International Transmission of Regulatory Capital Shocks

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This draft: June 2012

Abstract

One reason for the recent global financial crisis is the deregulation of financial markets. Variations in regulatory capital requirements in one country may affect not only the domestic economy but also spread to other countries. This paper assesses the effects of a US-specific regulatory capital shock on house prices and economic activity in the USA and the euro area using a global vector autoregression (GVAR) framework. The GVAR is then used to conduct a counterfactual experiment of the effect of financial deregulation on housing and output, related to the change in the net capital rule for broker-dealers in April 2004. The results show the existence of a significant effect of such shocks on economic activity in both countries and on house prices in the USA. Without the rule change, house prices and output in the USA and output in the euro area would have been about 5-6% lower in 2007.

JEL Classification: C15, E17, G18, G24

Keywords: Global VAR, counterfactuals, deregulation of capital requirements, broker-dealer assets, SEC net capital rule change, house prices.

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1 Introduction

Financial liberalization leads frequently to an expansion of credit and to asset boom-bust cycles in emerging countries. Indeed, in industrialized countries, financial market deregulation since the mid-1990s may have led to a surge in capital inflows and the emergence of housing bubbles even in economies with well developed financial markets. Therefore, the housing bubbles in the USA and Europe in the last decade could have been a result of an increased supply of mortgage credit enables by the deregulation wave on the financial markets. Following a dismantling of prudent banking regulation, financial intermediaries can ease capital requirements, which sets free reserves and enables them to increase leverage and provide more credit. As a consequence, shocks originating in credit markets and pro-cyclical loan supply can cause the banking system to introduce additional volatility to the business cycle. Due to the highly credit-intensive nature of real estate investments, such reforms may trigger higher house prices. Economic activity can also be strongly affected partially due to collateral effects for credit-constrained mortgage borrowers, who can increase consumption and investment by extracting housing equity out of the increased value of their collateral. Moreover, the globalization of trade and the integration of financial and credit markets can enable a quick transmission of a country-specific financial market deregulation shock not only to the financial markets of other economies but also to the real economy. The recent global financial crisis of 2007-09 shows that a US-specific shock on financial markets can cause fast a global financial crisis. While it originated in the USA, the subprime mortgage crisis was not limited to the sphere of financial markets but has also affected housing markets and economic activity worldwide. Financial market deregulation can lead to a redistribution of capital flows from one region to another and affect the real sector of the economy through variations in credit provision.

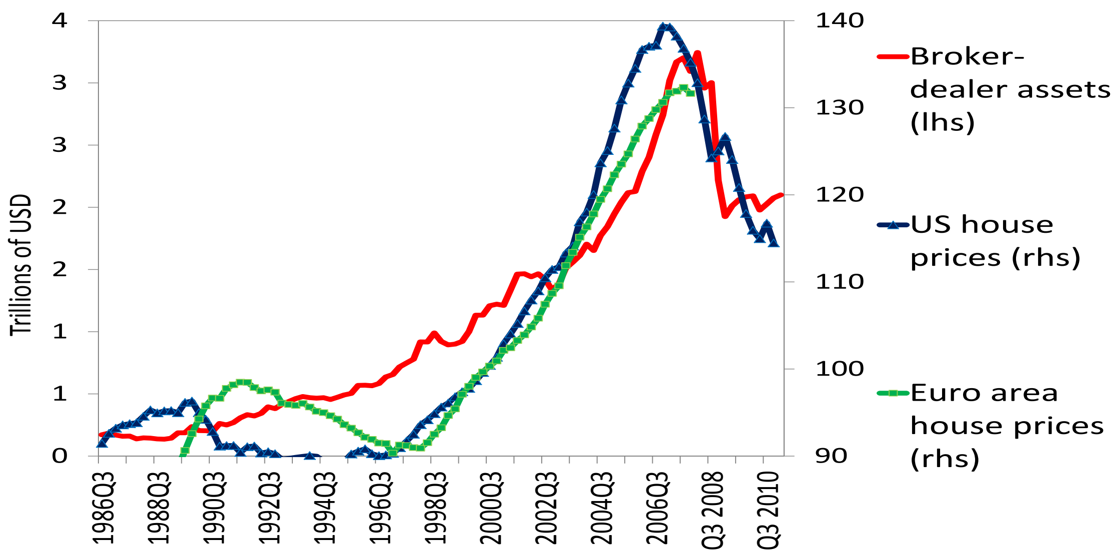
This paper contributes to the existing literature by assessing empirically the effects of a US-specific financial deregulation shock on housing markets and economic activity, and its transmission to the euro area. In order to assess the effect of a US-specific economic shock and thereby account for the interlinkages between the USA and the euro area, a GVAR approach, developed by Pesaran et al. (2004) and extended by Dees et al. (2007), has been applied. Moreover, this research employs a counterfactual experiment to quantify the effect of financial market deregulation, associated with an easing in regulatory capital requirements, on house prices and output, partially following the procedure developed in Pesaran et al. (2007).

