezza describes what he calls "the simplest consistent monetary circuit" he inadvertently uses two production circuits even if he purports to use just one. Namely, in Zezza's model after receiving the good part of the revenues ($80) due to selling its products to the workers, the owner of firm A makes a purchase of goods ($40) from firm B and vice versa, the owner of firm B makes a purchase of goods ($40) from firm A. From the perspective of firm A this actually implies a second circuit. In other words, it is hard if not impossible to implement Graziani's definition even for the most restricted example economy let alone to use this definition productively in describing the relation between different economies.

The KMS theory deals with circulation instead. From the KMS perspective Graziani's circuit is just one example of circulation with a period lasting from start of the circuit to its completion and two nodes: households (workers) and firms. The KMS theory focuses on nodes and defines circulation from that inverse perspective saying: each node must discharge into circulation the amount of money flowing in within the same period. This surely holds true for Graziani's workers and firms as everything clears at the end by the very definition of the production period, but it is much more general and can be utilized for an arbitrary number of nodes (agents or representative agents).

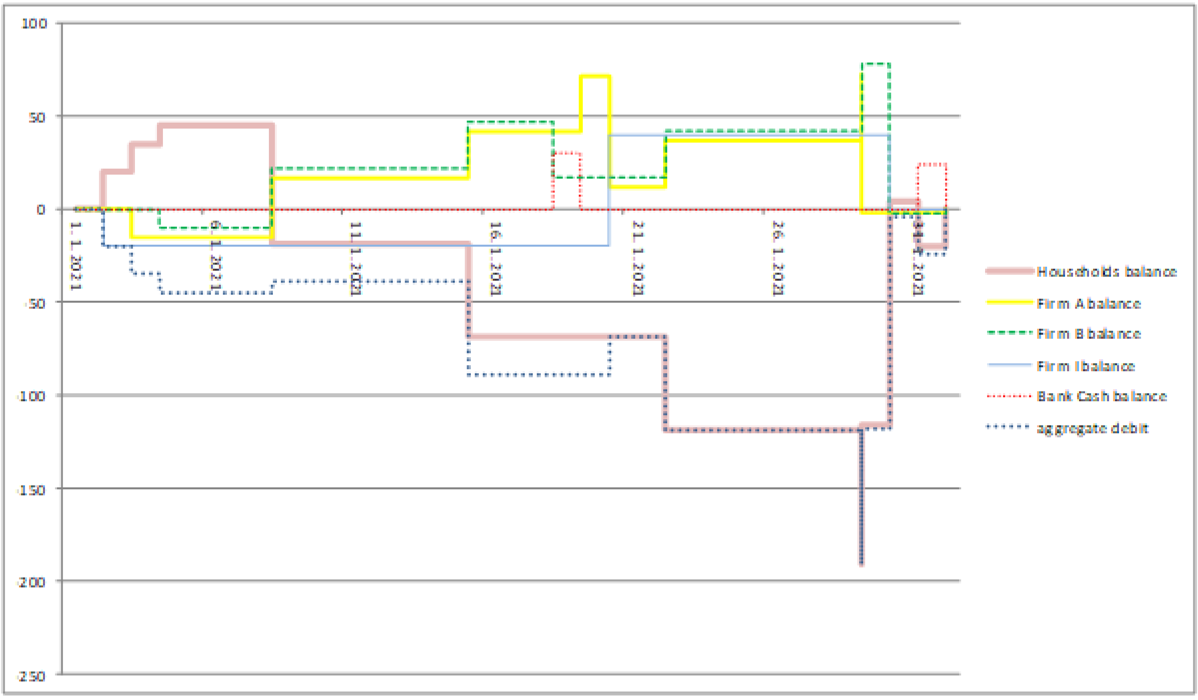

Figure 3 Agents' balance curves for the KMS example

Figure 3 shows the KMS perspective on the monetary circuit. Each agent can be viewed separately through its balance curve. The focus is not to find the circuit in the itinerary as implied by Graziani (2003), but to find and understand the wavelength and minor oscillations within the balance curve of each agent. As a matter of fact based on this curve, the thoroughly disaggregated quantity equation (2) and (3) subsumes all the relevant indicators of each agent. Explained in different terms, trying to describe all the factual itineraries that money follows before it makes a full cycle as proposed by Graziani implies a complexity of the calculus that grows geometrically with the number of nodes as opposed to the complexity of the calculus used by the KMS that grows arithmetically with the number of nodes.

