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Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy

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Abstract

It is widely acknowledged that introducing a price on carbon represents a crucial precondition for filling the current gap in low-carbon investment. However, as this paper argues, carbon pricing in itself may not be sufficient. This is due to the existence of market failures in the process of creation and allocation of credit that may lead commercial banks – the most important source of external finance for firms – not to respond as expected to price signals. Under certain economic conditions, banks would shy away from lending to low-carbon activities even in presence of a carbon price. This possibility calls for the implementation of additional policies not based on prices. In particular, the paper discusses the potential role of monetary policies and macroprudential financial regulation:

modifying the incentives and constraints that banks face when deciding their lending strategy - through, for instance, a differentiation of reserve requirements according to the destination of lending - may fruitfully expand credit creation directed towards low-carbon sectors. This seems to be especially feasible in emerging economies, where the central banking framework usually allows for a stronger public control on credit allocation and a wider range of monetary policy instruments than the sole interest rate.

Keywords: green investment, low-carbon finance, banking, credit creation, green macroprudential regulation, monetary policy

JEL classification: E50, G20, Q56

1. Introduction

Transitioning to a low-carbon society will require a large amount of economic resources to be invested in 'green' sectors[1] (Ceres, 2014; IEA, 2012; McCollum et al., 2014; WEF, 2013). Investment is, from a macroeconomic perspective, expenditure: investing consists in purchasing investment goods and services - e.g. wind turbines – to be used in the production of some consumption good or service – electric energy.

Like any other type of expenditure, investment requires firms to have at their disposal a sufficient amount of financial means. Given the upfront costs of investments – particularly high in the case of renewable energy production - firms are typically unable to finance them through their own savings and thus necessitate access to external finance[2]. In other words, they need to borrow money from someone else before being able to invest.

External finance can originate, to a first approximation, from three main sources:

- Bank lending. Firms ask a banking institution for a loan; if the loan application is accepted, the agreed amount of credit is put at their disposal on a deposit account, which firms can then use to purchase the goods and services they need.
- Market debt. Larger firms or projects can raise finance on private capital markets by issuing debt instruments. The market for 'green bonds'[3], for instance, is experiencing a phase of strong expansion.
- Market equity. Private investors can also be interested in obtaining part of the project/firm ownership. In the case of companies, this can happen via the purchase of shares of publicly listed companies, or through private equity investment.

Among these, bank lending is particularly important, for two main reasons. First, bank loans represent the most common source of external finance for firms. Gross bank lending to British businesses in 2013, for instance, was almost three times the gross issuance of corporate bonds and more than ten times that of public equities (Bank of England, 2014). Bank of England (2013b) also shows how the dynamics of total net external finance has been strongly driven by changes in bank lending, both before and after the financial crisis. This is true also for the Euro Zone and the United States (ECB, 2012). The relevance of bank lending as a source of external finance is especially strong for small and medium enterprises and in emerging markets (Eickmeier et al., 2013).

Second, in modern societies banks are very special entities, capable of having a critical impact on the functioning of economic systems. There is in fact a crucial but often overlooked difference between banks and non-bank private investors: while the latter operate by reallocating the existing stock of credit, commercial banks are the only economic agents – together with central banks - capable of creating new credit[4] (Disyatat, 2011; McLeay et al., 2014; Ryan-Collins et al., 2011). Despite its wide repercussions on the rest of the system, the ability of banks to expand the money supply is only

[1] 'Green' investment indicates here investment in all productive sectors that help to improve the environmental sustainability of the economic system: production of energy from renewable sources, improvement of energy efficiency in buildings and transportation, management of natural capital, waste management, water management, sustainable agriculture, and others.

[2] For instance, BDRC Continental (2014) estimates that in Q4 of 2013 the proportion of British firms using external finance was: 74% for firms with 50-249 employees; 65% (10-49 employees); 53% (1-9 employees); 35% (0 employees).

[3] Green bonds are fixed-income instruments aimed at financing low-carbon or other environmentally sustainable activities (CBI, 2013; HSBC, 2014).

[4] The terms 'credit', 'broad money', and 'money supply' are here interchangeably employed as synonyms, and indicate the widest monetary aggregate in the economy, the majority of which is made of bank deposits of various kinds. 'Credit' does not include, as sometimes happens in the literature, the much wider amount of financial assets existing in the economy.

loosely regulated and substantially autonomous, as confirmed by the ineffectiveness of recent central banks attempts – both the traditional ones based on interest rates and the 'unconventional' ones centred around the expansion of central bank reserves – to reactivate bank credit creation (BIS/NIESR, 2013).

Among the policies put forward to try to expand the amount of bank credit flowing to low-carbon sectors, the introduction of a carbon price - either through a tax on the polluting content of goods and services or through the creation of a market of emission permits - is the one that has gathered the vaster consensus among scholars and policy-makers. Making green products relatively more convenient through prices would boost their demand, increase the profitability of firms operating in low-carbon sectors and thus facilitate the creation of credit directed to them.

However, despite being a necessary precondition to steer the economic system towards a rapid low-carbon transition, the introduction of a carbon price may not be sufficient. The autonomy of the private banking sector in creating and allocating credit is in fact at the origin of a major market failure, as, even in the presence of profitable investment opportunities and the 'right' prices, banks may not be willing to provide the amount of credit the economy requires to move closer to full capacity utilization. Under certain economic conditions, of which the current historical period is a clear example, banks are more interested in adjusting their balance sheets by constraining credit and securing safe assets rather than pursuing the highest rates of return on investments (Koo, 2014; Zenghelis, 2012). In such circumstances, the introduction of a price on carbon may not be enough to stimulate low-carbon investment.

This eventuality, jointly with the uncertainties and political difficulties surrounding the introduction of a carbon price, calls for considering additional policies targeted directly at the credit system. In particular, this paper will discuss the relevance and feasibility of using macroprudential financial regulation[5] to expand the amount of credit flowing to low-carbon activities. For instance, differentiating the reserve requirements that banks have to respect according to the 'greenness' of the activities they finance may represent a solid incentive for them to shift part of their lending towards low-carbon sectors (Banque du Liban, 2010; Rozenberg et al., 2013).

As it will be argued in section 7, this 'green' macroprudential regulation is likely to work only at certain conditions. In particular, it has a better chance to be effective in emerging economies, where central banks usually exhibit a higher degree of control on the dynamics of credit, thanks to the employment of a wide range of 'quantitative' monetary policy tools. In high-income economies, on the contrary, the reduction of monetary instruments to the sole interest rate makes it very hard for central banks to modify private banks' lending behaviour. Nonetheless, even in these countries, the employment of quantitative monetary policies aimed at strengthening the public control on the allocation of credit - often with some specific sectors in mind - is far from unprecedented (Elliott et al., 2013).

This paper thus aims to bring the green growth and sustainable development discussion closer to the one on monetary macroeconomic dynamics. A proper understanding of the interactions between these two bodies of knowledge – traditionally separate from one another - appears to be critical for the achievement of a sustainable economy.

The structure of the paper is as follows. Section 2 presents estimates of the green investment gap and discusses the main obstacles to filling it. Section 3 explains the process of credit creation and allocation by commercial banks. Section 4 introduces the concept of credit market failure and argues for the implementation of environmental policies not based on carbon pricing. Section 5 examines

[5] The term 'macroprudential regulation' denotes the set of financial regulatory instruments put in place to improve the stability and resilience of the financial system.

the recent regulators' attempts to limit banks' autonomy through financial regulation and their effects on green investment. Section 6 reviews macroprudential policy proposals aimed at increasing credit flows to low-carbon investment. Section 7 focuses on the idea of green differentiated reserve requirement ratios, discussing the conditions under which the policy is likely to be effective. Section 8 analyses the potential role of development banking. Finally, section 9 concludes and discusses the role of economic theory.

2. Filling the green investment gap

The transition to a sustainable economic system will require economic resources to flow to low-carbon productive sectors. Although the transition to a green economy is inherently systemic and would have to involve the entire economy, three key sectors exist: 1. production of energy from clean and renewable sources (for instance, solar panels and wind turbines); 2. improvement of energy efficiency (in buildings and transport especially); 3. conservation and smart use of natural capital (sustainable agriculture, fishing, water, waste and other sectors). The expansion of low-carbon investment will have to take place simultaneously to a rapid decline of investment in polluting and energy-intensive sectors[6].

