11th Biennial IFC Conference on "Post-pandemic landscape for central bank statistics"

BIS Basel, 25-26 August 2022

A characterisation of financial assets based on their cash-flow structure[1]

Celestino Girón,
European Central Bank

[1] This presentation was prepared for the conference. The views expressed are those of the author and do not necessarily reflect the views of the BIS, the IFC or the central banks and other institutions represented at the event.

A characterisation of financial assets based on their cash-flow structure

Celestino Giron[1]

Abstract

In the International Economic Accounting Standards, the classification criteria for financial assets aim to bring out the economic substance underlying the specific arrangements adopted to establish the links between borrowers and lenders. Differences in the cash flows associated to the assets, like how the payments are determined or their distribution over time, are key to their economic effects. While these cash flow differences are implicitly considered by the Standards, they are only sometimes used explicitly for asset classification prescriptions. In this paper we provide a taxonomy of cash-flow structures and a formal characterisation of assets on that basis. This taxonomic discussion can inform the current process of review of the Standards and, beyond that, contribute to the classification of assets in practice.

Keywords: International Economic Accounting Statistical Standards, 2008 System of National Accounts, Financial accounts, cash-flows, vectorial spaces

JEL classification: E01, G23, C18

Contents

[1] European Central Bank (ECB).

1. Introduction

The statistical classification of complex financial assets is sometimes subject of controversy among macroeconomic statisticians. Thus, it is not always clear for instance whether a specific asset should be treated as a loan or as other account payable, or whether it is a forward derivative or an option.

These difficulties are not due to the absence of appropriate classification criteria in the statistical standards, but rather to the fact that those criteria are based on institutional features that are not always easy to identify. Moreover, growing complexity in the design of financial assets is progressively disconnecting the institutional features from the underlying economic substance, which is the fundamental concept lying behind the classification criteria.

A fundamental part of the economic substance behind an asset lies in the characteristics of the cash flows associated to it, including their distribution across time. They determine the specific role of the asset in order to carry value forward, i.e. to act as a store of value, and the nature of the liquidity, maturity and risk services embedded in them; these features explain the asset price. However, the statistical standards pay little attention to the cash flows and their time profile to characterise financial assets, beyond broad distinctions such as between debt and equity instruments depending on whether a predetermined stream of payments is present or not.

This note presents a taxonomy of cash flows aimed to assist the classification of financial assets in macroeconomic statistics. Under the approach in this note a financial asset is a collection of cash flows, an array of payments associated to discrete moments in time (although a generalisation as continuous payments can be made). Algebraically, they are then vectors in an infinite multidimensional space given by time. The individual payments consist in the provision of goods and services, or other financial assets, i.e. other cash flows. The asset stock, the value of the cash flow, is, in this algebraical presentation, a function defined on the arrays containing the cash payments.

The taxonomy is not intended to replace the rich classification criteria available in the standards, but to complement it. It can help decide on the classification of borderline cases by checking which cash flow taxonomical category the asset belongs to, or approximates the most. At the same time, the taxonomy can be used to define the assets in the standards themselves and thus contribute to clarity and certainty in the methodological prescriptions.

Section 2 briefly summarises the classification criteria available in the standards, Section 3 is the core of the paper and presents the methodological approach taken and the taxonomy proposed. Section 4 illustrates the application of the taxonomy to some specific difficult classification issues identified in the context of the review of the Economic Accounting Statistical Standards. Section 5 concludes.

2. Financial assets in macroeconomic statistics

The 2008 edition of the System of National Accounts (2008 SNA[2]) defines assets as economic objects which carry value forward from one period to the next i.e. (act as store of value) and on which property rights can be exercised (see 2008 SNA, paragraphs 3.30, 3.31). Financial assets can be defined as the subset of assets characterised by the fact that they have been specifically designed to be store of value, by virtue of a legal contract or a social consensual agreement, as opposed to non-financial assets, which act as store of value not by design, but as a side effect of their main role in production processes (fixed assets), rent source (non-produced assets) or artistic or sentimental motives (valuables).

2008 SNA enumerates the categories of assets that would be classified as financial assets. These are *"financial claims, shares or other equity in corporations plus gold bullion held by monetary authorities as a reserve asset"* (2008 SNA 3.36). Most financial assets are "financial claims", which are economic relations between economic agents by virtue of which one party is obliged to provide payments to the other (2008 SNA 3.33 to 3.35). Equity consists in rights on the residual value of corporations and do not entail any obligation of predetermined payments from the corporation to the holders (2008 SNA 11.81). Finally, gold is considered as a financial asset under certain circumstances and its role as store of value is backed only by an implicit consensual contract.

Financial claims are in turned broken down into various categories on the basis of institutional features, including their negotiability and the classification of the unit for which the claim represent a liability. The main categories of financial assets envisaged, including those that are not financial claims, are Monetary gold and SDRs, Currency and deposits, Debt securities, Loans, Equity and investment fund shares, Insurance, pension and standardized guarantee schemes, Financial derivatives and employee stock options and Other accounts receivable. These categories are further broken down in sub-categories.

