1 FUNDAMENTAL LIQUIDITY [1]

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1 INTRODUCTION

In this paper I would like to encourage a discussion about a basic issue that in the midst of a crisis by necessity tends to be brushed under the carpet for the simple reason that financial decision makers spend much of their time on putting out fires. The topic is the one of true asset market liquidity. It is perhaps only a bit of an exaggeration to say that liquidity is an intellectual blind spot in our understanding of markets.

Indeed, what is a *fundamentally liquid* market? The phenomenon of liquidity has been largely absent from the formal discourses in financial economics until quite recently, and a history of not understanding the factors and differences in liquidity across multiple securities, markets and times has probably had deleterious effects on finance theory as well as on the practice and policy making of finance. Given that not even a clear definition exists, this would seem a hopeless endeavour. But the worry I have is that if we do not know what liquidity is, then we cannot know whether liquidity is good or bad or how we can arrange markets to improve upon their current liquidity. But even if we knew how to make a certain market a bit more liquid, what do we know about why the market has the liquidity it currently has in the first place? How can we know liquidity is resilient? A simple idea would be to say that liquidity is fundamental, or resilient, if the security serves a useful purpose, and that the liquidity would therefore survive if some of the economic or regulatory parameters were to change a bit, say though the imposition of a small tax or the closing of a regulatory arbitrage loophole.

For instance, the empirical finance literature has shown in a series of impressive papers the extent and the dynamics of statistics such as bid-ask spreads, depth of the limit order book, volume, as well as a multitude of named, amalgamated, metrics that combine a few of these statistics.[2] We would argue that bid-ask spreads, volume, depth and the like are some of the *symptoms* of liquidity. If an investment company is going to arrange its trading, including minimising market impact, such metrics are very useful. They also have the advantage of being quick and easy to compute (which has the potential drawback that observers will focus solely on these measures for the simple reason that they are easy to compute). Still, they are not liquidity itself, at least not the liquidity that matters from an overall social welfare point of view. They are a short-cut to liquidity. They are a *reflection* of liquidity but they do not imply fundamental liquidity.

Does it follow from the observation about a symptom, say that a market's bid-ask spreads tightened, that this asset is *fundamentally liquid* or that the evolution has been welfare improving? Or more to the point, how confident are you to predict future liquidity on the basis of current symptoms, without also thinking about why this security is being traded in the first place and by whom? The literature has very largely shown for example that Mifid and RegNMS have reduced bid-ask spreads, and have concluded that therefore those markets have become more liquid, which in turn must mean they have improved social welfare. The last two implications might well be true, but I have yet to see any systematic analysis of the reasons why this ought to be expected, probably because the implication almost seems tautological. Does the fact that bid-ask spreads remained tight during the flash-crash make us rethink liquidity? And what if, as is commonplace these days, the exact same security is trading on many different exchanges and alternative trading venues? Which bid-ask spreads does one consider? What is more, since a large fraction of trades occurs off the lit exchanges in dark pools and on crossing networks, those trades do not even involve any notion of spread. One would like to find a measure for the overall market liquidity of the cross-listed security.

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2 See for instance the paper by Goyenko et al. (2006) for a survey of some of those measures and how they compare to each other.

All of these observations lead me to explore the idea that the *fundamental reasons* why a security can exhibit some of the liquidity symptoms ought to be referred to as the "true liquidity" of a security or a basket of securities in a given market as well as across all markets. Or put differently, there is *proximate liquidity* ("a low bid-ask spread") and *ultimate*, or *fundamental liquidity* ("a deep welfare-based desire to trade this security"). While both may coincide in many instances, confusing or confounding them would be dangerous.