The effects of a change in regulatory capital requirements are assessed by looking at variations in broker-dealer assets. The broker-dealer sector of the economy includes the securities firms and consists to a large extent by the investment banks. Broker-dealers are market-makers, they make markets for tradable assets by originating new securities and producing derivatives. With the increasing role of securitization, the capital market has partially substituted the less flexible retail deposits as a source of bank borrowing (see Altunbas et al. (2009) and Gambacorta and Marques-Ibanez (2011)) strengthening the role of broker-dealers for credit supply. They mirror the evolution of the market for mortgage securitization, as broker-dealer assets increased rapidly since the 1980s (see Figure 1), coincidently in line with the launch of securitization of residential mortgages (see Adrian and Shin (2010a)). According to Adrian and Shin (2010a), "the ultimate supply of securitized credit to the real economy is often channeled through broker-dealer balance sheets. As such, they serve as a barometer of overall funding conditions in a market-based financial system". Such funding conditions depend on fluctuations in haircuts and regulatory capital ratios. Indeed, when modeling the bank lending channel to account for non-depository borrowing, Disyatat (2011) argues that the only exogenous constraint to credit supply are regulatory capital requirements.

The counterfactual part of the methodology is constructed by looking at the effects of a specific event, namely the change of the existing net capital rule for broker-dealers by the Securities and Exchange Comission (SEC) in April 2004, assuming a zero or a constant growth of broker-dealer assets from April 2004 onwards. The SEC decision in 2004 allowed the big broker-dealers to apply for exemption from the since 1975 existing net capital rule, which requires them to value their securities at market prices and to apply a haircut. As a consequence of the regulation change, the five biggest non-bank investment banks – Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch and Morgan Stanley – were designated by the SEC as 'consolidated supervised entities' and could apply computer model simulations as in the Basel Accords to estimate the capital requirements. Several scholars, among them Ferguson (2008), Coffee (2008), Blinder (2009), Stiglitz (2009) and Hendershott and Villani (2012), have argued that these investment banks were thereby able to increase the limits of their leverage from a maximum leverage ratio of 12% prior to the reform to more than 30% afterwards. Stiglitz (2009) describes the SEC decision in 2004 as a meeting "attended by virtually no one and largely overlooked at the time, to allow big investment banks to increase their debt-to-capital ratio so that they could buy more mortgage-backed securities, inflating the housing bubble in the process". Further, Hall (2011) argues that the SEC rule change remove the limits on the amount of leverage banks can adopt as "the reason that Lehman was able to do what it did, which proved so destructive". The net capital rule change can have boosted the demand for credit default swaps and collateralized debt obligations (CDOs), leading to an enormous increase in the balance sheets of broker-dealers. Figure 1 shows that the assets of broker-dealers have grown to a much faster rate since the new haircut regulation in 2004, and in 2007 they have doubled their 2004-value. The assets amounted to $3.2 trillion in the third quarter of 2007 compared to $1.6 trillion in the second quarter of 2004. Adrian and Shin (2010b) show that the sizable increase in broker-dealer assets was accompanied by a strong build-up in their leverage, with leverage growth positively related to asset growth along the 45-degree line. This implies that the adjustment in leverage takes place primarily through balance-sheet variations rather than through changes in equity. Thus, variations of broker-dealer assets can be a good indicator of variations in regulatory capital ratios. A decrease in such ratios can free funds held as reserves against losses and be used for credit provision, which is used by mortgage borrowers for housing purchase and thus lead to further house price increases. Deregulation shocks are then passed to the economy through balance-sheet effects associated i.e. with collateral constraints for borrowers.

