The Basel III through the Prism of Velocity

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Abstract

In the modern economy, liquidity itself does not have an inherent value in most cases, further, the flow is often elusive. However, we all know that its macroeconomic impact is perceived when it moves with a velocity, particularly with an enormous impact at crisis. In this sense, velocity is worth being explored in its own right, which is the motivation of this paper. We extend the Irving Fisher's ingenious quantity equation of money by incorporating Dixit-Stiglitz preference and liquidity-related prices, which leads us to the concrete form of velocity function. Further, this paper offers macroeconomic implications for the Liquidity Coverage Ratio (LCR) to be introduced in 2015 as one of key measures in the Basel III Regulatory Capital Reforms. The role of High Quality Liquid Assets (HQLA) in financial stability becomes clearer through our velocity function.

Key words: Liquidity Coverage Ratio, High Quality Liquid Assets, Basel III, Liquidity Risk, Velocity

JEL Classifications: E40, E44, E50, E58

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I. Introduction

This paper aims to provide a macroeconomic perspective on financial stability through the prism of liquidity and velocity. We often observe a spectrum of assets whose stabilities of values are different. The role of asset as liquidity, after all, relies on the stability of its value as an instrument of purchasing power. In the extreme case of hyperinflation, even cash becomes almost useless as liquidity, and everyone is keen to take real goods and services. To a lesser extent, in the wake of the Lehman bankruptcy in the 2008 global financial crisis, one banker said that they were not able to sell even a short-term security that had been very liquid during the normal times. Indeed, the 2008 global financial crisis drove home the liquidity and thus one of the core measures under the Basel Accord III is the Liquidity Coverage Ratio(LCR henceforth) that is to be introduced in 2015.

The Basel Committee recommends the LCR with a minimum requirement that the ratio of high quality liquid asset to total net cash outflows over the next 30 calendar days is set at 60% in 2015 to enhance the resilience of banking sector to liquidity shocks. This minimum requirement will rise in equal annual steps to hit 100%, on 1 January 2019. The Basel Committee on Banking Supervision (2013) defines high quality liquid assets (HQLA henceforth) in relation to no loss of its purchasing power at converting, i.e., *"Assets are considered to be high quality liquid asset if they can be easily and immediately converted into cash at little or no loss of value".*

We all know that HQLA under the LCR is reserved against cash outflows for the survival of each bank at emergency and we all feel that the sufficient level of it will function as a safety device for the banking sector. However, its macroeconomic implications on the financial stability are not readily comprehensible, which motivates this study. We revisit the quantity equation of *money* by Fisher (1911) and extended it by linking an array of financial assets with total spending on final goods and services with the Dixit-Stiglitz utility maximization. As a result, the concrete and analytic form of velocity is drawn to allow us to deal with the liquidity-related issues.

The remaining part of this paper is organized as follows. A velocity function is driven from a simple model in section II. The comparative statics analysis with respect to key elements of a velocity function is conducted in section III, and results with and without the LCR are compared in section IV. Finally, section V concludes.

II. The Model

A hypothetical economy with financial assets circulating is assumed. Suppose financial assets, $x(i)'s$ that are mutually exclusive and completes the whole set of financial assets. An economic agent maximizes one's utility by allocating n assets with constant elasticity of substitution, $\eta = \frac{1}{1-\rho}$.

$$\max_{x(i)} \mathrm{U} = \left[\int_{i=0}^{n} \{x(i)\}^{\rho} di\right]^{\frac{1}{\rho}} \tag{1}$$

We recall *financialization* defined by Krippner(2005) as a pattern of accumulation where profits accrue primarily through financial channels and *financial* refers to activities relating to the provision of liquid capital in expectation of future interest, dividends or capital gains. Regarding economic systems at both macro and micro levels, Palley(2007) interpret financialization as a process whereby financial markets, financial institutions, and financial elites gain greater influence over economic policy and economic outcomes. The equation (1) is thus echoing the significance of financial sector relative to the real sector, the possible risk of debt deflation basically arising from the uncomfortable dichotomy between real and financial sectors.