The period in the KMS definition obviously can't pertain to any of the agent's production periods but it is an arbitrary unit called the mandatory clearing period overarching the production periods of the respective agents. The mandatory clearing period thus becomes a kind of common denominator of each and every "Graziani's" circuit. There is a special provision in (Kavčič, 2020, March) made for the agents that have production periods longer than the mandatory clearing period. The role of the numerator in this analogy belongs to an adjusted form of Graziani's production period. It was already Zezza (Zezza, 2011) who introduced the notion of financial period in place of the production period. The definition of the relevant period pertaining to each agent used by the KMS theory is transformed a bit further as follows. According to Graziani, firms must first indebt themselves with the bank for the value of wages which they pay to their workers and then certain time must pass by till the firms finish their products and sell them to earn money by which they pay back the initial loan. What constitutes the monetary circuit in a firm that spits out its products with a pace of a machine gun, like for instance the beverage industry? The whole production circuit takes maybe a day or two to process the ingredients in some canisters and boilers and then off it goes to the bottling and then on the pallets and to the retailers and consumers. Or should we include the time needed to grow the particular plants or fruits needed for the beverage as we supposed the existence of one integrated firm? The basic assumption of the profit paradox implementing the circuit theory isn't practically attainable. If the example assumes a long production period, taking into consideration the time needed to produce everything from the seeds on, then the workers (and the rentiers to that matter) would die of starvation in the meanwhile. If the example assumes short production periods exhibited by the modern-day production, then the firm doesn't need initial financing as it would start selling the moment it opens the gate. It is true that the majority of industry needs working capital which is by the accounting standards embodied in their inventory of the various stages of completion. However, this working capital in general doesn't need a proportional initial financing. It needed initial financing when the factory was constructed and put to use years or even decades ago. At an arbitrary moment, the amount of working capital employed according to the accounting standards bears no resemblance to the amount of initial financing needed. An economy can start without money and such events happened many times in the past. Money can be whisked out of thin air at will of the authorities any time. It is one of the basic premises of mutual credit CC as a matter of fact. However, no autonomous economy can really even start without stocks (inventory) let alone survive. Before the next harvest, we would all perish even if we could have planted anything as there would be no stocks which implies no seeds neither. Thus, the example economy must consider inventory and if so, then the relevant monetary circuit isn't determined by production. It is determined by finance. Not of the high finance of stock exchanges, and less or more risky financial instruments though, but of a simple firm's account balance and its turnover period. The turnover period of a business is a period of time in which the account's balance curve repeats its pattern. This notion of turnover period is in special cases an equivalent of the definition used by Marx (1867) and Keen (2011): »a time lag between outlaying M and earning M+«. In general however it is not. When setting up the conditions of the example economy an arbitrary moment in the repetitive cycle of »outlaying M and earning M+« must be assumed. This could be a moment when the opposite would hold i.e. a moment starting with »earning M+ followed by outlaying M« or any moment in between. From the mathematical perspective turnover period equals wave length and the exact moment of earning M+ is analogous to a phase shift. Let me demonstrate this by an example of a farmer and a wholesaler who usually buys the farmer's crop. In the example moment of observation the farmer completed his harvest and has a full silo of wheat. The farmer is just about to earn his M+ while the wholesaler is about to outlay (one of) his M(s). Thus, the role of the numerator in the KMS theory is assumed by turnover period. Generalizing the above narrative it can be claimed the following: let an economy consist of agents that have turnover periods shorter than the mandatory clearing period and let every agent discharge into circulation the amount of money that it earns within the mandatory clearing period then the economy can resemble the example environment of the profit paradox with the rest of its salient properties and in particular the set amount of the initial financing (money) required to satisfy all needs for new goods and services.

Cash based accounting & the only and final means of payment

Godley's transaction flow matrices utilize data of national accounts (SNA, NIPA) which are predominantly accrual based. However, the accounting identities subsumed in these matrices might still hold even when the underlying data would be cash based.