The starting point of my thinking is to move away from a narrow finance-centric focus and to go back to Economics 100 and to say that the fundamental job of the financial markets is to allocate resources to their best use while allowing investors to diversify their risky holdings doing so. In that sense one would expect a market to be more liquid the better it delivers on this promise, both in the sense of being better tailored to the required reallocation and in the sense of allowing this transfer to occur on a larger scale. In other words, a truly liquid security ought to have both a useful payoff profile and the scale. The standardised observable symptoms would then be expected to reflect the same. Or viewed from the opposite end, if a given market has tight bid-ask spreads or the like but delivers no useful role to market participants, any small transaction cost, tax or other impediment to trade would mean that the market effectively closes, and this lack of resilience is incompatible with the notion of true liquidity. Or consider a market with a large number of identical, wealthy and not very risk-averse investors. There is no trade in that economy, but if an outsider came in and wanted to trade a certain number of units of some security, the market impact of that trade is close to zero, and yet there is no liquidity in that market since apart from the small newcomer no-one has an interest in trading the security. Similarly, the bid-ask spreads remained very tight compared to historical norms during the flash crash episode of May 6th, 2010 as well as during the many other mini flash crashes, and yet few would argue that the markets were very liquid. We see that true liquidity is not simply a question of atemporal spreads but a deeper question of the role played by the market. This is the first question regulators need to ask themselves when they consider setting the rules of the game:

> "What is the aim of the game? What is the purpose of financial markets in the first place? Should the objective be finance-centric, and therefore focus on inward-looking liquidity metrics, or should the objective be broader and involve the economy as a whole, in which case the liquidity metric needs to be fundamental?"

For instance, let us assume that a regulator needs to form a prediction as to the future liquidity of the sovereign CDS market after the banning of naked shorts, or to form an estimate of the resulting liquidity losses. It would be difficult, even slightly odd, to do so through extrapolation of past proximate liquidity measures, but it would make a lot of sense to do so by asking the question as to the amount of true benefit that end-users get by being able to hedge their exposures, direct as well as indirect, to sovereign risk factors.

True liquidity also has the connotation of a certain stability, or permanence over the cycle. For instance, a market can be very "liquid" in a boom, when a certain lucky constellation of ephemeral coincidences obtains, but dry up quickly once this balance disappears. Governor Mersch (Mersch (2009)) makes the observation that the onset of the crisis has refocused the discussion from the topic of liquidity abundance to severe liquidity penury in just a few months. Since the holders of a security might have counted on the ability to offload the security in times of stress or thereafter, this security would fail the test of "over-the-cycle-liquidity." Some observers point out that our horizons and patience shrink as the time scales of market events speed up, see for instance Haldane (2010). Some might conjecture that by relying on the current real-time instantaneous measures of liquidity market participants may be subtly induced to ignore the bigger picture of fundamental liquidity over multiple, including longer, horizons. They become more high-frequency trader rather than more Warren Buffett.

Finally, regulations are not neutral in terms of liquidity. It is true, for instance, that government debt plays a crucial role in allowing reasonably safe intertemporal transfers of resources from today to later periods. Pension funds for instance come to mind. Still, the liquidity of some such bond benefits directly from regulations. A number of regulated investors for instance cannot invest is sub-investment grade bonds. This creates additional liquidity for government debt and removes some liquidity from corporates and the like. Or consider the kinds of securities that are accepted by central banks as collateral. The fact of being acceptable to a central bank by itself creates liquidity, at least as long as future acceptance is credible. The idea is that regulations can affect one side of a trade, either the natural demand or the natural supply of a given security by providing incentives to carry this natural demand or supply over to a similar security, but one that benefits from a regulatory advantage. The security that now suffers from an imbalance between demand and supply will suffer from a liquidity point of view because the depth is no longer there, even though its theoretical profile of cash flow reallocations is equally attractive.

2 HOW SHOULD WE THINK ABOUT FUNDAMENTAL LIQUIDITY?

A full formal treatment can be found in Rahi and Zigrand (2010). In a nutshell, we propose a metric that is not model-dependent, but its properties of course will be. Roughly, we define liquidity as the gains from trade achieved in equilibrium through the trading of securities. Financial markets are liquid if they allow investors to execute large amounts of welfare-enhancing security trades. One would expect that the proximate measures of liquidity offer a picture that is consistent with the fundamental measures of liquidity in normal circumstances. The gains from trade are determined by the magnitude of the change in both prices and quantities, i.e. by the extent to which the marginal valuations of investors change relative to autarky, and by the scale of the accompanying trades.