The budget constraint with expenditure level of y is,

$$\text{s.t.} \int_{i=0}^{n} x(i)p(i)di = y \tag{2}$$

The first order condition is,

$$x(i) = \left(\frac{p(i)}{p(j)}\right)^{\frac{1}{\rho-1}} x(j) \tag{3}$$

Plug this in the budget constraint, then

$$\int_{i=0}^{n} x(i)p(i)di = \int_{i=0}^{n} \left\{\left(\frac{p(i)}{p(j)}\right)^{\frac{1}{\rho-1}} x(j)\right\} p(i)di = y \tag{4}$$

After rearranging (4),

$$x(j) = \frac{p(j)^{\frac{1}{\rho-1}}\, y}{\int_{i=0}^{n} \{p(i)\}^{\frac{\rho}{\rho-1}} di}$$

(5)

Plug the equation (5) into utility function leads to an indirect utility function in the standard way as,

$$\mathrm{U} = \left[\int_{i=0}^{n} \{x(i)\}^{\rho} di\right]^{\frac{1}{\rho}} = \left[\frac{\left(\int_{i=0}^{n} p(i)^{1-\sigma} di\right) y^{\rho}}{\left(\int_{i=0}^{n} p(i)^{1-\sigma} di\right)^{\rho}}\right]^{\frac{1}{\rho}}$$

(6)

For reaching the unit level of this indirect utility, the expenditure will be,

$$\frac{\int_{i=0}^{n} p(i)^{1-\eta} di}{\left(\int_{i=0}^{n} p(i)^{1-\eta} di\right)^{\frac{\eta}{\eta-1}}} = \left(\int_{i=0}^{n} p(i)^{1-\eta} di\right)^{\frac{1}{1-\eta}}$$

(7)

This is the well-known constant elasticity of substitution (CES) price index of Dixit-Stiglitz preference. Also, in expenditure minimization problem, it becomes both the asset price and the expenditure to obtain unit utility.

Aggregating it with respect to the population, *H* results in,

$$\left(\int_{i=0}^{n} p(i)^{1-\eta} di\right)^{\frac{1}{1-\eta}} \times \int_{h=0}^{H} y(h) dh$$

(8)

where $\mathrm{Y} = \int_{h=0}^{H} y(h)dh$ is the real expenditure at the national economy populated by H people. The equation (8) is the *PY* part in the Fisher (1911)'s quantity equation of money, *MV=PY* where *M, V, P, Y* denote money, velocity, price level, and real income respectively.

The sum of asset held by an individual is $\left(\int_{i=0}^{n} x(i)di\right)$ when assets are indexed from zero to n. Suppose $v(i)$ is the asset-specific velocity. Basically the velocity is generated by more than two parties' transactions and thus it is given to each individual. The sum of asset circulations by H people will be,

$$\int_{h=0}^{H}\left(\int_{i=0}^{n} x(i)v(i)di\right)dh$$

(9)

The equation (9) expresses the aggregate flow of liquidity circulating in the hypothetical economy, i.e., *MV* part in the Fisher's quantity equation of money.

Putting together enables us to consider the quantity equation of *liquidity* as,

$$\int_{h=0}^{H}\left(\int_{i=0}^{n} x(i)v(i)di\right)dh = \left(\int_{i=0}^{n} p(i)^{1-\eta}di\right)^{\frac{1}{1-\eta}} \times \int_{h=0}^{H} y(h)dh$$

$$= \left(\int_{i=0}^{n} p(i)^{1-\eta}di\right)^{\frac{1}{1-\eta}} \times Y$$

(10)

The three cases can be thought as,

[Case 1] $x(i) > 0, v(i) > 0$: financial asset, $x(i)$ is demanded and it is circulating for transactions with a velocity.

[Case 2] $x(i) > 0, v(i) \approx 0$: financial asset is demanded but it is rarely circulating for transactions, i.e., showing almost zero velocity. It is still called liquidity because it functions as a store of value. For instance, the high quality liquid assets under requirement of the LCR belong to this category, in which the velocity is almost zero during the normal periods.