The difference between accrual based and cash based balances within each individual agent might cancel out each other on the aggregate level. Taking a comprehensive statement of cash flows (Kieso, Weygandt, & Warfield, 2020), illustration 5.24. as the basis, this surely holds true for the items: "Increase in accounts receivable" and "Decrease in accounts payable". What remains are: depreciation and change in inventory. The change in inventory does not cancel out among individual agents on the aggregate level, but does not represent a serious sum either. The only relevant item is depreciation (and similar like amortization and depletion) which comprise what is called consumption of fixed capital usually amounting to round 10% of GDP or more.

Interestingly, consumption of fixed capital is also the differentiator between the net and gross figures in national accounts. In the second column of the transaction flow matrix (Godley & Lavoie, 2007) appear the expenditure and income components of the gross domestic product (GDP). This implies that the investment must be taken gross by aggregating the purchases of new fixed assets without subtracting the calculated consumption of fixed capital. This holds true even when the purchases amount to zero as is the case in Zezza's example. The profits should also be taken gross then, meaning inclusive of depreciation (and other elements comprising the consumption of fixed capital), but this is not the case with Zezza's example as there is no consumption of fixed capital taking place.

So, what we have in the second column of the transaction flow matrix is (Godley & Lavoie, 2007):

$$Y = C + I + G = WB + F + INTf + T \tag{5}$$

Ignoring the government we arrive at Zezza's example:

$$Y = C + I = WB + F + INTf \tag{6}$$

Where:

C – consumption,

I – investment,

WB – wage bill,

F – profits (equal to gross operating surplus GOS)

INTf – interest payments

Transformed we get:

$$C + I - WB - GOS - INTf = 0 \tag{7}$$

From SNA (System of National Accounts 2008, 2009) we get:

$$GOS = NOS + CFC \tag{8}$$

Where:

GOS - gross operating surplus,

NOS – net operating surplus

CFC – consumption of fixed capital (equal to depreciation, amortization of intangible assets, depletion and similar).

Using the statement of cash flows from (Kieso, Weygandt, & Warfield, 2020) the following accounting identity can be laid down:

$$NCO = NI + CFC + \Delta INV + \Delta IBI \quad (9)$$

Where:

NCO – net cash from operating activities

NI – net income

CFC – consumption of fixed capital (equal to depreciation, amortization of intangible assets, depletion and smilar).

ΔINV – changes in inventory

ΔIBI – inter-balancing items that cancel out in the aggregate like for instance "Increase in accounts receivable" and "Decrease in accounts payable".

Transiting from an individual agent to the aggregate domain, the inter-balancing items disappear and changes in inventory can be neglected. Then we get

$$NCO = NI + CFC \quad (10)$$

And consequently merging equation (8) and (10) we arrive at:

$$NCO = GOS \quad (11)$$

Then (3) can be rewritten as:

$$C + I - WB - NCO - INTf = 0 \quad (12)$$

where all of the summands represent cash based items. (12) proves that Zezza's example is correct if it is interpreted as cash based not just in the particular, but also in general when consumption of fixed capital would take place.

However there is more that can be taken from (12). The fact that net cash from operations equals gross operating surplus is very convenient as it eliminates the biggest unknown in the national accounts i.e. the consumption of fixed capital.

The KMS money is the real money in line with (Graziani, 2003) performing the role of final payment. This means that all payments related to the real economy must utilize the KMS money. The agents that exploit overdrafts must pledge their future output to the KMS bank and can redeem their debt only by the KMS money. The agents that are auto-financed are interested to get rid of the "bad" money as soon as possible in line with Gresham's law as the KMS money loses its value at maturity and is in that sense bad. Agents are provided with the requisite funds to deliver their output via overdrafts. There is no room neither is there any need for near-money 1[1] to be used instead of the KMS money for the real economy and related financial transactions. Consequently, in the KMS type of economy the community bank or a syndicate of community banks manages all the relevant GDP related transactions and hence holds possession of the data which constitute the model according to (Godley & Lavoie, 2007). In comparison to gross operating surplus, its replacement net cash from operations is thus available to central banks and other statistical organizations without contentious accounting tweaks and is available online.

If the data that is otherwise imputed into the tables, like for instance homeowners income, is purposely ignored or extrapolated, then the system can feed a model that can be used to steer the economy online compared to the present data availability with delays of a quarter or more. It should be noted that such setup is ideal for the application of AI algorithms that would relief the authorities and investors of much of the effort for the common good.