The notion that liquidity manifests itself in the interaction of the scale of trades and the alignment of marginal valuations is commonsensical to market practitioners. For instance, for a new derivative contract to establish itself successfully on an exchange it needs to attract trades that benefit from this new security because of a hedging need between natural counterparties with a need for sizable trades. Purely speculative contracts attract less liquidity in part due to the no-trade theorems. Most new derivatives contracts listed fail because they fail to attract sizable demand and supply exhibiting mutual benefits.

Heuristically, our fundamental liquidity metric, which can be applied to a single security as well as to an exchange or to the overall market, can be written as follows:

Fundamental liquidity
=gains from trade mediated through securities markets
=(scale of trades)× (measure of change in marginal valuations)

This measure of liquidity is intuitive. The first component, the scale of trades, is related to the market impact of trades, or depth. If markets are deep, an agent can trade a large amount without adversely affecting the terms of trade. By itself, however, this is not a sufficient measure of liquidity. A market could be very shallow at the margin and yet already at equilibrium have realised large amounts of welfare improving gains. The second component of our liquidity metric, i.e. the change in marginal valuations induced by trading, measures the usefulness of security markets in terms of the gain in efficiency that trading secures for investors.[3] This efficiency gain is reflected in the degree to which marginal valuations are aligned

3 Formally, the measure of change in marginal valuations is given by the mean-square difference between the marginal valuation (the so-called state-price deflator p satisfying: $price = E[p*payoff]$) in equilibrium after trading the given securities on one hand and the marginal pre-trade valuation on the other hand, $E[(p_{post\text{-}trade}-p_{pre\text{-}trade})^2]$. The paper by Chen and Knez (1995) exhibits a wealth of useful properties of this metric, as well as empirical methods to implement it. The scale or depth of the market is measured by a first-order approximation to the market impact function, essentially equal to the harmonic sum of all of the market participants' risk tolerances (and therefore a larger addressable market or individually more risk tolerant end-users, or both, will naturally exhibit a larger scale).

relative to autarky as agents trade their way from the endowment point towards the contract curve. This will naturally depend upon the potential gains from trade, the degree of competition in intermediation, and the payoff characteristics of the securities available for trade. By itself, alignment of marginal valuations is not a sufficient characteristic of liquid markets either, for it could be that there is a large adjustment in marginal valuations, and yet the amount traded and its welfare impact are small.

The advantages of this metric are manifold. First, our liquidity metric is expressed not in terms of an abstract unit but directly in terms of real resources saved, a proof of which can be found in Rahi and Zigrand (2010). While the metric appears abstract, it can be shown that it is exactly equal to the additional real resources that can be consumed as a result of being able to reallocate resources using this security.

Second, being in terms of real resources saved implies that liquidity can be aggregated and disaggregated easily, including across multiple trading venues, a feature that few other liquidity metrics have been designed to do since they focus on one given security at a time. In other words, regulators may not be mainly interested in whether an option with strike price 35 and time-to-maturity of 18 months is liquid, but whether the options market in general is liquid. The metric proposed here works out-of-the-box on one security, on one family of securities, or indeed on all securities, and the liquidity of a portfolio of securities is equal to the sum of liquidities of its constituent elements, i.e. the sum of all real additional resources available because of the trades mediated through the given assets.

3 WELFARE EFFECTS OF LIQUIDITY

When thinking about the longer term organisation of the financial architecture, as opposed to putting out the fires of the current crisis, measures need to go back to the basics and make sure they think about overall welfare as opposed to incremental tinkering with welfare. It is tempting for example to observe the effects or the proximate causes of a crisis and to act and legislate with an overly strong emphasis on these, and with insufficient perspective about the larger picture. We give a few illustrations.