Investment in green sectors has been growing at a fast pace in recent years. In particular, investment in new renewable energy production capacity – for which more and better data is available – has reached approximately US$244 billion in 2012, an amount five times larger than in 2004[7] (FS-UNEP and BNEF, 2013). The expansion has been particularly robust in developing regions, with China currently the main investor in renewable energy at around US$67 billion. The scale of investment is confirmed by CPI (2013), which, with a tracking method based on a wider class of investment rather than just energy supply, estimates global 'climate finance' in 2012 to be around US$359 billion. However, investment in clean energy is currently declining. 2012 and 2013 recorded an annual drop of 10% and 11% respectively, mainly as a result of the reduction of investment in Europe and US (BNEF, 2014). This has been due to a variety of factors, among which the cutback of feed-in tariffs and other similar policies have played a particularly important role, highlighting how these forms of energy production are still very dependent on public support.

Despite the upward trend of the last decade, a large gap still exists between the current amount of green investment and what would be required to decarbonise the economy and respect the 2°C threshold in temperature increase, agreed as an objective at the 2009 Copenhagen Conference (UNFCCC, 2009). Figure 1 shows some recent estimates of this 'green investment gap', calculated as the amount of additional investment[8] in low-carbon activities to be carried out each year over the next few decades to decarbonise the economic system. Values range from $650 to $900 billion. This scale is confirmed by McCollum et al. (2014), which use a number of Integrated Assessment Models to find that climate policies consistent with the 2°C target would entail additional investment in both energy supply and demand of about $800 billion. UNEP (2011) calculates that the yearly additional investment required to deliver a green economy – a wider objective than decarbonising the economic system - would be on average around 2% of the global GDP over the 2010-50 period ($1 to $2.6 trillion).

[6] According to FS-UNEP and BNEF (2013) gross investment in power capacity based on fossil fuels in 2012 was equal to US$262 billion.

[7] Data reported in FS-UNEP and BNEF (2013) cover investments in: solar, wind, biomass & waste, small hydro, biofuels, geothermal and marine. Large hydro (>50 MW) is excluded.

[8] The amount of investment reported is 'additional' to the underlying business-as-usual scenario considered, which broadly represents a prosecution of current trends. Given the large degree of uncertainty and methodological assumptions to be made in their computation, additional investment figures should be considered as indicative, and representative of just a portion of the wider social and institutional reform required to support a low-carbon transition.

[FIGURE 1 ABOUT HERE – File name: "Fig 1 – Green investment gap"]]
[CAPTION: The green investment gap: required additional annual investment in low-carbon sectors[9]]

The green investment gap thus appears to be very wide[10], and no certainty exists regarding the means in which to fill it. Two main factors are currently preventing economic resources to flow in larger amounts to low-carbon sectors.

The first factor is the depressed macroeconomic environment. Since the 2007 financial crisis, the global economic system – and high-income countries in particular – has been suffering a period of sluggish economic activity that has led to recession and high unemployment[11]. Low investment levels in advanced economies are a direct consequence of the endemic lack of confidence that is afflicting economic agents. Both households and non-financial firms are currently experiencing a robust process of deleveraging: rather than spending, agents prefer to postpone investment and save their income in order to repay the previously accumulated debt, or to protect themselves from possible future downturns[12] (Koo, 2014; Zenghelis, 2012).

The second factor limiting green investments is their unattractive risk/return profile. In particular, the risks – either real or perceived – associated with them have always been large[13]. The relative immaturity of the industry increases the perception of risks related to technology evolution and market development. Most importantly, green investments are perceived as being still strongly dependent on public support, which unfortunately has not been as transparent and predictable as it would have to be. Many governments are currently backing off from providing support to the sector because of the stress posed by the economic crisis. In some cases, this has gone so far as to introduce retroactive adjustments – as in the recent Spanish case - producing strong credibility issues for years to come (FS-UNEP and BNEF, 2013).

In light of these risks, returns on green investments should be very high in order to attract investors. However, there is no empirical evidence this is the case (EDHEC-Risk Institute, 2010). Ceres (2014) points out how green investment performance depends on the specific type of asset class considered. The returns of direct infrastructure investment, for instance, seem to be roughly meeting investors' targets. Fixed-income instruments linked to low-carbon investment ('green bonds') in general offer coupons in line with similar non-green instruments. However, public equities have significantly underperformed during the last few years compared to the rest of the market, and private equity investments have often failed to fulfil investors' expectations. In general, therefore, financial returns on green investment do not seem to be currently able to compensate for the higher-than-average perceived risks.

Additional features of low-carbon investments contribute to make them unattractive to investors. For instance, they are usually carried out over a long-term time horizon, which is unappealing to

[9] Data sources: IEA (2012), McKinsey (2010), WEF (2013). Data from McKinsey (2010) have been transformed from Euros to US$ using an exchange rate equal to 1.4 US$ per Euro.
[10] However, such a surge in investment is far from unprecedented, as argued by Bowen et al. (2014).
[11] Aggregate investment has plummeted in the United States, the European Union, Japan and other advanced economies as an immediate consequence of the crisis, passing from an average of 21.7% of GDP in 2007 to 17.8% in 2009 (IMF 2013). It has slightly recovered since then, but is still far from the pre-crisis level. On the contrary, the average investment share in emerging markets has passed from 29.4% in 2007 to 31.5% in 2012. China's investment share now reaches nearly 47% of its GDP, against the 16.2% displayed by the United States.
[12] The situation in which all economic agents simultaneously attempt to save is usually referred to as the "paradox of thrift" (Keynes 1936): what is wise in a microeconomic perspective - a household or a firm trying to reduce its over-indebtedness by reducing spending and increasing savings - can have dreadful consequences from a macroeconomic point of view. The lack of private demand in a moment of crisis further worsens the situation by forcing firms out of the market and workers into unemployment.
[13] See Frisari et al. (2013) for a mapping of risks affecting clean energy investments.

153 investors interested in short-term investment. Some of them – especially direct infrastructure
154 investments – are very illiquid, and it proves very difficult for investors to sell their share before the
155 project's conclusion. They also typically involve very high initial capital costs. Nelson and Shrimali
156 (2014) estimate that upfront capital costs represent 84-93% of total project costs for wind, solar, and
157 hydro energy (compared to 66-69% for coal and 24-37% for gas). Consequently, many low-carbon
158 investments tend to be subject to relatively high financing costs.

159 **3. Access to finance and credit creation**

160 The two conditions discussed in the previous section – the depressed macroeconomic environment
161 and the unattractive risk/return profile of low-carbon activities – represent major obstacles to the
162 achievement of the single most important precondition to carry out investment: the availability of
163 financial resources. Investment is, from a macroeconomic perspective, expenditure[14], and, in order
164 to be able to spend, economic agents require financial resources (i.e. 'money', or 'credit'). Without
165 credit, firms may not be capable of investing, even if they are willing to.

166 In modern economic systems, credit can flow to productive activities in two ways. First, credit can be
167 transferred from the agents that happen to hold it (financers) to those interested in using it
168 (entrepreneurs). In the case of low-carbon investment, there is currently a large discussion regarding
169 the potential role of institutional investors[15] in providing green finance (Della Croce et al., 2011). The
170 amount of financial assets currently managed by institutional investors in the OECD countries, which
171 Nelson and Pierpont (2013) estimate at around $76 trillion, could easily provide the required finance
172 for the transition to a green economy. Some institutional investors are currently investing in green
173 activities for 'ethical' reasons (GIIN, 2013). However, CPI (2013) estimates that institutional investors
174 are currently providing as little as 0.11% of total climate finance. In order for the low-carbon sectors
175 to obtain a critical mass of finance, it is crucial to attract the majority of investors who are not
176 moved by ethical reasons, but just by the desire for economic return.