A closed system

Zezza's example is understandably a closed system as is usual for the elementary models in order to avoid complexity. It means it has no exports and imports at all. No realistic economy can be closed in that sense. However, adopting the principle of clearing (Schumacher, 1943), an economy can operate in a kind of semi-closed mood,

[1] In their critique of the Full reserve banking initiative Sawyer & Fontana (2016) contend that Full reserve banking arrangements would soon be undermined by the powerful incentives for banks, non-bank financial intermediaries and shadow banking to create near-moneys.

retaining the benefit of simplicity on the one hand and letting agents exchange their goods and services freely for their benefit on the other. In that sense the KMS economy is designed to maintain a special "rest of the world" (ROW) account and assigns it with a proportionate overdraft (Kavčič, 2020, March). In addition to that, the KMS is supposed to facilitate an exchange facility which would enable agents to exchange freely the KMS money for any other.

None of the above arrangements changes the nature of mutual credit either principally or practically. When the exchange with some other economy is balanced, there is no direct effect on the GDP, but indirectly exchange increases satisfaction of agents, increases usability of exchanged goods and promotes growth. When the KMS money is exchanged among the members of the community, there is no negative impact on the balances in the KMS bank. The exchange transaction just shifts funds from one account to the other, one agent steps in in place of the other one. The other currency or even some other financial instrument that is the subject of exchange does not enter in the KMS economy at all. The situation is best explained by the analogy with Bitcoin. The nature of Bitcoin has not changed since its inception. It is expressed in mathematical and logical terms and profoundly transparent. It was such when only a bunch of geeks knew it and used it as a game token and it is the same now with its market capitalization of a few hundred billion dollars. This market capitalization is expressed in dollars, in Bitcoins the whole money mass will never exceed 21 million. The bottom line is that exchange is good as long as it is balanced and the KMS is designed to keep it so.

APPENDIX C

The compensation calculation

Equation (3) indicates that in order to calculate the proper overdraft limit of each economic agent (business), calculated "net cash by the operating activities" abbreviated to NCO needs to be included in (3). NCO is an accounting item that appears on the statement of cash flows. It is a cash-based equivalent of net income (USA) or profit (UK). According to Kieso & Weygandt (2020), net cash is usually calculated via the indirect method but it can be also calculated via the direct method. NCO calculation according to the indirect method:

Net cash by the operating activities = net income – depreciation – net changes in accounts receivables and payables – net changes in prepaid expenses.

NCO calculation according to the direct method takes data directly from accounts receivables and accounts payables. However, within the KMS, NCO of each economic agent can be calculated by the KMS also in an alternative manner. The calculation uses the basic Statement of cash flows accounting identity (Kieso, Weygandt, & Warfield, 2020):

$$\mathrm{NC} = \mathrm{NCO} + \mathrm{NCI} + \mathrm{NCF} \tag{13}$$

where:

NC net increase/decrease in cash.

NCO net cash provided/used by operating activities

NCI net cash provided/used by investing activities.

NCF net cash provided/used by financing activities.

Generally, due to the ledger type of currency, in the KMS the above variables can be calculated for each respective account holder directly from transactions provided that all transactions are marked accordingly either due to regulatory or KMS requirements. Thus:

NC net increase/decrease in cash. Can be calculated as the difference between the ending and the beginning value of the summed up balance of both accounts (the real and the financial partition/account).

NCO net cash provided/used by operating activities. Can be calculated as the difference between the ending and the beginning value of the narrow quasi-real balance. The narrow quasi-real balance is artificially calculated cumulative time function derived at by adding up the real transactions from both accounts (the 'real' + the 'financial') however stripped of the purchases of newly produced fixed assets and also stripped of the dividends as these two types of real transactions are deemed investing activities from the accounting perspective. Thus the narrow quasi-real balance equals quasi-real balance as defined for (2) further stripped of the dividends.

NCI and NCF however don't need to be calculated separately because NCO which is needed in (3) can be calculated directly. Even when NCO would be calculated from (13) as the balancing item, it would suffice to calculate just the sum of both (NCI + NCF) for that purpose which makes sense because it might require some extra and unnecessary efforts to mark transactions with the purpose of discerning between the investing and the financing ones. Thus:

NCI + NCF the sum of both variables can be calculated as the difference between the ending and the beginning value of the balance of all financial transactions from both accounts (the 'real' + the 'financial') with the added up real transactions belonging to the purchases of newly produced fixed assets and to the dividends.