- Liquidity played a crucial role in the development of the current credit crisis, and again in the flash crash. In the credit crisis it was the disappearance of the overnight and ABCP markets that contributed to the downfall of SIV and conduit type structures. The symptoms were suggestive of an illiquid market, and the fundamental measure of liquidity was in agreement since a non-negligible part of the interest in the pre-crisis CP, SIV, CDO etc. markets did not arise because of the fundamentally useful allocational services rendered by these securities but rather relied on narrow regulatory arbitrage margins. Some of these markets have yet to recover accordingly given the absence of compelling economics. On the other hand, we would venture to suggest that CDOs in general can contribute to social welfare if set up properly to address those potential welfare improving gains from trade, rather than as a mere vehicle to exploit low-margin regulatory arbitrages.

- In the flash crash, it was the absence of any buy-and-hold buyers (especially at the NYSE due to the slight delays) that led to the disappearance of liquidity and to the extreme prices at stub quotes as market orders wiped out the limit-order book. This raises interesting questions about the fundamental liquidity of markets that operate at such micro-second scales: is it really necessary and socially useful to trade that quickly and to quote stuff and to submit thousands and thousands of quotes for the same stock, far removed from the best bid and the best offer, per second? Or can the continuous auction be replaced by a repeated batch auction, and what would the unintended consequences of that be? The answer to these questions are not known, but they are the object of much scrutiny. If liquidity was not grounded in welfare (the fundamental liquidity metric we propose is solidly welfare based) then the structure of trading did not really matter.

- Similarly, during the unravelling of the sovereign credit crisis in Europe, CDS spreads that reflected the markets concerns about a sovereign's creditworthiness were attacked by the officials of the respective countries and institutions as being the unrepresentative quotes determined in an illiquid and one-sided market, and therefore that any interpretations of these spreads in terms of informed creditworthiness would be unwarranted. Serious studies ought to be conducted that show the welfare benefits arising from sovereign CDSs, including the informational benefits that both markets and central banks need to monitor, as well as the indirect social costs that can arise if illiquid spreads can infect other markets through threshold effects and the resulting damage done through positive feedback loops.

These few examples illustrate two of the many facets of liquidity, proximate and fundamental.

4 LIQUIDITY AND DIVERSITY DYNAMICS

Liquidity for a given security is not constant and varies with the cycle. For instance, securities markets exhibit occasional bouts of insidious positive feedback effects that wipe out liquidities. Some securities are more prone to such amplifying feedback effects than others, and some classes of securities recover quickly while others never do. The securities that suffer less over the cycle from bouts of vanishing risk appetite are often those securities that serve a useful role to society and for which there is a natural demand and supply balance. Since the underlying services rendered are going to be in demand again, once risk aversion abates the market's liquidity is restored, and in anticipation of this, the downfalls during the downwards amplification episode are milder also. For instance, some structured vehicles existed solely to exploit small arbitrage or rates spreads, rather than serve the purpose of enabling investors to trade towards the contract curve. All it takes is a small change in regulations to eliminate any interest this given security could have held.

We construct now a more elaborate example in order to illustrate that healthy trades require a double coincidence of wants, and that the gains from trade are themselves endogenous. The formal model can be found in Danielsson and Zigrand (2008). Assume that there is a diverse population of intelligent forward-looking investors who trade with each other on the basis of unexploited gains from diversification, hedging or indeed differential risk-aversion. They are also facing risk-sensitive regulatory constraints, say of the VaR type, either because VaR-type rules are mandated by Basel II or because the debt and equity holders of the company would like to reign in moral hazard on behalf of traders who otherwise may engage in excessively risky trades. The securities that the investors can use to accomplish those gains from trade exhibit good liquidity given that the initial diversity of players and the availability of useful securities allow all investors to reap diversification, allocational and risk-transforming benefits. Now suppose that an initial negative shock hits a small class of securities. This shock will on one hand lead to capital losses to the holders of the securities, and on the other hand it will lead to an elevated level of risk as signalled by the VaR measures. Both effects lead investors to reduce their risky holdings so as to stay compliant with the VaR constraints, or otherwise they need to raise new capital, which is often difficult exactly in such circumstances and new issues also take time. Since many financial institutions now need to unload some of their risky portfolios, such prices fall. The renewed fall and the further heightened VaR levels mechanically force a further round of fire sales and so forth. This is the insidious positive feedback loop studied in Danielsson et al. (2010) and Zigrand (2010). Even though the original holdings were not necessarily speculative and levered positions, financial institutions (FIs) still felt compelled to sell them off, at least temporarily, appearing as if their risk appetite had vanished. What is more, though, is that in such a situation pretty much all FIs find themselves acting in a more risk-averse fashion, but the largest increase in risk aversion occurs in the behaviour of the intrinsically more risk-loving FIs who were holding the riskier and perhaps more levered portfolios in the first place. In other words, not only do most FIs suddenly act in unison, driven by a latent risk-appetite factor, their *diversity* has been reduced as well. Of course some FIs will appear to have mastered the onset of the