Individual assets are placed into one category or the other on the basis of their economic substance, rather than their legal form, and how this substance aligns with the corresponding classification categories. Thus, for instance repurchase agreements and securities lending with cash collateral are seen as the same kind of claims in substance irrespective of their formal differences and classified in both cases as deposits (if liabilities of a deposit taking corporation) or loans (otherwise).

Moreover, the emphasis if put on the economic *effects*, rather than on the economic *purposes*. For instance, the classification does not distinguish between financial derivatives used for hedging from those motivated by trading, completely disregarding the purpose of the deal. An exception to the economic effect principle is the functional classification of cross-border transactions in the Balance of Payment, where the focus is turned to the economic purposes.

At the same time, the classification of individual assets into the macroeconomic categories is not always without difficulties. A recent example of this is the debate around the classification of balances arising in cash collateral agreements, where the

[2] https://unstats.un.org/unsd/nationalaccount/sna2008.asp

global statistical community is still struggling to agree on the appropriate classification for them, either as deposits, loans or other accounts receivable[3].

3. Cash-flow taxonomy

We define a financial asset at time *t*, a^t as an array of future cash payments $a^t = \{a^t_{t+i}\}, i = 0, 1, 2 \ldots$ where i is a temporal index pointing at future payments amounting a^t_{t+i}. As time passes, i.e. *t* increases, past flows are disappearing from the array. For financial claims, any a^t is accompanied by another array l^t such as $l^t = -a^t$; $l^t_{t+i} = -a^t_{t+i}$ representing the liability view of the claim. When *t* is evaluated at the time of claim inception, $l^t_{t+0} = -a^t_{t+0}$ are the funds transferred to the debtor by the creditor when the claim is initiated.

We classify cash flow arrays according to their temporal profile and whether the payments a^t_{t+i} are prefixed or not. This would give us the following broad categories:

General financial claims

These cash flow streams present a flow at inception representing a payment from the creditor to the debtor when the claim is initiated (for instance the funds raised in the issuance of a debt security) and several payments from the creditor to the debtor in the subsequent (periods covering coupon payments and redemption of principal).

All flows are predetermined. These are the sign restrictions: $a^t_{t+0} < 0$; $a^t_{t+i} \geq 0 \; \forall i > 0$. Figure 1 shows the profile of one such assets with 7 cash payments and another with an infinite series of payments.

General financial claim — Figure 1

Figure 1.1

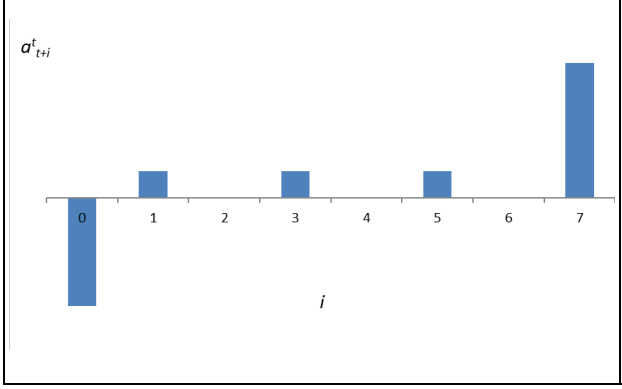
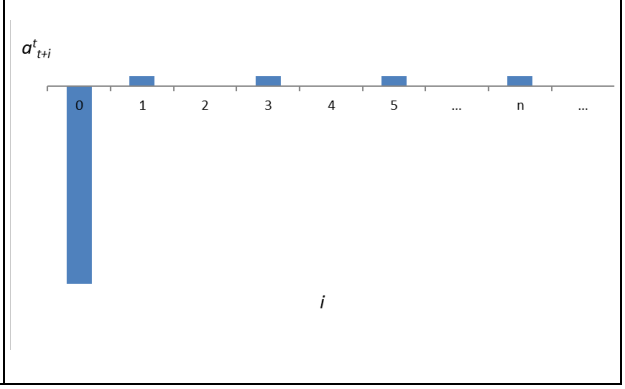


Figure 1.2



The profile of 1.2 correspond to loans, non-transferable deposits and debt securities (other than zero-coupon debt). Figure 1.2 is the profile of perpetual debt.

Dual payments

A particular case of the category above is one where only two payments exist, one at inception and one at redemption. Depending on whether the initial payments or equal or not to the one at the end, this would be the profile of a zero-coupon bond

[3] https://www.imf.org/-/media/Files/Data/Statistics/BPM6/FITT/f10-treatment-of-cash-collateral.ashx

(payment at the end larger than at inception, Figure 2.1 for a 7-period asset) or of other payables (Figure 2.2, showing a short-term payable)