The GVAR results show that a US-deregulation shock to the securities sector play an important role in propagating economic activity in both, the USA and the euro area. Instead, house prices respond significantly to Us regulatory capital shocks only in the USA which might be due to the less flexible mortgage markets in the euro area or to a reallocation of capital towards the US financial market. Indeed, the counterfactual results show that if broker-dealer assets had grown to a lower pace from the second quarter of 2004 onwards, output in both countries would have stagnated since the third quarter of 2005. If broker-dealer assets have remained unchanged since 2004, house prices in 2007 in the USA would have been about 5% lower, while euro area house prices would have increased by 2.5%. This finding may be associated with an increasing engagement of European banks in the US mortgage market through the shadow banking sector.

Figure 1: Broker-dealer assets and house prices



2 Literature review

The literature base relevant to these study areas, highlights three key components: financial market deregulation, international transmission of credit shocks and global linkages among housing markets. The first strand of research explores the role of financial market deregulation for economic activity. Recent studies (see Brunnermeier et al. (2009), Cukierman (2011), Duca et al. (2011), Shivdasani and Wang

(2011), Turner (2011)) raise the concern that financial market deregulation in industrialized countries may be responsible for the recent housing bubbles and the global financial crisis. A number of financial market reforms have taken place in the USA and Europe since the early 1990s. First, as a consequence of the advances in financial technology and the improvements in internal bank risk measurement, the Gramm-Leach-Bliley Act, enacted in November 1999, effectively repealed the Glass-Steagall Act of 1933, thus enabling commercial and investment banks, securities companies, and insurance companies to consolidate. Indeed, Cukierman (2011) argues that this deregulation contributed to the growth of the shadow banking system which led to "regulatory arbitrage that transferred a significant fraction of financial intermediation to non-bank financial institutions such as broker-dealers and hedge funds". Second, credit may have become more easily available to households with low credit scores due to two financial innovations, as argued by Duca et al. (2011). One is the use of credit scoring since the mid-1990s (see also Gerardi et al. (2010)) which enables to sort subprime mortgage borrowers and price the risks for such mortgages. Until then, only prime borrowers could become a loan. The other is the SEC rule change in April 2004, prior to which the housing market was about to move from boom to bust according to Hendershott and Villani (2012). Third, the deregulation in the USA might also have been related to the financial market deregulation surge in Europe in the last two decades. Indeed, Brunnermeier et al. (2009) and Shivdasani and Wang (2011) identify the Basel II capital framework for securitization as a potentially important driver of the high leverage in asset-backed securities (ABS) via structured CDOs.

The empirical literature on the role of financial market deregulation has been scarce and since the global financial crisis the interest of policy makers in this research area has been growing. Most of the empirical studies, however, are looking at deregulation shocks derived from a theoretical model. Berka and Zimmermann (2011) construct a model to look at the effects of countercyclical and procyclical shocks in capital requirements on different macroeconomic variables during a downturn of the economy. They find that the Basel II Accord requirement of lower capital requirements during a downturn lowers bank lending, because badly-capitalized banks are not able to attract savers. Based on results from a general equilibrium model, Covas and Fujita (2010) conclude that the Basel I and II Accords increase the variation of output fluctuations by between 5 to 10 basis points with significantly larger effects around business cycle peaks and troughs. Devereux and Yetman (2010) develop a two-country model with highly leveraged financial institutions holding interconnected portfolios and subject to capital constraints. They find that, under a high level of financial integration and binding leverage constraints, a negative productivity shock in one country has globally substantial effects on the economy. Kollmann et al. (2011) investigate in a two-country business cycle model with a global bank how capital requirements affect the international transmission of productivity and loan default shocks. They conclude that global banks are important for the international transmission of the crisis as shown by the sizable decline in economic activity in both countries following an exceptionally large country-specific loan loss. Finally, Gerali et al. (2010) estimate a dynamic stochastic general equilibrium (DSGE) model of the euro area and find that negative shocks to bank capital may have substantial effects on the economic activity.