[Case 3] $x(i) \approx 0, v(i) \approx 0$: this asset has neither demand nor velocity, for example, the asset is on hot sale waiting for potential purchasers around.

Finally, the case of $x(i) = 0,\ v(i) > 0$ has little economic meaning.

From equation (10), we elaborate asset i's price, $p(i)$ by introducing market illiquidity as

$$p(i) = s(i)e^{-\lambda\left(\int_{i=a}^{n} x(i)di\right)} \qquad (11)$$

This price function with liquidity risk parameter, $\lambda > 0$, is introduced as in Schnabel and Shin (2004), in the way that the market price is the function of liquidity risk parameter, λ that makes asset demand curve steeper. The demand curve for the asset i also becomes steeper when the size of illiquid assets ranging from a^{th} *to* n^{th} in the exponent part of equation (11), that is, $\left(\int_{i=a}^{n} x(i)di\right)$ increases. So, realized market price of asset, $p(i)$

becomes less than or equal to the fundamental value of asset, $s(i)$. The more agents perceive liquidity risk, i.e., the increase in λ or the more the size of illiquid assets is, the less $p(i)$ becomes.

This means that assets ranging from a^{th} *to* n^{th}, are illiquid assets categorized as the Case 3, $x(i) \approx 0, v(i) \approx 0$, putting downward pressure on asset prices. So, the quantity equation of *liquidity* is elaborated as,

$$\int_{h=0}^{H}\left(\int_{i=0}^{a} x(i)v(i)di\right)dh = \left(\int_{i=0}^{n}\left[s(i)e^{-\lambda\left(\int_{i=a}^{n} x(i)di\right)}\right]^{1-\eta} di\right)^{\frac{1}{1-\eta}} \times Y \tag{12}$$

The dichotomy between liquid and illiquid assets is depicted in Figures 1 and 2 that tells crisis from non-crisis periods. The assets ranging from 0 to a are functioning as liquidity, while assets from a to n are illiquid.

The derivative of left hand side of equation (12) with respect to a gives,

$$\frac{d\left[\int_{h=0}^{H}\left(\int_{i=0}^{a} x(i)v(i)di\right)dh\right]}{da} = Hx(a)v(a) \tag{13}$$

It should be equal to the derivative of the right hand side of equation (12) with respect to a, that is,

$$\frac{d\left[\left(\int_{i=0}^{n}\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]^{1-\eta}di\right)^{\frac{1}{1-\eta}}\times Y\right]}{da}=x(a)\lambda Y\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}$$

(14)

From the equality of the equations (13) and (14), the velocity of a liquid asset is drawn as in equation (15),

$$\mathrm{v}(a)=\frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}\lambda Y}{H}$$

(15)

The velocity is found to be the function of fundamental asset price, the total number of financial assets, the elasticity of substitution among financial assets, liquidity risk parameter, and real income that are fundamental elements in the liquidity flows. These elements reflect the technological and institutional changes that Fisher had originally considered as the determinants of velocity. The next section will link these elements composing the velocity with liquidity-related issues by interpreting the results from comparative statics analysis.

III. Comparative Statics Analysis

This section will analyze the velocity function via results of comparative statics, i.e., one will see how the elasticity substitution among assets, liquidity risk, asset price, total number of assets, total number of liquid assets change the velocity and interpret the results linking the previous studies.