Dual payments Figure 2

Figure 2.1

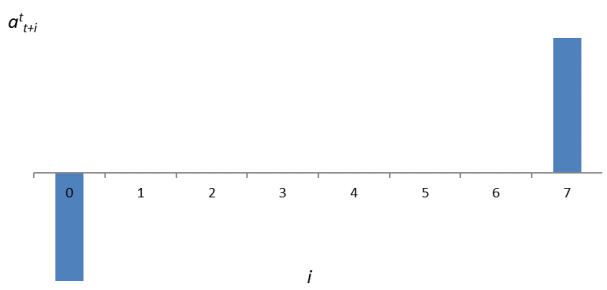
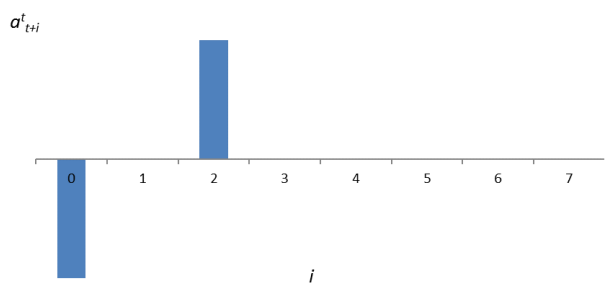


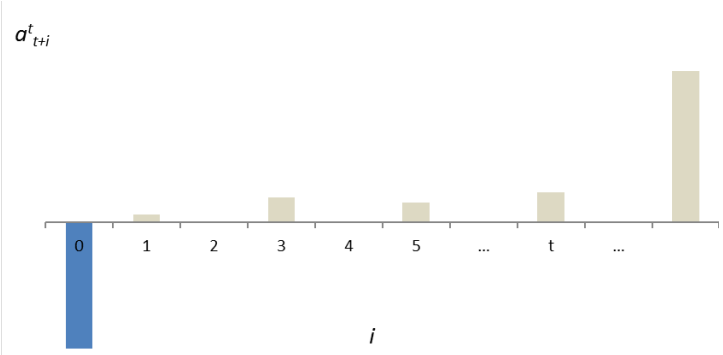
Figure 2.2



Equity

Equity cash flows have the same sign restrictions as financial claims ($a^t_{t+0} < 0$; $a^t_{t+i} \geq 0 \; \forall i > 0$), but the amount of the flows is not predetermined. Similar as for perpetual debt, the time horizon is in principle infinite, but with the prospect of having here at some point a higher flow that would terminate the payment stream. Figure 3 shows this marking the stochastic nature of the flows in green.

Equity Figure 3



This is the profile of a corporate stock, the flows after inception representing dividend payments, and the final payment being the corporate residual value (which could be zero, but never negative).

Forwards

This cash flow is characterised by no flow at inception and stochastic flows, which can be positive or negative, over the rest of its life. The sign restrictions only apply to the first flow then ($a^t_{t+0} = 0$). Figure 4.1. shows the corresponding profile for a 7-period stream assuming that the stochastic payments take place at any time during those periods, but it can also be the case that single payment takes place at the end of the cash-flow life.

We find this cash-flow profile in forward contracts, like swaps or other futures (which can lead to periodic payments as in 4.1 if there is periodic settlement, or to a single payment).

Options

As opposed to forwards, here a negative payment is made at inception and a stochastic *non-negative* payment is made at the end of the cash stream. The sign restrictions are then as follows: $a^t_{t+0} < 0$; $a^t_{t+k} \geq 0 \; for \; a \; k$; $a^t_{t+i} = 0 \; \forall i \neq 0, k$. Figure 4.2 shows the corresponding profile.

Naturally, this is the cash-flow presented by call and put options, the initial flow corresponding to the premium and the last payment to the gain obtained for exercising the option (which can never be negative as the holder can decide not to exercise the option if the difference between market and strike price lead to a loss).

Forwards and Options Figure 4

Figure 4.1 (forwards)

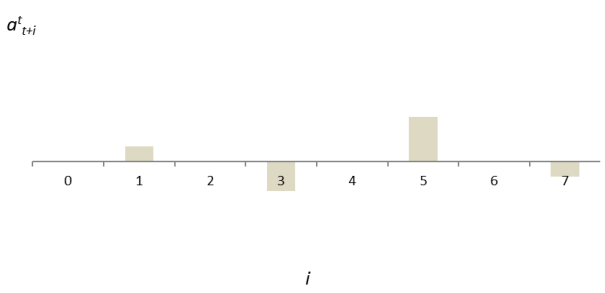
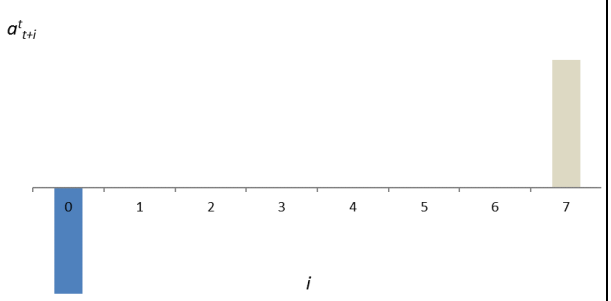


Figure 4.2 (options)



Actual cash flows might fall under one of the categories above or have a mix nature having features of some of them. At the same time, this approach allows to express assets (cash flows here) as linear combination of other cash flows, which enables complex, non-standard assets to be expressed as combinations of assets falling under the categories above (see a more formal discussion in the Box on the cash flow vectoral space). In fact, the categories above can in same cases be expressed on the basis of some of the other categories proposed. For instance, the generic financial claim case in Figure 1.1 can be split into the sum of four zero-coupon cash-flows as in 2.1. Likewise, the profile of equity (Figure 3) can be seen as closely related to that of an option (Figure 4.2). Section 4 elaborates further on the latter.