crisis better than some others, with a few having been so lucky to have profited opportunistically, the market as a whole will act more alike because the distribution of the effective risk-aversions has become more uniform, as well as higher.[4]

Diversity often has a positive effect on stability, refer for instance to the colourful introductory text by Page (2011). It also has such a positive effect on liquidity. In contrast, in a world that has become less diverse there are bound to be fewer gains from trade, and market liquidity dries up. This is one aspect that current regulations do not seem to have taken on board. Regulators explicitly refer to their determination to apply uniformity to all players. We appreciate their reasoning, but we feel it overly simplistic and short sighted. A crisis driven by positive feedback loops can be dampened if investors step in as the markets fall and forward looking benefit-risk ratios improve. This requires the existence of investors able to step in, unhampered by regulatory VaR and other constraints. Some investors subjected to such rules may happen to be sitting on dry powder and are able to buy, but what is required is a large enough measure of investors free to buy. The few who did step in during the last crisis and stabilise markets were the sovereign wealth funds, the Buffetts, some hedge funds, as well as the central banks. The stabilising effects on markets and on liquidity of regulatory diversity cannot be overstated. Similarly, imposing bans on naked short selling of CDS may (and we presume this is part of the original intention) remove one of the two sides of a trade and imposes uniformity. If all FIs desire to hedge a risk, it requires a speculator to step in, for a fee. If speculators cannot step in, then a more uniform market will support little trade and little hedging can be done.[5]

While the uncertainty unfolds, risk appetite and diversity vanish, and liquidity vanishes as a result since only few of the ultimately desirable trades get done. But in this dismal episode the seeds of recovery are sown because the forward looking risk premia and Sharpe ratios on fundamentally useful securities are very high. Asset prices are so low that new demand, through slow-moving new capital raised to explore the favourable investment opportunities, pushes prices up. Together with the natural upward drift that must exist so as to rationalise the high risk premia in the first place, those markets that do exist for a reason gradually recover and FI capital replenishes. Those securities, especially those in zero net supply, that turn out not to have played any welfare improving roles do not exhibit high forward looking Sharpe ratios, and therefore they do not recover and simply vanish. As capital is replenished, the endogenous risk recedes, allowing both a more natural level of risk appetite and a more diverse risk appetite to return. The stranglehold of the risk-appetite factor that drives much of the movements during a crisis recedes, and securities prices and returns disperse again more, driven by a larger set of factors that includes their own more idiosyncratic ones.

5 PATH DEPENDENCY AND LIQUIDITY

With the main ideas and concepts of liquidity defined and illustrated, I would like to explore some fascinating implications.

If fundamental liquidity is equal to scale times pricing improvement towards more efficient markets, *scale* is the variable that directly depends on institutional details. Consider for instance the treasury futures. The pricing benefits are easy enough to figure out, and even if the overall scale of trades that can be supported by this market was known beforehand, it still is not necessarily known beforehand how the scale will be distributed across fragmented and competing market places. The CBOT, now part of the CME Group, has always had the lion's share of this market despite the fact that competitors, such as Eurex US, have offered

4 In the original paper it is shown that as the feedback loops become more violent, the ultimate distribution of effective risk aversion coefficients is exactly uniform among those FIs who operate under the VaR-type rules.