The compensation proof

For the sake of the compensation calculation the accounting identity (13) can be written for the real flows and for the financial flows separately as both flows are clearly discernible and each of them satisfies on its own the double entry accounting principle. The accounting identity dealing with the real flows can be then written as:

$$\text{NCr} = \text{NCOr} + \text{NCIr} + \text{NCFr} \tag{14}$$

where the ending r denotes the real part (according to the KMS criterion) of the respective accounting item.

(13) is a form of statement of cash flows and thus meant originally for businesses and eventually for other institutions like for instance government, state agencies and other political bodies. It isn't meant for households. Nevertheless, it can be applied to them as well. In the same way as NCOr is calculated for businesses as the aggregate of all real transactions, so it can be calculated for the households as well and it represents their saving– the amount that they don't spend on consumption. NCIr for households is zero, as households don't buy fixed assets by the definition of the GDP calculation. NCFr can also be calculated for households as the aggregate of the real financial transactions. It is important to note here that "real" in NCFr means "real" from the KMS perspective i.e. basically a transaction that contributes to the GDP. Further on "financial" in NCFr means "financial" from the accounting perspective meaning an income or an outlay not related to the operations. (14) can be aggregated across all economic agents:

$$\sum \text{NCr} = \sum \text{NCOr} + \sum \text{NCIr} + \sum \text{NCFr} \tag{15}$$

On the left hand side we have the sum of all real transactions aggregated across all agents. It equals zero because the real transactions on its own satisfy the double entry accounting principle. The third summand on the right hand side Σ NCFr represents dividends only, as all other items in the calculation of NCFr (net cash provided or used by the business financing activities) represent financial transactions from the KMS (and GDP) perspective. The dividends however cancel each other across all agents and what remains is:

$$\sum \text{NCOr} = -\sum \text{NCIr} \tag{16}$$

With other words, using the cash based accounting identities, aggregate net cash from operating activities equals the aggregate of fixed assets purchased within the KMS economy. (16) is a cash based equivalent of the saving = investment identity. When the overdraft limit of each agent calculated by (2) is increased for the value of net cash from operating activities as implied by (3), then in the aggregate this compensates for the missing liquidity due to the omission of fixed assets in the quasi-balance curve used in the overdraft limit calculation.

APPENDIX D

For the aggregate overdraft calculation the equivalent of equation (3) is simply aggregated across all account holders to reach the version of the quantity equation valid for the economy. This appendix discloses an alternative and potentially simpler method. Instead of considering the holder's accounts, stripped of purchases of fixed assets, the balance of the accounts should be taken inclusive of purchases of fixed assets, but still stripped of all financial transactions:

$$v' = \frac{to}{m'_{max} - m'_{min}} \tag{17}$$

where:

v' velocity of money for the real balance

to period turnover, calculated as a sum of all deposits within a period (the same as in equation (2))

m'_{max} the maximum real balance of the holder's accounts within a period

m'_{min} the minimum real balance of the holder's accounts within a period

The real balance of the holder's accounts is the balance of both accounts, stripped of all financial transactions, but inclusive of all real transactions (meaning that purchases of fixed assets are included). The basis for the aggregate overdraft limit calculation is then:

$$m'_{min}(1) = -\frac{to(1)}{v\prime(0)} + m'_{max}(0) \tag{18}$$

where:

$m'_{min}(1)$ a theoretical overdraft limit for account i to be used in the aggregate calculation; equation (18) is not used to calculate individual overdraft limits

$to(1)$ forecasted turnover of an account in the coming period

$v'(0)$ money velocity of an account in the previous period calculated based on the real balance

$m'_{max}(0)$ the maximum real balance of an account for the previous period

Equation (18) can be aggregated across all account holders for the entire economy.

$$\sum m_{min(i)}(1) = \sum -\frac{to_{(i)}(1)}{v\prime_{(i)}(0)} + \sum m'_{\max(i)}(0) \tag{19}$$

The liquidity of a KMS-based economy is then achieved when the following rule is satisfied:

$$\sum m_{min(i)}(1) \leq \sum -\frac{to_{(i)}(1)}{v\prime_{(i)}(0)} + \sum m'_{\max(i)}(0) \tag{20}$$