The concept of asset stock in this context can be formally introduced by defining a function on the cash flow arrays that would convert them into scalars. This function can be seen as being the traditional "net present value" using a discount rate that is given by the market, in case this exist, which would be a market of cash flows. In formal terms: $s(a^t) = npv\,(\{a^t_{t+i}\}, r\,) = \sum_i \frac{a^t_{t+i}}{(1+r)^i}$, *s( )* denoting stock and *r* being the discount rate[4]. When evaluated at inception, *s( )* yields zero by construction for all cases presented above (unless the flows are unbalanced in terms of market

[4] A generalization can be made by having a different discount rate r_i for each of the payments. When the payments are uncertain a^t_{t+i} must be understood as the mathematical expectation of the payment.

perception and the whole cash-flow has an initial value; this is known in the market practice as being "out of the money", as opposed to being "in the money"). As time elapses and in particular the initial payment is dropped from the subsequent arrays, the market value and the stock valuation are different from zero.

Cash

A last category of cash flow is a degenerate case that presents just a single certain payment in any future moment i as decided by the creditor. As opposed to all other categories presented above, the stock function does not evaluate to zero at inception, but to the value of that one and only flow, as by convention the flow is discounted as if it would take place at $i=0$.

To this category belong assets without liabilities, like monetary gold, or to transferable assets like banknotes, coins or transferable deposits.

The individual payments forming generic cash streams are typically assets of this kind (cash streams of a single flow). The payments can also consist in the provision of goods and services, or of non-financial assets. Finally, the individual flows in the cash streams can also be generic financial assets, i.e. generic cash flows entailing more than one cash payment. This evokes the inspiring image that financial assets are payment streams in which each payment is itself a payment stream, and so on in infinite recursion.

1

Cash flow vector space

The universe of cash flows has the algebraical structure of an infinite-dimensional vector space over the field of the Real numbers. In this box, we apply the standard vector space concepts to this specific vector space.

The two binary operations of the vector space are defined as follows:

$a^t + b^t = \{a^t_{t+i} + b^t_{t+i}\}, i = 0,1,2 \ldots ; \quad a^t = \{a^t_{t+i}\}, b^t = \{b^t_{t+i}\}$

$\alpha a^t = \{\alpha a^t_{t+i}\}, i = 0,1,2 \ldots \; ; \; a^t = \{a^t_{t+i}\}, \alpha$ a real number

Linear combinations of assets/ cash flows applying the definitions above are also assets $c^t = \alpha a^t + \beta b^t$ in the vector space, which formalises the statement in the man text that cash flows can be expressed as combinations of other cash flows.

Given a group of assets, the set of all assets that can be constructed by means of linear combinations of the group also has the structure of vector space, and constitutes a sub-space of the larger cash flow vector space. It is said that the group of assets *spans* the sub-space.

The converse is not true, and a given asset might not be able to be expressed as a combination of another set of assets (i.e. the former is not in the span of the later). More in general, a set of assets is said to be linearly independent if none of the assets in the set can be expressed as a linear combination of the others.

Interesting sets of assets are those whose components are linearly independent and span the whole cash-flow vector space. A set like this is called a basis and can be used to express any other asset. As the cash flows ae generally arrays of infinite length, such basis should have infinite members, and the expression of a generic asset in the basis would be:

$$a^t = \alpha_1 u^t_1 + \alpha_2 u^t_2 + \cdots + \alpha_n u^t_n + \cdots$$

where $(u^t_1, u^t_2, \ldots, u^t_n, \ldots)$ is a basis and the set $(\alpha_1, \alpha_2, \ldots, \alpha_{n1}, \ldots)$ are called the components of a^t in the basis.

The so-called canonical basis is the set of assets $c^t_j = \{c^t_{j,t+i}\}$, $c^t_{j,t+j} = 1 \;\; c^t_{j,t+i} = 0 \; \forall i \neq j$ and the components of any asset a^t in that basis are nothing but the individual cash payments a^t_{t+i} .

More interesting are basis other than the canonical one. Beyond the trivial representations resulting from the canonical basis, assets can be expressed as combinations of proper assets included in generic basis. An interesting line of research is the construction of a basis of options (as defined in Section 3), so that we can conclude that options are the building blocks of any other financial asset (see a related discussion concerning to equity in Section 4).

Although the generic cash flow vector space is infinite-dimensional, interesting sub-spaces cover assets of finite payment streams. Those sub-spaces are spanned by finite basis, and the corresponding assets are represented with finite components sets. The change of representation from one finite basis into another one can be done by constructing a matrix formed by columns having the components in the old basis of the assets in the new basis; the components of an asset in the new basis results from pre-multiplying the components of the asset in the old basis by the inverse of the matrix above (this is the so-called change of basis matrix).