5 The signalling value of the CDS would then also deteriorate as dissenting voices will find themselves heard less, over and above the knock-on effects of lower liquidity on the CDS markets to lower liquidity on those markets where one of the sides used to hedge their exposure through proxy sovereign CDS

this contract on possibly more attractive terms for final users. But on June 16th, 2005 Eurex US admitted they were unable to wrestle volume from CBOT and exited the market. The market for Treasury futures in general when defined by its payoffs is very liquid in our sense, although this does not necessarily mean that any precise such form will be exhibiting great proximate liquidity statistics. Or seen the other way around, one cannot deduce from the fact that the Eurex US treasury futures appears to be illiquid that the treasury futures market is illiquid. The relevant market for welfare purposes is the overall market for treasury futures.

As a further example, consider the decisions of a central bank that between two payoff-equivalent securities accepts one security as collateral but not another. The security deemed eligible by the central bank would be more liquid, even for identical payoff profiles, since the scale is magnified through the additional acceptance and useful properties the security inherits as a result. Similarly, assume that one security is admissible in satisfying the Basel III Liquidity Coverage Ratio but another very payoff-similar one is not. Given the charges suffered by the non-admissible one, market liquidity will be reduced.

Liquidity exhibits interesting path-dependencies and positive feedback rules of its own. Ever since the research by Becker (1974), Schelling (1978), Arthur (1990) and others has the economics profession focused more of its attention on the interaction between increasing returns, path-dependency, social, network and positive feedback effects. Just as the story of VHS vs Betamax illustrates these links, liquidity does as well. Strategic complementarities exist that imply that the larger the number of people with a coincidence of wants who trade a certain contract on a certain exchange, the more likely I am to join them, everything else equal. Ideally all would like to coordinate on the same market (everything else equal, meaning that the chosen market does not charge monopoly rents etc.). If initially two exchanges have started to offer roughly the same contract, a small difference or sheer luck could have led one of the two to become dominant. Once one of the exchanges is dominant, trying to steal liquidity away from this dominant exchange requires therefore a very clear advantage, such as more efficient, cheaper, faster or subsidised (e.g. the so-called "maker-taker" model) trade executions. But it can be done, as Eurex proved to LIFFE, and as alternative trading venues in conjunction with high-frequency traders have shown when competing with the main incumbent exchanges.

The crucial question that academics, politicians, regulators and market participants are trying to come to grips with at this very moment is whether *overall* fundamental (i.e. welfare based) liquidity in today's fragmented markets is larger than it would have been had markets remained monopolised.

6 LIQUIDITY, NETWORK EFFECTS AND CONTAGION

Securities markets are interconnected in a sophisticated web of relationships. For instance, a bank that sells a derivatives product to a customer hedges its exposure either in the underlying market (the so-called "delta-hedging") or using yet other derivatives products. A large trade in one option leads to the repricing of hundreds of contracts, including all other options with different strikes and maturities as well as all products with embedded options. In the modern fragmented world of alternative trading venues, such as the exchanges and the MTFs in Europe, any trade on a given trading venue may lead to a counteracting trade on another trading venue to align prices.

It follows that liquidity for one product on one given trading venue depends through this web of links on the liquidity of other securities on possibly other trading venues. The question arises how the liquidities of different products on different venues depend on each other. For instance, suppose a bank sold an OTC put option to a client. The liquidity of that OTC put market depends on the ease by which the bank can hedge its exposure, which is reflected in the liquidity of the hedging market, and the liquidity of the hedging market in turn may depend on yet other market liquidities. Now assume there is a shock to liquidity on the hedging market, say short selling of the underlying stock is restricted. If the market

for puts and the market for stocks are complementary, then the market for put options will be hit by a detrimental liquidity shock as well. On the other hand, assume that there are two alternative trading venues that list the underlying security that serves as hedge. Assume also that due to a computer outage one of the two trading venues needs to shut down. One can then imagine that liquidity can move from the shut to the second, open, underlying market. Liquidity is badly affected on the shut market, but it reappears to some extent on the second open market, with a small but not catastrophic effect on liquidity in the options market. Here the two trading venues for the underlying security are substitutes while the overall any one of them is complementary to the options market.