Concerning the second key component identified in the literature, Galesi and Sgherri (2009) Chen et al. (2010), Bussiere et al. (2011), Chudik and Fratzscher (2011) and Bagliano and Morana (2012) use a GVAR[1] to explore different types of financial shocks. Chen et al. (2010) accounts for 'financial distress' including a variable of the expected default frequency of banks and of nonfinancial corporates. Such variables reflect the impact of the structure of bank's or firm's balance sheet and investors' risk appetite. They find that a shock increasing the probability of bank default is transmitted through the banks' balance sheets, which tighten lending conditions and worsen thereby borrowers' balance sheets and real activity. These results are significant and show the importance of balance sheet channels in the transmission of 'financial distress' globally. Chudik and Fratzscher (2011) use a GVAR to assess the transmission of the global financial crisis 2007-2009 arising from US-specific shocks in liquidity and risk to money and equity markets across industrialized and emerging countries. Their main findings are that, while the tightening in liquidity constraints in the interbank markets had a severe impact on advanced economies, the crisis in emerging economies spread as a consequence of the decline in risk appetite and the 'flight to safety' of investors. Bussiere et al. (2011) also study the role of risk aversion shocks for real effective exchange rates in the euro area, measuring such shocks by variations in the VIX index, an appreciation of the US dollar, Japanese yen and Swiss frank or a depreciation in the Korean won and the Polish zloty. Moreover, studies by Xu (2010), Beaton and Desroches (2011), Eickmeier and Ng (2011) and Helbling et al. (2011) assess in more detail the international transmission of credit shocks, most of them including total credit to the private sector. Helbling et al. (2011) and Eickmeier and Ng (2011) include also the corporate bond credit spread as a credit price variable. Xu (2010) finds strong evidence of the spillover of US credit shocks to the UK, euro area and other industrialized countries. Helbling et al. (2011) argue that the credit shocks are as important as productivity shocks and that US credit shocks have a significant impact on the evolution of world growth during global recessions. Galesi and Sgherri (2009) conclude that credit shocks plays a significant role in the transmission of financial shocks in the long run. Eickmeier and Ng (2011) identify credit supply shocks in a GVAR using sign restrictions and find that negative US credit supply shocks have important implications on domestic and foreign output and credit.

Concerning the third research area, only a few studies (see Vansteenkiste and Hiebert (2009), Holly et al. (2010), Beltratti and Morana (2010), Eickmeier and Hofmann (2011) and Bagliano and Morana (2012)) use a GVAR or a FAVAR[2] to account for international housing market linkages across countries. Holly et al. (2010) assess the role of fundamentals for the speed of adjustment of real house prices among regions in the USA. They find a cointegration relation between per capita disposable income and

[1]Bagliano and Morana (2012) estimate a factor augmented VAR (FAVAR) model.

[2]A FAVAR is estimated by Beltratti and Morana (2010), Eickmeier and Hofmann (2011) and Bagliano and Morana (2012).

house prices for most of the US states. Vansteenkiste and Hiebert (2009) find that house price spillovers among euro area countries are limited, and rather shocks in domestic long term interest rates have more permanent effects of housing variables. Beltratti and Morana (2010) show that US shocks associated with global macroeconomic and financial disturbances are important for fluctuations in real house prices internationally. Bagliano and Morana (2012) also find that the international transmission of financial shocks takes place through the US house price dynamics.

3 Model specification and estimation

The theoretical insights and the existing empirical studies on the role of credit suggest that increases in credit supply, often related to deregulation, can enhance the variations in he business cycle dynamics. To study the effect of a US-specific deregulatory capital shock on house prices and economic activity and thereby account for the interlinkages between the USA and the euro area, I incorporate broker-dealer assets in a GVAR framework. The GVAR model was pioneered by Pesaran et al. (2004) and further developed by Dees et al. (2007). It is a multi-country framework which allows for interdependencies among countries. The GVAR is often used to analyze international transmission mechanisms and spillover effects across economies. In the first stage, individual region-specific vector error-correcting models including foreign variables as weak exogenous, denoted by VECMX, are estimated. In the second stage, the individual country models are linked to a global VAR model simultaneously using trade or financial weights.