4. Cash-flows and the classification of financial assets in macroeconomic statistics

The taxonomy in Section 3 constitutes an instrument for the classification of financial assets in macroeconomic statistics. It can serve to improve the definitions in the statistical standards and to resolve borderline cases when other criteria do not suffice to decide on classification. Moreover, it can inform alternative classification structures.

An example of a context where the taxonomy might be of use for deciding on the classification of a category of assets is the discussion on the classification of Credit Default Swaps (CDS) that has taken place in the context of the review of the statistical standards[5]. A CDS is a contract between two parties whereby one of the parties (the investor or the protection buyer) to buy protection against the risk of a credit event (typically bankruptcy) on a specified entity. The protection buyer pays a series of fees (premiums) to the protection seller, and, if the credit event takes place, the protection seller pays a compensation to the buyer for the loss. The premium payments are called "the premium leg", and the compensation payment "the contingent leg".

The controversy on the CDS classification comes from the fact that some of the characteristics of CDS are those of a forward contract (market value switching from positive to negative and vice versa, multiple payments along the life of the contract) and some others are those of an option (payment at inception, presence of a contingent non-negative payment in any case), which makes it difficult to decide whether they belong to one category or the other.

A close examination of the cash flows of a CDS against the background of the categories put forward in Section 3 can help take a decision. A CDS cash flow presents a series of fixed payments (the premium leg) and a contingent inflow only if the credit event takes place (which is never negative). The sign restrictions are then $a_{t+k}^{t} \geq$

[5] https://www.imf.org/-/media/Files/Data/Statistics/BPM6/FITT/F-5-treatment-of-credit-default-swaps.ashx

$0\ for\ a\ k;\ a^t_{t+i} \leq 0\ \forall i \neq k$. Panel 5.1 shows this cash flow associated to a CDS contract and compares it with the categories forward and option of the taxonomy.

CDS against forwards and options Figure 5

Figure 5.1 CDS cash flow

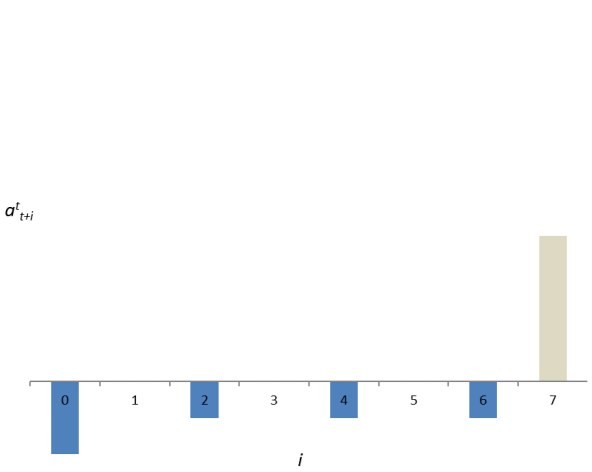


Figure 2.2 Forward

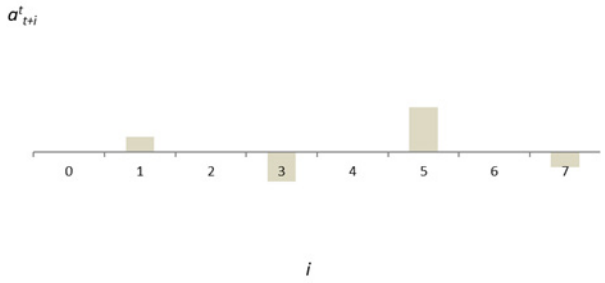
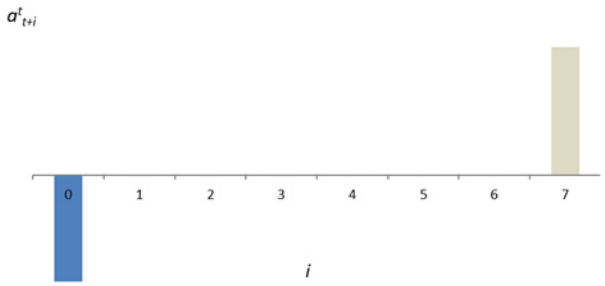


Figure 5.3 Option



The CDS cash stream is similar to that of an option and has little in common with that of a forward; in particular, it doesn`t present the flipping contingent cash payments during the contract life. The sign restrictions are not those of a forward. Actually, one can even say that the option cash stream is a particular case of the CDS one, where the premium leg has a single payment at inception in the case of an option. This analysis would support a classification od CDS together with generic options[6].