177 The second way to make credit flow to low-carbon sectors is to create it ex nihilo. In modern
178 economic systems credit creation is a prerogative of the private banking system (McLeay et al.,
179 2014; Ryan-Collins et al., 2011). To illustrate this concept, Figure 2 shows a simplified representation
180 of the typical bank balance sheet. There are two main items on the asset side. The first is the stock
181 of central bank reserves. Reserves are deposits that private banks hold at the central bank – in a
182 similar way to households and firms holding deposits at private banks - and they are employed to
183 settle interbank transactions. The second item on the asset side is the stock of loans granted. Loans
184 represent a debt that clients have towards the bank, thus appearing on the asset side of the bank's
185 balance sheet and on the liability side of clients' balance sheets. The main variable on the liability
186 side is represented by the stock of clients' deposits – that is, claims that clients have towards the
187 bank. Finally, banks' capital – also called 'equity' or 'net worth' - is defined as the difference between
188 assets and liabilities, and represents the value of assets that would remain if all liabilities were
189 extinguished. Assuming that the bank is solvent, its net worth appears on the liability side, so that
190 the two sides of the balance sheet match each other.

191 [FIGURE 2 ABOUT HERE – File name: "Fig 2 – Bank balance sheet]
192 [CAPTION: The process of credit creation by private banks]

193 Credit creation takes place with the act of lending. When banks decide to grant a loan to a client
194 they do so by expanding both sides of their balance sheet: on the asset side a new loan is created,

[14] Private investment, in other words, is part of GDP when computed using the 'expenditure approach', together with private consumption, public consumption and net exports.

[15] Institutional investors are pension funds, insurance companies, mutual funds and other non-bank organizations managing large amounts of money on behalf of their clients.

while on the liability side a new deposit is put at the disposal of the customer. In other words, banks do not have to wait for a deposit to come in in order to lend the money but they create the new deposit themselves, just by typing it into the account of the customer who received the loan (McLeay et al., 2014). The balance sheet of the customer is expanded in a similar way: a new deposit is created on the asset side, while a new debt towards the bank appears on the liability side. This operation broadens the stock of money supply – or 'broad money' - existing in the economy, as the deposit that the bank has put at the disposal of its clients is then employed to purchase whatever goods and services are desired, thus introducing the money in circulation into the wider economy. Banks' ability to expand the existing money supply has critical consequences on the functioning of economic systems and the availability of bank credit often represents the single most important precondition for achieving growth (Bernardo and Campiglio, 2014; Schularick and Taylor, 2012).

This discussion is relevant for green investment because not enough credit, whether reallocated by non-bank investors or newly created by banks, seems to be flowing to low-carbon sectors. Investors and private banks respond to incentives very similar to those that drive the behaviour of firms. The relatively higher degree of risk associated with low-carbon sectors represents a major disincentive to channel resources to them. Additionally, global markets are currently characterised by the widespread desire for liquid, short-term assets, which is at odds with the illiquid, long-term features of typical green investments (Spencer and Stevenson, 2013).

4. Carbon pricing and beyond: the relevance of credit market failures

The first and foremost policy usually indicated as the solution to the low-carbon investment challenge is the introduction of a price on carbon[16] (Nordhaus, 2013; Weitzman, 2014). Two main ways exist to implement a carbon price. The first is to fix the price by introducing a tax on the carbon content of goods and services – a 'carbon tax' (OECD, 2013). More generally, the idea is to coordinate the whole fiscal system in order to orient the monetary incentives of economic agents towards low-carbon investment and spending (Green Fiscal Commission, 2009; OECD, 2010). This includes not only implementing carbon taxes, but also phasing out subsidies to fossil fuels and introducing feed-in tariffs in support of renewable energy. The second way to establish a carbon price is to create a cap-and-trade system of emissions allowances (World Bank and Ecofys, 2013). In this case, the quantity of allowable emissions is fixed and the price is freely determined by the market.

The implementation of a price on carbon should be able to correct the market failure related to the exclusion of environmental goods from the market pricing system, which makes it unattractive for the private sector to invest in green sectors. A comprehensive price system, capable of internalizing environmental externalities in economic decisions, should put households, firms and financial institutions in the position of wanting to participate to low-carbon sectors.

However, two categories of complications affect this policy strategy. First, a carbon price may never be implemented. Proposals of carbon taxes or carbon markets are likely to encounter strong political and social resistance on the grounds that they will harm business and increase energy bills[17]. Even if these policies are introduced, they may not last for long, as the recent events in Australia clearly show[18], or incur in major execution problems as it happened to European Union Emissions Trading

[16] A carbon price is usually defined as the price to be paid for the emission of 1 tonne of CO_2 into the atmosphere.

[17] See for instance the large media campaigns run in the United States by organizations as Americans for Prosperity and American Energy Alliance.

[18] Australia introduced a carbon tax in July 2012. However, a new Prime Minister was elected in September 2013 after an electoral campaign strongly centred on repealing the tax. The carbon tax was eventually repealed in July 2014 (see Financial Times, 'Australia abolishes tax on carbon emissions', July 17th, 2014).

Scheme[19] (EU ETS). The uncertainty regarding the long-term policy commitment – which has been amplified by the recent reversal of public policies supporting renewable energy – is a major obstacle for green investment, as even in the presence of the 'right' prices firms may decide to wait to internalize them because they do not believe they will last.

Second, this paper argues that even a stable and credible carbon price may not be sufficient to steer the required amount of economic resources to green investment. This is due to the existence of an additional market failure, related to the process of creation and allocation of credit, which may lead banks and other investors not to react as expected to price signals.

This 'credit market failure' lies in the misalignment between the legitimate pursuit of private interests by commercial banks – which create the majority of the money supply - and the development objectives that a society sets to itself, the achievement of which is conditional to the availability of financial resources and a certain degree of monetary stability[20]. Banks' ability to expand the existing money supply is in fact substantially autonomous. This is particularly true for high-income countries, where the desire to keep interest rates stable has led central banks to leave the dynamics of the money supply in the hands of the private banking system (see section 7). Public regulators, to the contrary of what postulated by the 'money multiplier' theory[21], have therefore very limited control on the amount of credit that is being created, and how this is allocated throughout the economic system.

As a consequence, the dynamics of money supply is likely to be sub-optimal from a social perspective. In particular, the 'endogenous' fluctuations of the financial system are much larger and more frequent than what would be optimal for a robust and sustained economic development. During phases of economic expansion, banks are willing to create a large amount of credit for the rest of the economy even – or especially - at a high degree of risk, because they are confident that loans are going to be repaid or that they will recoup with the underlying asset. A sort of 'collective euphoria' leads to the formation of excessive debt, which ultimately becomes unsustainable, triggering a financial crisis and a spiral of panic on the credit market (Minsky, 1992). Banks then stop lending to firms even in the presence of potential profitable investments, and become interested only in hyper-secure, highly liquid assets.

The current historic period happens to provide a rather clear example of this situation. Banks are currently focusing on reducing their balance sheets and shifting away from risky activities rather than making credit available to the productive economy. This means that the supply of credit has been strongly constrained (BIS/NIESR, 2013; Feyen and Gonzalez del Mazo, 2013), as private banks are trying to achieve lighter balance sheets. Credit rationing, together with the weak demand for credit from the private sector, has led to substantially flat credit growth in recent years (BIS, 2013a), which in turn had disastrous consequences for the wider economic system and is still posing a significant obstacle to investment and economic recovery.

The autonomy of the private banking system in determining credit dynamics can be appreciated by looking at the ineffectiveness of the policies put in place by major central banks in the attempt to revive credit creation. At first, they employed their 'traditional' monetary policies based on the

[19] The EU ETS has been afflicted by a range of implementation problems, the most relevant of which currently is the very low price of allowances. A proposal to strengthen the scheme has been rejected by the European Parliament in April 2013 (see The Economist, 'ETS, RIP?', April 20th, 2013).

[20] The detachment between banks' private interests and wider social objectives is so pronounced that some authors are arguing for the implementation of a 100% reserve ratio, which would transfer the power of money creation in the sole hands of central banks, leaving private banks with the ability to lend only in presence of backing deposits (Benes and Kumhof, 2012; Jackson and Dyson, 2013).