3.1 The GVAR model

For each country a country VAR model augmented by foreign-specific variables, which is denoted by VARX, is estimated including a constant and a deterministic trend. A second-order VARX(2,2) is written as

$$x_{it} = a_i + b_i t + \Phi_{i1} x_{i,t-1} + \Phi_{i2} x_{i,t-2} + \Psi_{i0} x^*_{i,t} + \Psi_{i1} x^*_{i,t-1} + \Psi_{i2} x^*_{i,t-2} + u_{it} \tag{1}$$

for i the index for the USA (us) or the euro area (ea), where x_{it} is a k_i x 1 vector of country-specific variables, x^*_{it} is a k^*_i x 1 vector of foreign variables specific to country i, Φ_{i1} and Φ_{i2} are k_i x k_i matrices of lagged domestic-country coefficients, Ψ_{i0}, Ψ_{i1} and Ψ_{i2} are k_i x k^*_i matrices of lagged foreign-country coefficients, and u_{it} is a k_i x 1 vector of idiosyncratic country-specific shocks. In the special case of $\Psi_{i0} = \Psi_{i1} = \Psi_{i2} = 0$ the model in (1) reduces to a standard VAR process of order 2. The foreign ('star') variables x^*_{it} are usually calculated as country-specific weighted averages of the corresponding variables in the other countries in the GVAR. However, in the case of only two regions, weights are equal to one and the 'star' variables are respectively the endogenous variables of the country counterpart. The 'star' variables are treated as weak exogenous or 'long-run forcing', meaning that they are not caused by the domestic variables in the long run. The two VARX models (for the USA and the euro area) are estimated separately conditional on x^*_{it}, using reduced rank regression, taking into account error-correcting and trending properties. In cases where cointegration is found, each country-VARX model is estimated under its vector error-correcting (VECMX) form. Rewriting the country-specific VARX model in equation (1) in an error correction form

$$\Delta x_{it} = a_i + b_i t + (\Phi_{i1} + \Phi_{i2} - I_{k_i}) x_{i,t-1} + (\Psi_{i0} + \Psi_{i1} + \Psi_{i2}) x^*_{i,t-1} - \Phi_{i2} \Delta x_{i,t-1} + \Psi_{i0} \Delta x^*_{i,t} - \Psi_{i2} \Delta x^*_{i,t-1} + u_{it}, \tag{2}$$

allows for cointegrating relationships between non-stationary variables, both within and across countries. The error correction term is given by

$$\Pi z_{it} = (\Phi_{i1} + \Phi_{i2} - I_{k_i}, \Psi_{i0} + \Psi_{i1} + \Psi_{i2}) z_{it} = \alpha_i \beta_i' z_{it} \tag{3}$$

with $z_{it} = (x'_{it}, x^{*'}_{it})'$. Conditional on a given estimate of β_i, the remaining parameters of the VECMX models are consistently estimated by OLS regressions. After estimating each country-VECMX model, the endogenous variables of the USA and the euro area are collected in a k x 1 global vector x_t, where $k = k_{us} + k_{ea}$ is the total number of the endogenous variables in the global model. Due to the contemporaneous dependence of the domestic variables, x_{it}, on the foreign variables, x^*_{it}, the country-specific VARX models given in (1) are solved simultaneously for all k domestic variables. To construct the GVAR, equation (1) is rewritten as

$$A_{i0} z_{it} = a_i + b_i t + A_{i1} z_{i,t-1} + A_{i2} z_{i,t-2} + u_{it}, \tag{4}$$

where $A_{i0} = (I_{k_i}, -\Psi_{i0})$, $A_{i1} = (\Phi_{i1}, \Psi_{i1})$ and $A_{i2} = (\Phi_{i2}, \Psi_{i2})$ with dimensions k_i x $(k_i + k^*_i)$. While the matrix A_{i0} has full rank k_i, the other two matrices might have a reduced rank, depending on the number of lags of the foreign variables. In order to write the country-specific variables z_{it} in terms of x_t, 'link' matrices for each of the countries W_i have been constructed, so that $z_{it} = W_i x_t$. W_i is a $(k_i + k^*_i)$ x k matrix of constants defined in terms of the country specific weights, which in the case of two countries are equal to one. Hence, W_i consists of zeros and ones so that it satisfies $z_{it} = W_i x_t$. Given that, (4) can be written as

$$A_{i0} W_i x_t = a_i + b_i t + A_{i1} W_i x_{t-1} + A_{i2} W_i x_{t-2} + u_{it}. \tag{5}$$