If we can interpret the changes in elasticity of substitution among assets as the outcome brought by securitization and financial innovations, it is intriguing to see its effect on velocity. For example, securitization weakens the classic distinction of equity and debt via its sophisticated techniques of bundling, repacking, and trading risks, so the elasticity of substitution, η can be varied and possibly in the increasing way. Then, greater reaction of agents in response to relative asset price changes, that is, the increase in η, can be related to developments of information and communication technology, deregulation, and similar banking strategies (Schnabel and Shin 2004). Pattanaik and Subhadhra (2011) also claims that financial innovations and securitization like Collateralized Debt Obligations(CDO) increases the velocity. Equation (16) shows that the increase in elasticity of substitution raises the velocity as,

$$\frac{\mathrm{dv}(a)}{\mathrm{d}\eta} = \frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n} x(i)di\right)}\right] n^{\frac{1}{1-\eta}}\, \lambda Y[\ln(n)]}{H(\eta-1)^2} > 0$$

(16)

For the liquidity risk parameter, λ,

$$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} = -\frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n} x(i)di\right)}\right] n^{\frac{1}{1-\eta}}\, Y \left[\lambda\left(\int_{i=a}^{n} x(i)di\right) - 1\right]}{H}$$

(17)

It implies that

$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} > 0$ when $\lambda\left(\int_{i=a}^{n} x(i)di\right) < 1$

$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} < 0$ when $\lambda\left(\int_{i=a}^{n} x(i)di\right) > 1$

(18)

The increase in liquidity risk does not necessarily reduce velocity, which depends on the size of $\lambda\left(\int_{i=a}^{n} x(i)di\right)$, that is, market illiquidity part. Higher liquidity risk reduces velocity only when $\lambda\left(\int_{i=a}^{n} x(i)di\right) > 1$, that is, if market illiquidity part is greater than one, then the rise in liquidity risk parameter lowers velocity. Immediately after the 2001 September 11 attacks, the US Fedwire system recorded high velocity of liquidity in the US interbank system by tighter liquidity management (McAndrews and Potter 2002). Possibly, it corresponds to the case with $\left(\int_{i=a}^{n} x(i)di\right) < 1$, i.e., market illiquidity part is less than one, which limits the drastic decline of asset prices, and thus increase in liquidity risk in that alert situation rather increases velocity. This also helps to take an overall view on the velocity, i.e., high velocity can be a sign of vitality closely related to real sector transaction as seen in its positive relation with real income in Appendix, but velocity can also be high due to the high speed liquidity managements at emergency when market illiquidity part is not too large.

The rise in asset price $s(i)$ raises velocity as,

$$\frac{\mathrm{dv}(a)}{\mathrm{d}s(i)} = \frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n} x(i)di\right)}\right] n^{\frac{1}{1-\eta}} \lambda Y}{Hs(i)} > 0$$

(19)

It recalls Adrian and Shin (2014) arguing that rising asset prices means rising bank indebtedness that spurs additional demand for assets arising from leverage targeting behaviors, which is likely to lead to a higher velocity.

For the number of financial assets and velocity, we have

$$\frac{\mathrm{dv}(a)}{\mathrm{d}n} = \frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n} x(i)di\right)}\right] n^{\frac{1}{1-\eta}}\, \lambda Y[1 + n(\eta - 1)\lambda x(n)]}{Hn(\eta - 1)}$$

(20)

If the elasticity of substitution is greater than one, i.e., $\eta > 1$, then definitely $\frac{\mathrm{dv}(a)}{\mathrm{d}n} > 0$. When the elasticity of substitution is less than one, the sign of $\frac{\mathrm{dv}(a)}{\mathrm{d}n}$ becomes ambiguous. Financial deregulations implemented in the way of increasing the number of financial asset, can increase or decrease velocity of which direction depends on the elasticity of substitution among assets. The increase in the number of *liquid* assets, however, only raises velocity as,

$$\frac{\mathrm{dv}(a)}{\mathrm{d}a} = \frac{\left[s(i)e^{-\left(\int_{i=a}^{n} x(i)di\right)}\right] n^{\frac{1}{1-\eta}}\, \lambda^2 Y\, x(a)}{H} > 0$$

(21)

IV. Liquidity Coverage Ratio

Liquidity requirements are the core part of the Basel III regulatory framework and this section will take a closer look at the velocity when the LCR is imposed. In December 2010, the Basel Committee on Banking Supervision (BCBS) announced the introduction of a Liquidity Coverage Ratio (LCR) to be placed in 2015. The LCR is supposed to promote the short-term resilience and financial stability by ensuring that banks have *sufficient* high quality liquid assets (HQLA) to survive a financial stress scenario, lasting for 30 days. Fundamentally, what is the *sufficient* level of HQLA? This study attempts to answer to this question through the lens of velocity.