[21] According to money multiplier theory central banks are capable of controlling the dynamics of the broad money supply by adjusting the amount of the monetary base (Mishkin, 2011).

manipulation of the price of central bank reserves – the reference interest rates - lowering them to unprecedented low levels, very close to zero (BIS, 2013a). However, these price-based policies have been almost completely ineffective in reactivating lending and growth. Central banks then resorted to 'unconventional' monetary policies, focused on quantities rather than prices. These have taken the form of a 'Quantitative Easing' (QE), an expansion of central banks' balance sheets through the creation of new reserves at the disposal of the private banking system – achieved through the simultaneous purchase of financial assets, typically government bonds, from the secondary market - in the hope that it would resume its lending to businesses[22] (Fawley and Neely, 2013).

The effect of the QE measures have been ambiguous (Bridges and Thomas, 2012; Ryan-Collins et al., 2013). Figure 3 compares the recent dynamics of narrow and broad money for the Euro Zone, the United States and the United Kingdom. The effect of QE on the monetary base is evident, especially for the US and the UK: the amounts of central bank reserves rose steeply as a result of the Fed and Bank of England interventions on the markets. However, the dynamics of broad money in these countries remained substantially flat, indicating that the banking system did not respond as hoped to regulators' policies and is, to the contrary of what textbook economic knowledge would imply, ultimately autonomous in its lending decisions[23].

[FIGURE 3 ABOUT HERE – File name: "Fig 3 – Quantitative easing"]
[CAPTION: Monetary base and broad money in the Euro Zone (EZ), United States (US) and United Kingdom (UK). August 2008 = 100.[24]]

At the moment, banks are just not willing to lend, whatever the price of central bank reserves is, and despite the presence of potential profitable investments. Two factors concur in generating this result. First, the dire economic situation contributes to deteriorate the risk/return profile of the majority of investments by increasing potential risks. Second, during slumps the risk aversion of banks increase, often beyond what would be 'reasonable'. Economic agents – in the financial markets above all – tend in fact to exhibit irrational conducts and herd behaviour (Shiller, 2000), which may result in an overestimation of investment risks and an exceptionally high demand for ultra-secure assets like US government bonds. Under similar circumstances, a carbon price may not be sufficient to stimulate credit creation in favour of low-carbon activities. Or, to put it differently, the carbon price that would be required to overcome the endemic lack of confidence present on financial markets would be so substantial to be politically infeasible, or highly detrimental for the economic system[25].

[22] Quantitative Easing measures were also aimed at achieving other objectives rather than just stimulate credit creation. For instance, the purchase of sovereign bonds has effectively helped in calming the markets, especially in the case of the Euro Zone. This is testified by the very low interest rates on sovereign debt titles in the US, the UK, Germany, and by the decrease of interest rates for other economies after the 2011 spikes. In the case of US, additional benefit was given by the fact that corporate mortgage-backed assets were also purchased by the Fed, thus getting rid of a vast amount of 'toxic titles'.

[23] This notion is usually referred to as the 'endogenous money theory', which argues that private banks decide how much credit to create - that is, how many loans to grant - independently of how many reserves they have. Only afterwards, they ask for reserves to the central bank, which, unless it wants to cause a credit crunch and a financial crisis, will satisfy any demand for reserves coming from the private banking system. The causation process is thus completely reversed with respect to the money multiplier theory. See Lavoie (2003), Benes and Kumhof (2012), Disyatat (2011), Kydland and Prescott (1990).

[24] Monetary base is defined as: cash and reserves (UK); monetary base (US); base money (EZ). Broad money is defined as: M4 (UK); M2 (US); M3 (EZ). Sources: European Central Bank for the Euro Zone; Federal Reserve Economic Data (FRED) for the US; Bank of England for the UK.

[25] Fay et al. (2013) develop a similar analysis, arguing that the potential inability to change prices and the potential ineffectiveness of price signals at triggering the desired change call for the implementation of 'green

For all the reasons above, hedging the risk of non-implementation by creating a portfolio of policies with the same objective – that is, increase low-carbon investment - would represent the most prudent course of action, as some may be more easily implementable or effective than others (Rozenberg et al., 2014). Certainly, policies come at a cost: each policy must be designed, implemented, enforced, monitored and evaluated. However, putting all hopes on a single policy - carbon pricing – could result in massive costs in the unfortunate event that a carbon price is never implemented, or insufficiently so, and no back-up plan has been put in place.

5. Macroprudential regulation and its repercussions on low-carbon investment

Banking regulators have been recently trying to correct the credit market failure by reducing the autonomy of private banks in creating credit. This attempt has been motivated by the desire of avoiding a repetition of the 2007 financial crisis, which was triggered by an uncontrolled growth of bank credit. The set of policies under discussion has taken the name of 'macroprudential regulation' (Galati and Moessner 2011).

The main effort in this direction has been the 'Basel III' Accord, which introduces stricter standards for banks on both the liquidity of their assets and the robustness of their capital (BIS, 2013a, b). In a nutshell, liquidity rules require banks to satisfy two conditions: 1. hold enough liquid assets – that is vault cash, central bank reserves and other highly liquid assets as sovereign bonds – to face a prolonged funding stress scenario (LCR – Liquidity Coverage Ratio); 2. match long-term assets – that is, with maturity over a year - with similarly long-term liabilities (NSFR – Net Stable Funding Ratio). The regulation regarding capital on the other hand introduces a range of ratios to be respected between the banks own capital and the stock of assets, which in some cases are adjusted according to their degree of risk (see Figure 2). The objective in this case is to prevent excessive leverage by the banking system, as their ability to create credit, if uncontrolled, can pose systemic risks to the functioning of economies.

The new Basel III regulation is thought to be negatively affecting the already problematic access to finance of low-carbon sectors (Liebreich and McCrone, 2013; Spencer and Stevenson, 2013). For instance, imposing liquidity requirements would most likely produce a reallocation of investments towards liquid shorter-term assets, while low-carbon initiatives typically require long-term credit. In general, banks would tend to shy away from whatever they consider to be too risky, preferring to invest in very liquid standardized assets such as sovereign bonds rather than in projects characterized by a range of technological, financial and policy uncertainties as the low-carbon ones.

The new rules concerning capital would also be likely to have a negative impact on green activities, as they would tend to reduce bank lending across all productive sectors, including the low-carbon ones. There are in fact only two strategies available to banks for which the capital requirement ratio is not respected: the first one is to increase their capital by issuing new shares or retaining profits; the second is to reduce the expansion of their balance sheet by constraining new credit creation or by selling their assets. For those capital ratios where assets are weighted according to their risk, banks can also improve their situation by reallocating their portfolios towards less risky assets, as they are already currently doing. None of these eventualities is likely to be beneficial for low-carbon sectors.

However, it is unclear to what extent this flight to liquid low-risk short-term assets is taking place because of financial regulation, or just as a market-driven reaction of the banking system to the current economic situation. As a matter of fact, banks seem to be finding no particular problem in respecting the new rules (Cohen, 2013). However, even if Basel III was not currently acting as a

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industrial policies', which include a wider variety of policy instruments, both market-based and of the command-and-control type.

constraint on banking behaviour, it could do so in the future, once the deleveraging process terminates and private agents start to borrow and spend again.

Hence, the crucial question becomes: can banking requirements act as a constraint on credit creation, either now or when the economy will be in the next expansion period? This is important because if requirements were indeed able to act as a constraint, then easing the constraints for specific destinations of lending – say, low-carbon productive activities - would give the banking system an incentive to create a proportionally larger amount of credit for the chosen sectors.

6. Green macroprudential regulation

The idea of easing public requirements for banks lending to low-carbon activities seems to have attracted some interest. Rozenberg et al (2013), for instance, argue for the introduction of differentiated reserve ratio requirements directed in favour of green sectors. Reserve ratio requirements relate the amount of reserves that banks possess - either in the form of cash kept in their vaults or as deposits held at the central bank – to the stock of their clients' deposits (see Figure 2). The reserve ratio is thus a form of liquidity requirement and gives an indication of how resilient a bank would be to an unexpected withdrawal of funds from its clients' deposits.