This thought experiment is not just an intellectual exercise. It ought to be of great importance for financial stability to know the map of links across trading venues and markets and to know the circumstances under which a given link in this network is complementary or substitutable. In fact, the network must also consider balance-sheet links between various financial institutions. As highlighted by Governor Mersch (Mersch (2009)), the usefulness of the assets held by banks on their balance sheets as liquidity buffers depended on not having to honour the liquidity backstops they provided to various SPVs that refinanced themselves by short-maturity ABCP (in what used to be a very liquid ABCP market) so as to hold less liquid MBSs and tranches of collateralised debt obligations and the like. The initial subprime losses ripped through the network like an e-coli contagion and did not only expose the various liquidities to be highly complementary, but led also to a dearth of liquid instruments[6] that would have breached further thresholds with the potential to create further nefarious feedback loops had the central banks not implemented the various liquidity replenishment programmes. As it was, endogenous risk in this network led to the simultaneous drying up of many liquidities that in normal times were thought of as neither complementary nor as substitutable, but as the overall risk appetite generated by endogenous risk vanished, it led to a forceful and simultaneous scaling back of many different liquidities. It appears that in periods of stress, liquidities tend to become more complementary and less diverse.

For an equity-specific pure market example (more fully argued in Rahi and Zigrand (2010)), consider the extraordinary events of Thursday 26th of November 2009. The UK stock markets basically consist of the London Stock Exchange as the main venue with around 60% of trading volume for FTSE-100 stocks, with Chi-X, BATS and Turquoise as the main MTFs. Since these exchanges list a large common set of securities, one could not unreasonably view them as being competing exchanges, or substitutes. On that day due to a server error, the LSE halted trading at 10:33, placing all order books into auction mode until trading resumed at 14:00. If these venues were strong substitutes, then one would have thought that the negative liquidity shock on the LSE would lead to a positive liquidity shock on the MTFs. But the opposite happened. Our model suggests that these markets ought to be understood as liquidity complements.

We come back once more to the CDS market and to the proposal to ban naked shorts on sovereign CDS. The liquidity into which small and medium Portuguese infrastructure companies can tap in order to issue bonds or stocks does not exist in a vacuum. For instance, the liquidity for these securities is related to the extent by which a non-Euro area sovereign wealth fund can arrange this investment. The liquidity of the infrastructure bonds in euros is complementary to the liquidity of the dollar/euro forex market and to the liquidity of the Portuguese sovereign CDS market. A negative liquidity shock to the CDS market will transmit the shock contagiously to all markets that are complementary and linked. The welfare losses accumulate through positive feedback effects. Those feedback effects are worsened further by the fact that liquidity restrictions tend to reduce the number of market intermediaries willing or able to make markets.

6 When analysing bank balance sheets, central banks and regulators worry about both the liquidity of any given security held by credit institutes and with the *amount* of such liquid instruments held, as illustrated by the paper by Giordana and Schumacher (2011) in this issue of the Revue de Stabilité Financière. The crisis affected *both*. Our paper deals mainly with the intrinsic fundamental liquidity of a given instrument and less with whether any one financial institution holds enough such instruments.

7 CONCLUSION

We outlined our thinking on the sort of liquidity that is explicitly welfare based as opposed to ad-hoc. We argued that assets that are fundamentally liquid in this sense possess natural properties in terms of real resources saved. Being in terms of gains from trade, fundamental liquidity looks through the symptoms of liquidity and links liquidity to the reasons why market participants choose certain markets in the first place. This allows a deeper understanding as to why certain markets are more liquid than others, links liquidity to the bio-diversity in the market, and in particular it offers a window to the future by allowing informed predictions as to the effects of institutional or business-cycle changes on future liquidities. The fundamental liquidity measure allows comparisons of liquidity over various horizons and across various markets, and allows for an intuitive understanding of liquidity dynamics and liquidity path dependencies. In particular, it lends itself easily to the analysis of network effects and cross-market contagion.

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