The HQLA conserved by the LCR is categorized in the liquid asset but almost zero velocity at normal times, i.e., $x(i) > 0, v(i) \approx 0$ as outlined in section II. To impose the LCR means taking out HQLA from usual liquidity flows during the normal periods, and thus preventing drastic fall of asset prices on the brink of crisis. So, the idle money effect by holding certain amount of HQLA incurs opportunity cost, but those HQLA is expected to contribute to financial stability.

To reflect it, we modify the quantity equation of liquidity, i.e., from asset (0) to asset (L) are HQLA to meet the requirements from the LCR, and thus asset(L) to asset(a) are virtually circulating as expressed in the left hand side of equation (22). In the right hand side of equation (22), the purpose of LCR is reflected in the exponent term, i.e., it prevents liquidity price from plummeting like,

$$\int_{h=0}^{H}\left(\int_{i=L}^{a} x(i)v(i)di\right)dh = \left(\int_{i=0}^{n}\left[s(i)e^{\left(-\lambda\frac{\left(\int_{i=a}^{n} x(i)di\right)}{\left(\int_{i=0}^{L} x(i)di\right)}\right)}\right]^{1-\eta} di\right)^{\frac{1}{1-\eta}} \times Y$$

(22)

The velocity with the LCR is, therefore,

$$v(a) = \frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n} x(i)di\right)}{\left(\int_{i=0}^{L} x(i)di\right)}}\right] n^{\frac{1}{1-\eta}}\lambda Y}{H\left(\int_{i=0}^{L} x(i)di\right)}$$

(23)

Apparently, the introduction of the LCR changes the velocity, of which magnitude depends on the range of high quality liquid asset, $\left(\int_{i=0}^{L} x(i)di\right)$ both in the denominator and in the exponent term in the nominator in equation (23).

When more HQLA are conserved by the LCR, i.e., when there is the rise in L, velocity depends on the relative size of HQLA and market illiquidity as seen,

$$\frac{\mathrm{d}v(a)}{\mathrm{dL}} = \frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n} x(i)di\right)}{\left(\int_{i=0}^{L} x(i)di\right)}}\right] n^{\frac{1}{1-\eta}} Y\lambda\, x(\mathrm{L})\left[-\left(\int_{i=0}^{L} x(i)di\right) + \lambda\left(\int_{i=a}^{n} x(i)di\right)\right]}{H\left(\int_{i=0}^{L} x(i)di\right)^{3}}$$

$$\frac{\mathrm{d}v(a)}{\mathrm{dL}} > 0 \;\; when\, \lambda\left(\int_{i=a}^{n} x(i)di\right) > \left(\int_{i=0}^{L} x(i)di\right)$$

$$\frac{\mathrm{d}v(a)}{\mathrm{dL}} < 0 \;\; when\, \lambda\left(\int_{i=a}^{n} x(i)di\right) < \left(\int_{i=0}^{L} x(i)di\right)$$

$$\frac{\mathrm{d}v(a)}{\mathrm{dL}} = 0 \;\; when\, \lambda\left(\int_{i=a}^{n} x(i)di\right) = \left(\int_{i=0}^{L} x(i)di\right)$$

(24)

The increase in HQLA by the LCR, i.e., the increase in L, will raise velocity when market illiquidity part is greater than the size of HQLA under the requirements of the LCR. This result is intuitive. The downward pressure of asset prices is relatively large in the first case of equation (24), so the greater size of HQLA will play a buffer role to slow down the decline of asset price, offsetting the idle money effects arising from the LCR and thus increase velocity.