Differentiating reserve requirements means to impose different reserve requirements to different banks, depending on the destination sector of lending. In the case of green differentiated reserve requirements, the reserve ratio that banks have to satisfy would be lower than average for loans directed towards low-carbon sectors. Given that banks obtain their profits from lending, and that a lower reserve ratio expands the potential amount of credit that a bank can create, this policy should give an incentive to banks to direct a larger amount of lending towards green investment.

In Rozenberg et al. (2013), the mechanism would work as follows (Figure 4). A firm is interested in investing in low-carbon activities - for instance, producing energy from wind. It presents the details of the project to an independent monitoring unit - e.g. an agency of the Ministry of Environment - that calculates the amount of polluting emissions that will be cut thanks to the project, and issues a corresponding amount of certificates. The firm then applies for a loan and, if the loan application is accepted, it hands the certificates to the bank. Finally, the bank can then use the certificates at the central bank as part of its reserve requirement.

[FIGURE 4 ABOUT HERE – File name "Fig 4 – Green reserve requirements"]
[CAPTION: Green differentiated reserve requirements in Rozenberg et al. (2013)]

A similar scheme called 'National Energy Efficiency and Renewable Energy Action' (NEEREA) has been recently implemented in Lebanon (Banque du Liban, 2010; PWMSP, 2011).The scheme aims at providing cheap credit to the private sector for projects related to renewable energy production and energy efficiency in buildings. If the commercial bank decides to accept the loan request, the firm presents a technical study of the project, which is assessed by the Lebanese Center for Energy Conservation (LCEC), an agency affiliated to the Lebanese Ministry of Energy and Water. If the project is approved, the Lebanese Central Bank – Banque du Liban (BDL) - provides its support by reducing the bank's obligatory reserve requirements by an amount equal to 100-150% of the loan.

An analogous proposal involves setting differentiated capital requirements; that is, imposing different capital adequacy ratios according to the characteristics of the banking institute and the type of lending they provide. Capital requirements are likely to be more effective than liquidity ones in constraining bank lending, as even creating new central bank reserves would not change the capital ratio, or at least not in the way banks desire[26]. Therefore, implementing a regulatory

[26] In the case of central bank reserves being created simultaneously to a purchase of sovereign bonds from the banking system, there would be no expansion of the banking balance sheet, but just a change in the

framework where banks that lend to low-carbon (or other socially useful) sectors are required to respect looser requirements could fruitfully manage to direct larger flows of new credit creation towards them. A similar proposal involves calibrating the computation of Basel III risk-weighted capital ratios in a way that low-carbon activities would exert a lower pressure than alternative investments.

An alternative strategy is the one employed by the Chinese Central Bank – People's Bank of China (PBC). The PBC exerts a sort of soft pressure - called "window guidance" - on the banking system, for instance by holding monthly meetings with commercial banks to make sure that the allocation of credit across sectors follows the Central Bank's strategic plans. The Chinese window guidance framework has focused extensively on low-carbon sectors, which are considered one of the most important priorities for the country's development (Zadek and Chenghui, 2014). PBC (2013), for instance, states that "financial institutions were guided to intensify support (..) to sectors crucial for economic and social development such as (..) energy conservation and emissions reduction» and that «credit support to industries with high energy consumption and high emissions and industries with an overcapacity needs to be controlled.". The China Banking Regulatory Commission (CBRC) also published a document presenting the 'Green Credit Guidelines', in which it is stated that "banking institutions shall promote green credit from a strategic height, increase the support to green, low-carbon and recycling economy, fend off environmental and social risks, and improve their own environmental and social performance." (CBRC, 2012).

7. Would green reserve requirements work?

Among all the policies and policy proposals presented in the previous section, green differentiated reserve requirements seem to be the policy most seriously considered. However, would such a policy actually work? The answer depends on where the policy would be implemented. In many high-income countries, reserve ratios are in fact not likely to be effective as a constraint on bank lending behaviour, for at least two reasons. First, availability of reserves is currently far from being a problem for banks since central banks have inundated the interbank market with new liquidity through the Quantitative Easing policies presented in section 4. Additionally, and most importantly, in most modern banking systems, central bank reserves are not capable of acting as a constraint, even in non-extraordinary circumstances. This is due to the fact that in modern economies money does not have to be backed by any other asset. Central banks can potentially create reserves ad libitum, according to their objectives, simply by adding a new entry in their ledger accounts (Gray, 2011). Thus, reserves can become a constraint on banks behaviour only if the central bank – or more precisely, the monetary policy framework that the central bank has put in place – allows and wants them to act as such.

During the past decades, however, central banks in advanced economies have preferred to use as their main monetary policy instrument, the price of reserves – that is, the reference interest rate - rather than their quantity. The manipulation of the reference interest rate helps the central bank to have a better control on the interbank lending rate, which is the interest rate at which banks lend to one another. The two policies – a stable interbank interest rate and the use of reserves as a constraint – are incompatible with one other: if a central bank's desire is to keep the price of money in the interbank market around a certain range – as the European Central Bank, the Fed, the Bank of England, the Bank of Japan and many others do - then they have to satisfy any demand of reserves coming from the banking market. Denying new reserves to banks in moments of liquidity stress would automatically put pressure on the price of reserves on the interbank market, putting the interest rate out of the control of the central bank. Therefore, in advanced economies, reserve

composition of its assets. In the case of bonds being purchased from other holders – say, institutional investors – then both the asset side (new reserves) and the liabilities side (new deposits of institutional investors) would expand by the same amount, thus deteriorating the capital ratio.

requirements can't act as a constraint because central banks guarantee to satisfy any demand of reserves at the price they fix - the reference interest rate.

Not all countries, however, adopt the same monetary policy framework. For instance, the People's Bank of China is strongly involved in the management of credit allocation and employs a wider range of monetary policy tools other than the interest rate, including reserve requirements and other quantitative instruments (Ma et al., 2013; Porter and Xu, 2009; Turner et al., 2012). The PBC is able to make reserves act as a constraint by accepting a higher volatility of the interbank market interest rate: in periods of liquidity shortage, instead of depending on the unlimited reserves creation by the central bank as in advanced economies, banks will borrow from the interbank market affecting the rate they apply to each other[27].

Both China and a number of other emerging economies have used reserve requirements as a monetary policy tool in recent years[28] (Ma et al., 2013). This contrasts with advanced economies central banking practices, in which reserve requirements – made ineffective by the focus on the interest rate as sole monetary instrument – have been gradually reduced to very low levels, and in some cases abolished[29]. Emerging economies also provide a wide range of other examples of macroprudential quantitative policies aimed at mitigating systemic risk, giving central banks the capability of orientating credit creation towards the sectors considered as strategic for country development.[30]. A non-exhaustive list of policy tools include liquidity and capital requirements, caps on the loan-to-value ratio, caps on debt-to-income ratio, ceilings on credit growth, restrictions on profit distribution, and many others (Lim et al., 2011).

The PBC is also using so-called "dynamic" differentiated reserve requirements (Ma et al., 2013; Morgan Stanley, 2011; PBC, 2013): the reserve ratio is not fixed at the same level for every institution but can differ according to their size, their financial conditions – for instance, their capital adequacy ratio – and the sector they operate in. Figure 5 shows how from 2008, a wedge has been introduced between the reserve ratio requirements for small and large banks. A similar approach could be used to steer the creation of credit towards low-carbon productive activities, as Rozenberg et al. (2013) propose.

[FIGURE 5 ABOUT HERE – File name: "Fig 5 – Chinese reserve ratios"]

[27] However, the freedom of the central bank to let the interbank rate fluctuate is not limitless, as the recent 'cash crunch' illustrates. In June 2013, a range of circumstances created pressure on the Chinese interbank liquidity, causing the interbank interest rates to increase. The PBC initially decided not to intervene, refusing the injection of reserves that some banks needed to respect their reserve requirements. This behaviour was also apparently motivated by the desire to send a signal to domestic financial institutions, considered to have created an excessive and undesired amount of loans (hence the need for reserves). However, the dangerous spike in the interbank market interest rates, with the repo rate reaching 30%, eventually forced the PBC to provide the additional liquidity requested. A similar episode took place in December 2013. See The Economist, 'What caused China's cash crunch?', July 4th 2013.