While the cash flow of a CDS contract can be seen as a generalization of the option cash flow where the premium leg has more than one payment, the equity cash flow (Figure 3) can be seen as well as a generalization of the option cash flow where

[6] One of the arguments put forward to support the classification of CDS as forwards is the fact that the market value of the CDS can change sings, while that of an option is always non-negative. However, this happens only due to the relatively unimportant difference that the premium leg of an option has a single payment, while that of a CDS has many payments. We can divide the cash streams of both options and CDS into two sub-streams, one with the premium leg and another with the contingent payment, and the value of the total stream would be the sum of the value of the two sub-streams (see Box for a formal discussion on decomposition of cash flows into sub-streams). The value of the contingent leg is always non-negative during the life of the contract both for options and CDS. However, the value of the premium leg is zero after the initial payment for options (because no other premium payment is made), and always negative for CDS. Depending on whether the value of the contingent leg, which changes across time depending on the changes in the market perception of the likelihood of the credit event is higher or lower than that of the premium leg (in absolute value), the overall value of the CDS will be positive or negative. For options, being the premium leg zero, the value of the total cash stream will always be non-negative.

the contingent leg has more than a single payment at the end of the cash flow. Another way to say the same thing: the equity cash flow in case there is no interim payment (no dividend payment) is indistinguishable from an option cash flow. This similarity between options and equity is reminiscent to the well-known statement by Merton (1974) that equity of a levered company can be seen as a call option on the assets of the corporation, where the strike price is the value of its debt. This would suggest an alternative classification hierarchy where options and equity are placed next to each other.

Another issue where the analysis of the associated cash flow gives some insights on the statistical classification is that of Crypto Assets without liabilities designed as a general medium of payment (CAWLM). While the core of the discussion on these assets, which include bitcoin and similar cryptocurrencies, is whether they are financial or non-financial[7], the fact that they present a "cash" payment stream profile would suggest a classification closer to the assets having that profile (monetary gold, coins, banknotes and transferable deposits) should they be finally classified as financial assets.

5. Conclusion

The cash flow properties of the financial assets embed most of their economic substance, to the extent that it is analytically useful to look at financial assets just as such cash streams. The tentative taxonomy presented in this paper puts forward a few broad categories that can work as a classification system. We have also suggested ways to look at assets as linear combination of other assets and therefore a way for breaking them down into building blocks that can fit into the categories proposed.

While thinking about assets as cash flows is very common in many analytical fields, such as corporate structure theory, the International Economic Accounting Standards do not often make explicit use of cash-flow features to provide classification guidance. It would add certainty and clarity to the classification criteria if some reasoning such as the one followed in this paper is considered in preparing new guidance. This would also facilitate the use of macroeconomic statistics for certain analytical purposes.

Moreover, and irrespective of the explicit inclusion of a cash flow approach in the statistical standards or not, the analysis of the cash flows can always provide useful insights to decide on the classification of borderline cases.

At the same time, some work is needed to further formalise the approach suggested in this paper. This applies in particular to the mathematical underpinning sketched in Box 1, but also to the granularity of the taxa forming the taxonomy.

.

[7] https://www.imf.org/-/media/Files/Data/Statistics/BPM6/FITT/f18-the-recording-of-crypto-assets-in-macroeconomic-statistics.ashx

EUROPEAN CENTRAL BANK

EUROSYSTEM

A characterization of financial assets based on their cash-flow structure

Celestino Girón

***11th Biennial IFC Conference** on Post-pandemic landscape for central bank statistics*

26 August 222

What is this paper proposing?

- ✓ taxonomy of cash-flow structures
- ✓ characterization of financial assets on that basis …

to provide new classification criteria and contribute to the resolution of borderline cases

Financial asset in the International Economic Accounting Statistical Standards

Designed to carry forward economic value

Encompasses:
- ✓ Financial claims
- ✓ Equity
- ✓ Financial Gold

- *Currency and deposits*
- *Debt securities*
- *Loans*
- *Insurance technical reserves*
- *Financial derivatives*
- *Other accounts*

Individual assets classified on the basis of economic substance (no legal form) and economic effects (no economic purpose)

No (much) explicit mentioning to cash flow characteristics

Assets seen as cash flows

Arrays of expected cash flows

Also arrays of expected cash flows

$$a^t = \{a^t_{t+i}\}, i = 0, 1, 2 \ldots$$

a^t_{t+i}, *expected flow in t+i*

$$a^t = \alpha_1 u^t_1 + \alpha_2 u^t_2 + \cdots + \alpha_n u^t_n + \cdots$$

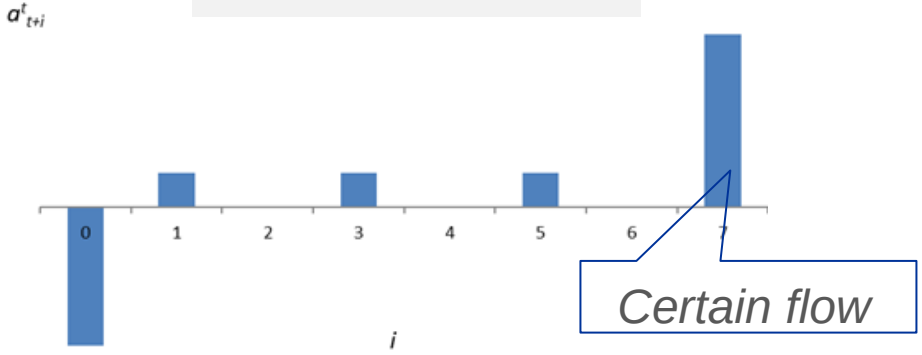
Assets can be expressed as linear combinations of other (linearly independent) assets