Market's perception about liquidity crisis is supposed to be captured by the liquidity risk parameter, λ. Depending on its magnitude, the downward pressure on asset prices can be strengthened or diminished. Equation (25) shows that velocity relies on the relative size of these two terms, i.e., HQLA and market illiquidity as,

$$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} = \frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n} x(i)di\right)}{\left(\int_{i=0}^{L} x(i)di\right)}} \right] n^{\frac{1}{1-\eta}}\, Y \;\left[\left(\int_{i=0}^{L} x(i)di\right) - \lambda\left(\int_{i=a}^{n} x(i)di\right)\right]}{H\left(\int_{i=0}^{L} x(i)di\right)^{2}}$$

$$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} > 0 \ \ when \, \lambda\left(\int_{i=a}^{n} x(i)di\right) < \left(\int_{i=0}^{L} x(i)di\right)$$

$$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} < 0 \ \ when \, \lambda\left(\int_{i=a}^{n} x(i)di\right) > \left(\int_{i=0}^{L} x(i)di\right)$$

$$\frac{\mathrm{dv}(a)}{\mathrm{d}\lambda} = 0 \ \ when \, \lambda\left(\int_{i=a}^{n} x(i)di\right) = \left(\int_{i=0}^{L} x(i)di\right)$$

(25)

The rise in the liquidity risk will increase velocity when downward pressure of asset prices is weakened by the LCR. From $p(i) = s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n} x(i)di\right)}{\left(\int_{i=0}^{L} x(i)di\right)}}$, the denominator in the exponent term is the size of HQLA by the LCR. If one wants to keep the velocity at the normal period level, then the point is how the LCR can prevent the downward pressure on asset prices, consequently offsetting the idle money effect by the LCR. It relies on the relative size between market illiquidity part and HQLA.

This study sheds light on the essence of financial stability, in other words, if we keep the velocity level regardless of crisis or non-crisis periods, the size of HQLA should match market illiquidity part, $\lambda\left(\int_{i=a}^{n} x(i)di\right)$, which answers to the question, *which level of HQLA is sufficient*. The sufficient level of HQLA certainly depends on liquidity risk and the size of illiquid assets. The results of comparative statics analysis with respect to other elements are in Appendix.

V. Conclusion

We aim to provide a simple framework to take a closer look at the upcoming introduction of the Liquidity Coverage Ratio in 2015. Financial assets are contained in the quantity equation of *liquidity* that allows us to pose various liquidity-related elements. Velocity can be interpreted as a sign of vitality in the real sector or merely as a sign of liquidity management speed (Afonso and Shin 2009). By singling out the velocity and its interactions with key fundamental elements, we come to touch upon what underlies in the regulatory measures of the Liquidity Coverage Ratio(LCR).

Most of comparative statics results regarding the velocity are qualitatively the same for the cases with or without the LCR, but the rise in liquidity risk or in the level of high quality liquid assets (HQLA) by the LCR does not necessarily change the velocity in one direction. It depends on the relative size between market illiquidity and high quality liquid assets(HQLA). It is because the LCR has both the idle money effect and the effect of preventing asset prices from plummeting.

So, higher level of HQLA is effectively working for preventing drastic drop of asset prices when market illiquidity part is relatively larger than the HQLA whereas higher level of HQLA has greater idle money effect when market illiquidity part is relatively smaller than the HQLA. If we regard stable velocity as the sign of financial stability, HQLA needs to be adjusted by the changes in liquidity risk and the size of illiquid assets. The former is more closely related to ongoing market perception and the latter is more about the outcome of market evaluation. The LCR is scheduled to hit 100% in 2019, which will alter the velocity of liquidity depending on the size of market illiquidity.