[28] In some emerging economies, including China, the increase in reserve requirements has been mainly aimed at limiting the macroeconomic consequences of their foreign exchange stabilization policies: to avoid an undesired appreciation of their currency as a result of their strong trade balances, many central banks have started purchasing foreign currency at a fixed rate, so as to prevent their households and firms from exchanging it in the market and causing an appreciation of the domestic currency. The purchase of foreign exchange by central banks is financed by the creation of new reserves. In order to limit the amount of liquidity created, central banks then increase the required reserve ratios so to freeze the excess liquidity. See Duncan (2012).

[29] Australia, New Zealand and United Kingdom are among the countries where no reserve ratio is applied (Gray, 2011).

[30] Credit control is particularly frequent in Eastern Asia - China, Thailand, Singapore, Korea, Malaysia - and Eastern Europe - Bulgaria, Romania, Russia, Serbia (Lim et al. 2011).

[CAPTION: Reserve ratio requirements in China, 2001-2013 (Source: Ma et al. 2013; Bloomberg)]

These policies may appear very far from the usual central banking practice in high-income countries. However, the vast majority of advanced economies have implemented some form of macroprudential policy at some point in the past. Elliott et al. (2013) review the long history of macroprudential instruments employed by the United States throughout the last century to promote or curb credit growth, often with specific sectors in mind (housing, for instance). These included underwriting standards, reserve requirements, deposit rate ceilings, credit growth limits, supervisory pressures and other policies, which have helped public authorities in their attempt of moulding the shape of the American economic system. The deregulation process during the '80s has been the main factor causing the gradual disappearance of these policies, which left the Federal Reserve with the manipulation of the interest rate as its sole monetary policy tool. A similar process was experienced by Japan, where the central bank conducted policies that resembled the current Chinese monetary framework until the deregulation and financial liberalization during the late '80s has made it impossible to continue (Fukumoto et al., 2010).

Furthermore, in the wake of the recent financial crisis and recession, a number of central banks have started to experiment new 'unconventional' measures, which often go beyond their traditional mandates. For instance, the central banks of high-income regions - Fed, European Central Bank, Bank of England and Bank of Japan - all began a policy of 'forward guidance', through which they aim to influence market expectations by expressing commitments regarding the future dynamics of interest rates. Sometimes these expressed intentions are linked to the achievement of some policy objective – such as a certain unemployment rate[31] – thus explicitly expanding central bank mandates beyond price stability to include wider macroeconomic considerations.

8 Merits and limitations of public development banks

The analysis in the previous sections focused on public policies aimed at inducing a large creation of credit by the private banking system towards the low-carbon sectors. However, public regulators also have the additional option to lend directly to the sectors they consider strategic. This can be achieved through public development banks, financial institutions devoted to supporting the process of national economic development[32].

National development banks include, to cite some of the largest, the China Development Bank (CDB), the German Kreditanstalt fur Wiederaufbau (KfW) and the Brazilian Banco Nacional do Desenvolvimento (BNDES). Development banks can also be incorporated in multilateral institutions such as European Investment Bank (EIB), the International Bank for Reconstruction and Development (IBRD) and the Asian Development Bank (ADB). Both multilateral and national development banks are able to provide credit to companies on terms more favourable than those of the market and lend to sectors that commercial banks are unwilling to finance. They also usually provide technical assistance to the projects and facilitate dialogue with political institutions.

Public development banks can play an important role in delivering finance to the low-carbon economy, and many of them have already set up specific lending programs. In the 2007-12 period, at least $425bn have been provided by development banks to projects on renewable energy production, energy efficiency and other environmental-related activities (BNEF, 2013). In 2012, investments reached $109bn, growing 19% from the previous year and thus in contrast with the negative trend of green investments in the same period (see section 2). Among national

[31] For instance, in August 2013 the Monetary Policy Committee of the Bank of England "agreed its intention not to raise Bank Rate from its current level of 0.5% at least until the Labour Force Survey (LFS) headline measure of the unemployment rate had fallen to a 'threshold' of 7%".(Bank of England, 2013a).

[32] For a detailed survey of national development banks, see de Luna-Martinez and Vicente (2012).

development banks, KfW has been by far the most active institution, followed by the China Development Bank. Multilateral development banks have also been the most active promoters of the diffusion of 'green bonds', which have strong potential for driving financial resources towards low-carbon sectors, especially if issued in large amounts and in a standardized fashion. The market is in a phase of rapid expansion, and the outstanding amount of green bonds is now valued at around $346 billion (CBI, 2013).

An even more targeted experiment has been started in the United Kingdom through the creation of the Green Investment Bank (GIB), a development bank aimed at helping the country to meet its environmental targets by reducing greenhouse gas emissions, increasing the production of energy from renewable sources, improving energy efficiency and reducing waste (GIB, 2013). The GIB has been founded in 2012 with an initial allocation of £3bn by the government (now at £3.8bn), and has since shown a promising capacity of crowding in private investments[33].

The amount of finance made available from national and multilateral development banks is thus far from negligible. However, it must be noted that their range of action is strongly limited by the fact that public development banks lack one of the most crucial characteristics of banks: the ability to autonomously expand their own balance sheets. The power of creating credit through the act of lending is in fact forbidden to development banks, which have to limit their lending to the amount of finance they are able to raise on the secondary markets through the issuance of, for instance, green bonds. The case of the Green Investment Bank is even more problematic, as the bank not only lacks the power to create new credit ex nihilo, but also the ability to borrow from the markets. The UK Treasury has frozen this possibility until at least 2015-16 to avoid the further expansion of the country's public debt. Consequently, the GIB will not be able to lend anything more than the endowment granted by the government, thus strongly limiting potential emission reductions.

Overcoming these obstacles is going to prove very challenging. For instance, the Bank of England could purchase debt securities issued by the Green Investment Bank, which could then lend the funds to low-carbon activities - a sort of 'green' quantitative easing (Murphy and Hines, 2010). This would probably prove to be extremely controversial under the current macroeconomic setting, as it would be similar to public credit creation by the Central Bank. However, as unconventional this proposal may appear, it is not unprecedented. At the end of World War II, the Canadian Central Bank created an Industrial Development Bank (IDB) aimed at supporting the small and medium enterprise sector. The IDB – which in its 31 years of operations lent money to approximately fifty thousand businesses – was entirely financed by the Central Bank, which purchased the whole amount of bonds issued by the IDB through the creation of new reserves (Ryan-Collins et al., 2013).

Despite their inability to leverage, which limits the effectiveness of their interventions, public development banks are likely to play a relevant role in the transition to a low-carbon society. Their developmental approach makes them the financial institutions most suitable to provide credit to sectors judged socially useful. Having development banks as more solid actors in the global credit system would help to increase the volume of resources to low-carbon sectors, expand the market for green bonds and act as a catalyst for the private sector investors.

9. Conclusions and further research

The climate change challenge will require a transition to a low-carbon economic system, characterized by the production of energy from renewable resources, high efficiency and a smart

[33] In their first 5 months of operations, the total amount of finance raised by GIB was approximately £2.3bn, of which 635 million was committed by the GIB itself, and the rest by private investors. The average mobilisation ratio was thus around 3:1 (GIB, 2013).

use of ecological resources. Investment in low-carbon sectors is, however, still far from what would be needed according to estimates, and investment in fossil fuel energy capacity still too high.

One of the main obstacles to filling the investment gap is the market failure related to the exclusion of ecological and common goods from the market pricing system. Introducing a carbon price, either through the fiscal system or via the creation of a carbon market, is thus a necessary precondition to induce private investors to be interested in green sectors.