$$l^t = -a^t \; ; l^t_{t+i} = -a^t_{t+i}$$

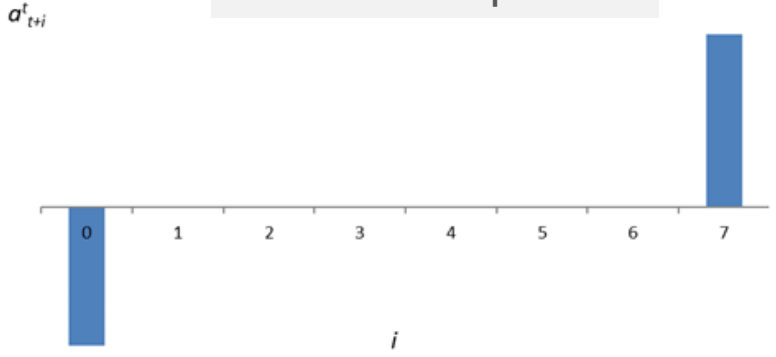
For financial claims, a "mirror" cash flow exists (a liability)

Taxons

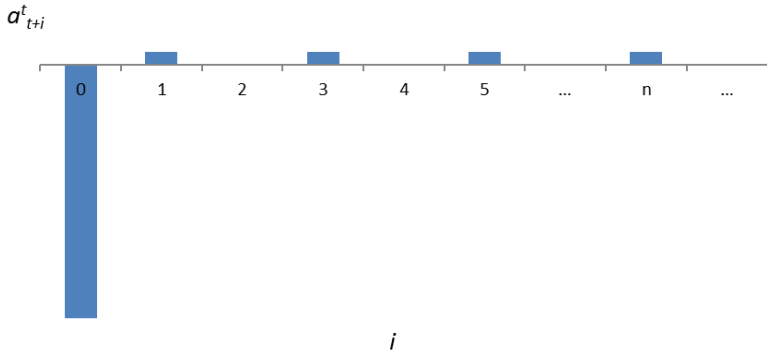
Generic claim



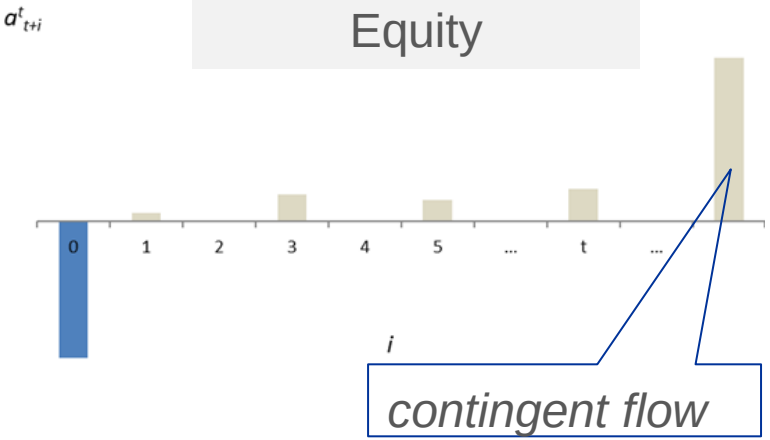
Zero coupon



Perpetual debt

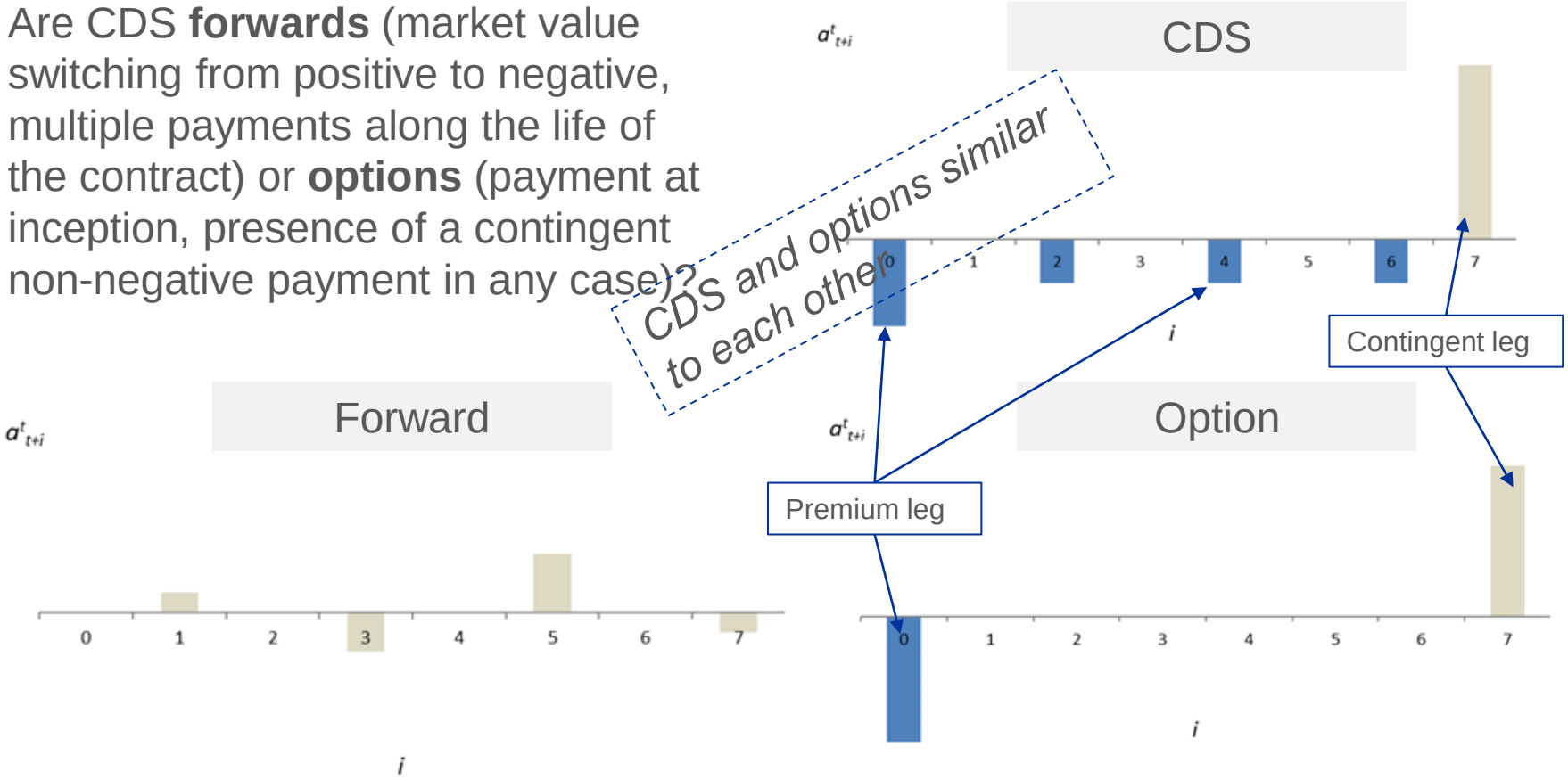


Equity



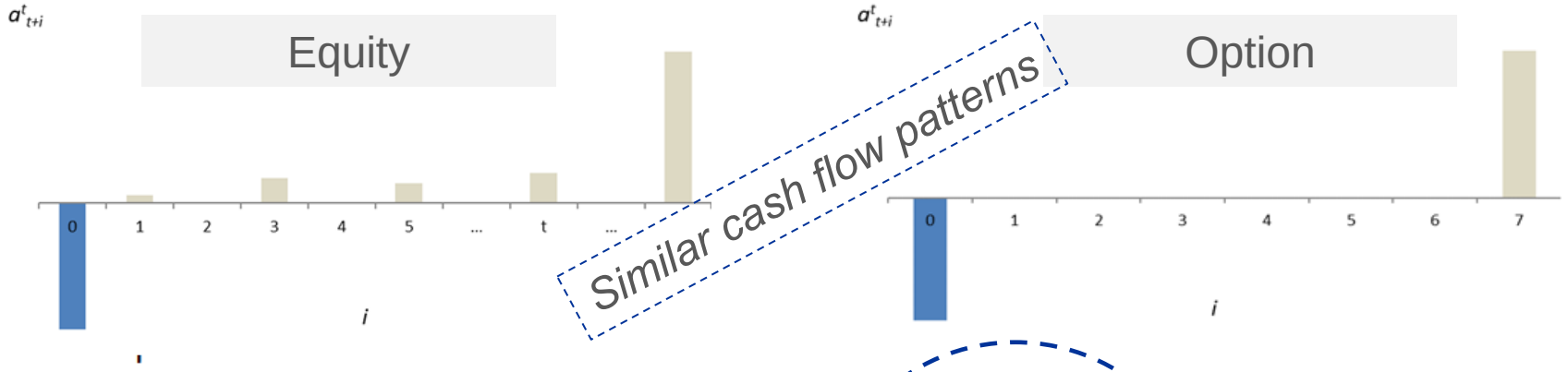
The case of CDS

Are CDS **forwards** (market value switching from positive to negative, multiple payments along the life of the contract) or **options** (payment at inception, presence of a contingent non-negative payment in any case)?



Options and equity

Are options and equity the same kind of assets?



Corporations			
Assets	100	40	Debt
		60	Equity

Dedbt holders		
Debt	40	

Shareholders		
Equity	60	

Corporations			
Assets	100	100	Equity

Dedbt holders			
Equity	100	60	Call option

Shareholders		
Call option	60	

Indeed, these two asset-liability configurations reflect the same economic substance, the same corporate structure

Wrap-up

- ✓ *Cash flow structures give relevant information on the economic substance of financial assets*
- ✓ *A taxonomy of cash flows can give answers to borderline classification problems and inform alternative asset classification systems*
- ✓ *Further research is needed to formalise the mathematical structure of cash flows (vector space) , including its extension to the continuous case*