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Appendix. The Results for Comparative Statics Analysis

	Without LCR	With LCR
$\frac{\mathrm{dv}(a)}{\mathrm{d}a}$	$\frac{\left[s(i)e^{-\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}\,\lambda^2 Y\,x(a)}{H} > 0$	$\frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n}x(i)di\right)}{\left(\int_{i=0}^{L}x(i)di\right)}}\right]n^{\frac{1}{1-\eta}}\,\lambda^2 Y\,x(a)}{H\left(\int_{i=0}^{L}x(i)di\right)^2} > 0$
$\frac{\mathrm{dv}(a)}{\mathrm{d}\eta}$	$\frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}\,\lambda Y[\ln(n)]}{H(\eta-1)^2} > 0$	$\frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n}x(i)di\right)}{\left(\int_{i=0}^{L}x(i)di\right)}}\right]n^{\frac{1}{1-\eta}}\,\lambda Y[\ln(n)]}{H(\eta-1)^2\left(\int_{i=0}^{L}x(i)di\right)} > 0$
$\frac{\mathrm{dv}(a)}{\mathrm{d}s(i)}$	$\frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}\,\lambda Y}{Hs(i)} > 0$	$\frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n}x(i)di\right)}{\left(\int_{i=0}^{L}x(i)di\right)}}\right]n^{\frac{1}{1-\eta}}\,\lambda Y}{Hs(i)\left(\int_{i=0}^{L}x(i)di\right)} > 0$
$\frac{\mathrm{dv}(a)}{\mathrm{d}n}$	$\frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}\,\lambda Y[1+n(\eta-1)\lambda x(n)]}{Hn(\eta-1)}$	$\frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n}x(i)di\right)}{\left(\int_{i=0}^{L}x(i)di\right)}}\right]n^{\frac{1}{1-\eta}}\,\lambda Y\left[\left(\int_{i=0}^{L}x(i)di\right)+n(\eta-1)\lambda x(n)\right]}{Hn(\eta-1)\left(\int_{i=0}^{L}x(i)di\right)^2}$
$\frac{\mathrm{dv}(a)}{\mathrm{d}Y}$	$\frac{\left[s(i)e^{-\lambda\left(\int_{i=a}^{n}x(i)di\right)}\right]n^{\frac{1}{1-\eta}}\,\lambda}{H} > 0$	$\frac{\left[s(i)e^{-\lambda\frac{\left(\int_{i=a}^{n}x(i)di\right)}{\left(\int_{i=0}^{L}x(i)di\right)}}\right]n^{\frac{1}{1-\eta}}\,\lambda}{H\left(\int_{i=0}^{L}x(i)di\right)} > 0$

Figure 1. The Non-Crisis Periods

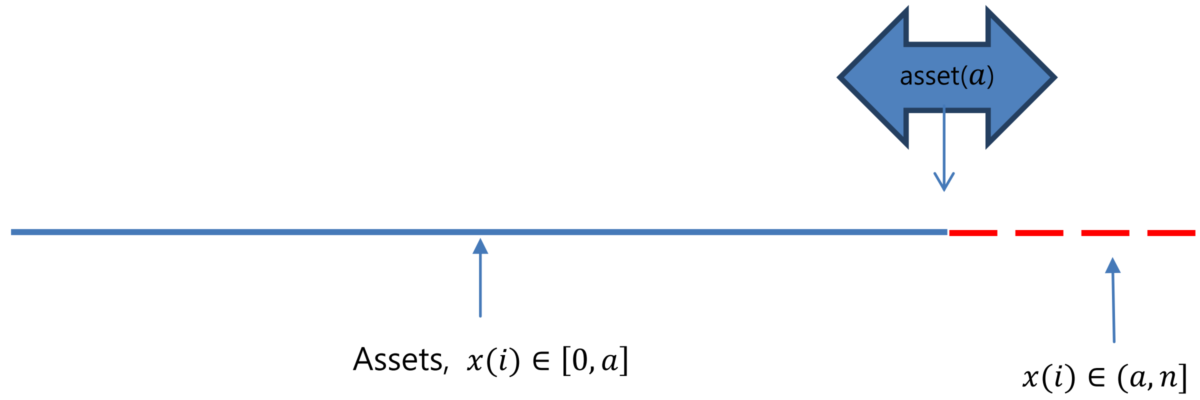

Figure 2. The Crisis Periods