However, a carbon price may not be enough. In order to carry out their activities, low-carbon firms necessitate credit. Under certain economic conditions, of which the post financial crisis period represents the most recent realization, banks may lack the confidence to create new credit even in the presence of right prices and profitable investments. This credit market failure, together with the deep uncertainties surrounding the future implementation of a carbon price, makes the case for considering a wider portfolio of policies. Examples include green differentiated reserve and capital requirements, modifying the risk weights for computing capital requirements in favour of low-carbon assets and other quantitative macroprudential policies aimed at easing lending conditions for low-carbon firms.

As unconventional as these policies may seem, they are far from unprecedented. Macroprudential regulation is currently implemented in a large number of emerging economies, and has been frequently employed in advanced economies in the past. However, the employment of these policies requires moving beyond current central banking practice in high-income countries, which in past decades have been using reference interest rates as their sole policy tool. Despite the wave of new financial regulation and the current reshaping of central bank mandates, adopting measures aimed at controlling credit allocation is going to prove challenging and controversial.

For this reason, much work remains to be done on the research side. In particular, the discussion of how to finance the transition to a low-carbon society would benefit from being founded on a well-developed and reliable set of economic theories. In particular, a stronger theoretical connection needs to be developed between two areas of research that have traditionally been separate: the economics of sustainability - the multidimensional analysis of how societies interact with their natural environment – and monetary and banking economics. The connection between these two spheres must be studied from both a policy and an economic theory perspective in order to reach a systemic understanding of how the transition – or the lack thereof - could affect the future dynamics of our economies. In particular, the role of banks and the wider financial system in facilitating the achievement of a sustainable economy constitutes a promising and relatively unexplored area of research that could shed light on the multiple layers of macroeconomic systems management.

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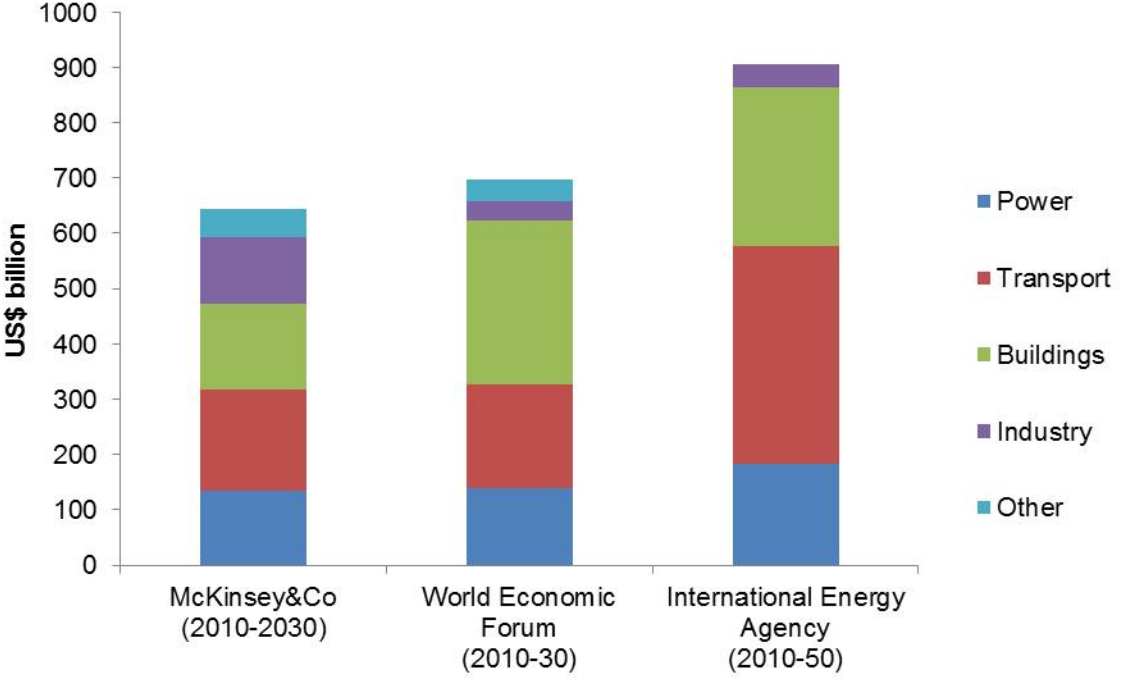
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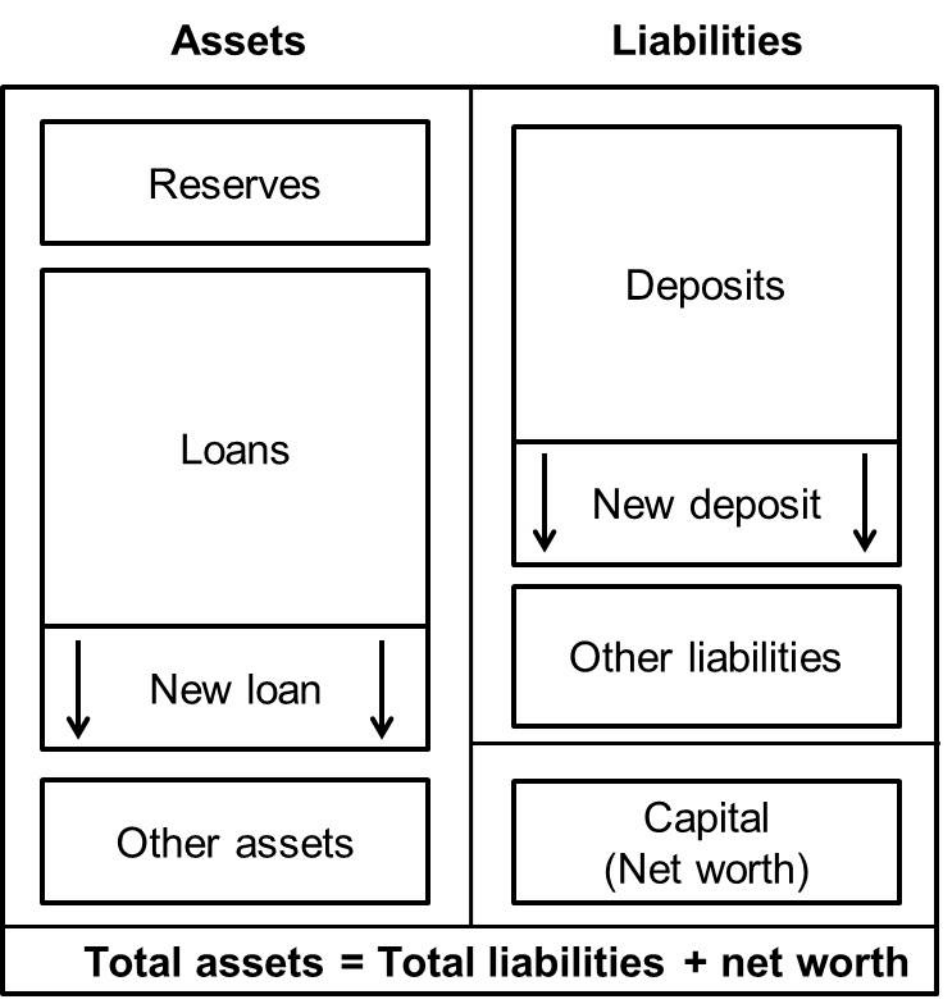
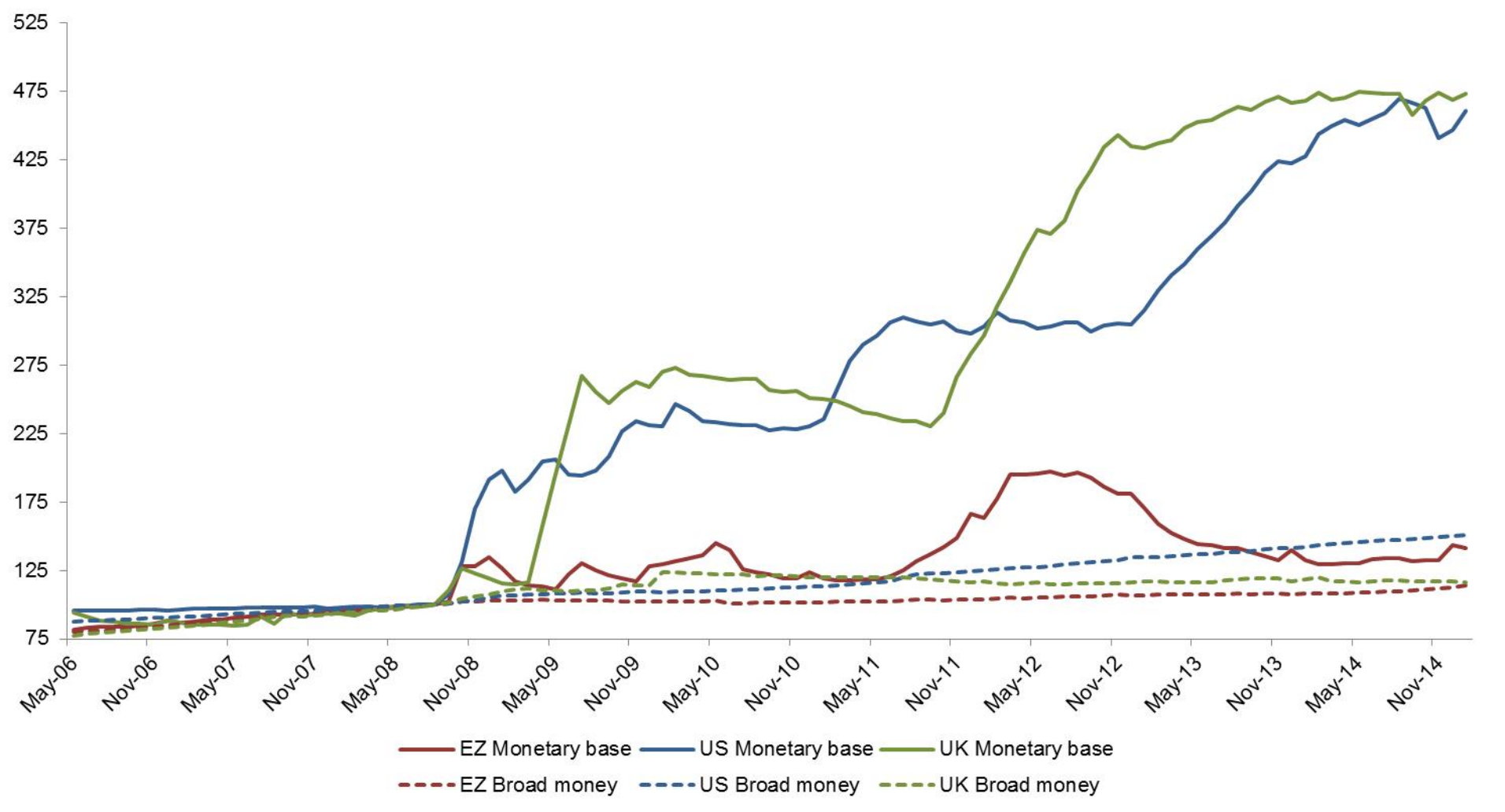


Reserve requirements:

$$\frac{\text{Central Bank reserves}}{\text{Stock of deposits}}$$

Capital requirements:

$$\frac{\text{Capital}}{\text{Total assets (risk-weighted)}}$$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EZ Monetary base
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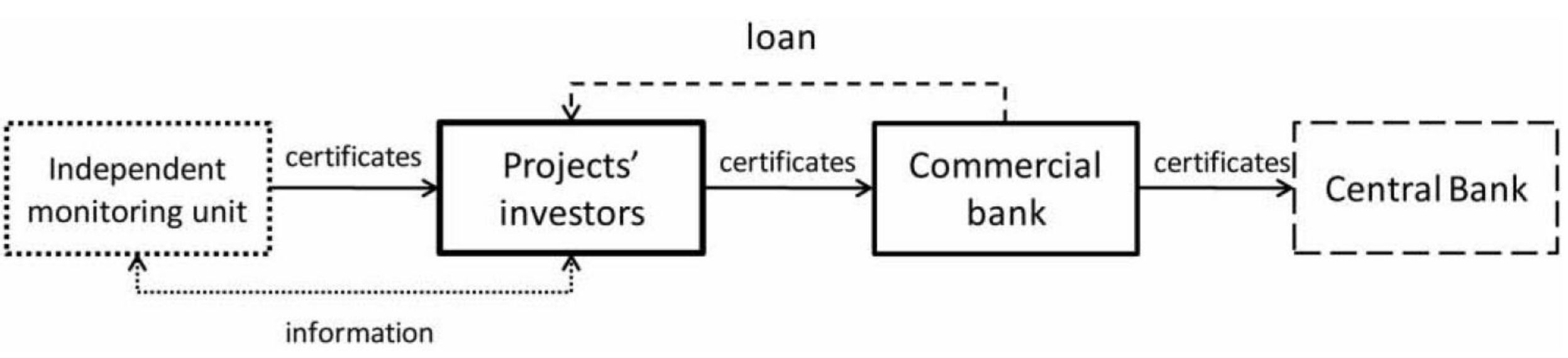
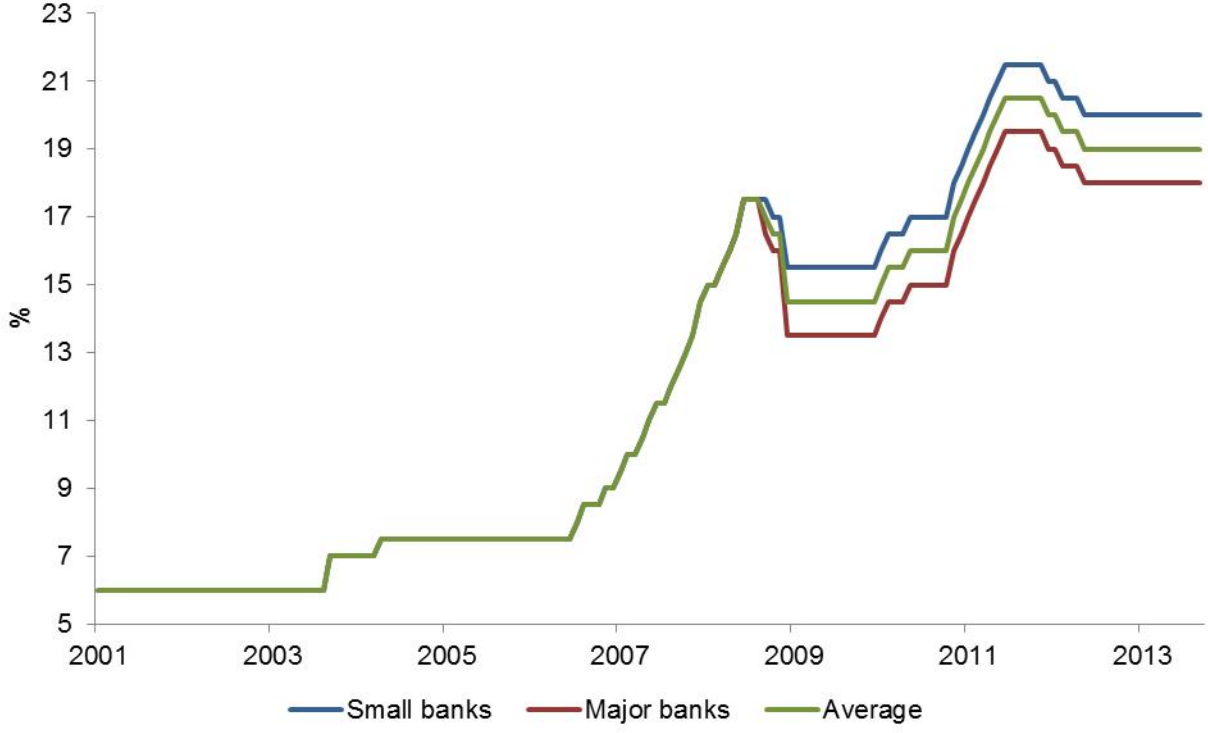

loan
Independent monitoring unit
certificates
Projects' investors
certificates
Commercial bank
certificates
Central Bank
information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2011
2013
Small banks
Major banks
Average