These equations are stacked yielding

$$H_0 x_t = a + bt + H_1 x_{t-1} + H_2 x_{t-2} + u_t, \tag{6}$$

where $a = (a'_{ea}, a'_{us})'$, $b = (b'_{ea}, b'_{us})'$, $H_j = (A'_{ea,j}W'_{ea}, A'_{us,j}W'_{us})'$ for $j = 0, 1, 2$ and $u_t = (u'_{ea,t}, u'_{us,t})'$. H_0 is a k x k matrix of full rank and hence nonsingular, so that the GVAR is given by

$$x_t = h_0 + h_1 t + G_1 x_{t-1} + G_2 x_{t-2} + v_t, \tag{7}$$

where $h_0 = H_0^{-1}a$, $h_1 = H_0^{-1}b$, $G_j = H_0^{-1}H_j$ for $j = 0, 1, 2$, and $v_t = H_0^{-1}u_t$. The GVAR in (7) can be solved recursively to obtain e.g. impulse responses or forecast values of the endogenous variables. The elements of the covariance matrix are given by the matrix $\hat{\Sigma} = E(v_t v'_t) = \hat{v}_t \hat{v}'_t / T$ with T the number of data points in the sample period.

3.2 Data and VARX specification

Our dataset comprises of 9 euro area countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands and Spain) and the USA. The euro area countries are combined using weights of purchasing power parity (PPP) to gross domestic product (GDP) to form an euro-area aggregate because of their common monetary policy since 1999. The variables which enter the GVAR model are real GDP, inflation, a 3-month money market rate, a 10-year government bond rate, oil prices, real house prices, real per capita disposable income and broker-dealer assets. All variables are used in quarterly terms. The first 4 variables are taken from the updated dataset used in Dees et al. (2007).[3] House prices are provided by the OECD constructing the series using national sources.[4] I use OECD data, as it compromises all necessary house price data and aims to collect as homogenous housing data as possible. Real per capita disposable income has been calculated using disposable income divided by interpolated annual population data and the consumer price index (CPI). Disposable income and population data are taken from Eurostat or national sources, the CPI from the Dees et al. (2007) dataset. Broker-dealer assets are from the US Flow of Funds database and constitute of total financial assets. The inclusion of long-term interest rate, disposable income and broker-dealer assets has been motivated by their role explaining house prices in the medium term. Per capita disposable income is included, as it is shown to be an important driving factor of housing demand in the long run (see McQuinn and O'Reilly (2006), McQuinn and O'Reilly (2007), Ortalo-Magne and Rady (2006), Gallin (2006) Vansteenkiste and Hiebert (2009) and Holly et al. (2010)). Long-term government bond yields are used as a proxy for average mortgage rates, given that only short time series exist for the latter for the euro area countries. Broker-dealer assets mirror well credit conditions in the financial market due to their function as an intermediary between financial institutions and the real economy. They may be an important determinant for housing demand as mortgage indebtedness increases as a consequence of loose credit standards.

Both the US and the euro area VARX models include as endogenous (domestic) variables real output

[3]For sources of these variables see Dees et al. (2007) and the GVAR toolbox manual.
[4]The house price index is the real transaction-based index from the Federal Housing Finance Association (FHFA).

(y_i), inflation rate (Δp_i), short-term interest rate (r_i), long-term interest rate (lr_i), real house prices (hp_i) and real per capital disposable income (di_i). Furthermore, oil prices ($poil$) and broker-dealer assets (bd) are also included as endogenous variables in the US VARX model. Following Dees et al. (2007), it is allowed that the evolution of the global macro-economic variables influences oil prices. The US model contains euro area real output and inflation rate as weakly exogenous. Dees et al. (2007) argue that thereby the USA is more fully integrated in the world economy and react to second round effects in the global economic system. The foreign variables which enter the euro area model under the condition of weak exogeneity include all endogenous variables from the US-VARX. Thereby, I assume that the US variables are long-run forcing the euro area variables. This is a plausible assumption due to the global role played by the US economy. In order to see whether such specification is appropriate, the weak exogeneity of these variables is tested below.

3.3 Model testing

Unit roots, cointegration rank and lag structure Each variable is tested for the presence of a unit root using a range of unit root tests. Table 1 plots the results from a weighted symmetric Augmented Duckey Fuller (ADF), a Phillips-Perron and a KPSS test. Given that most of the variables under study have a unit root, each country-VARX model is estimated individually in its VECMX form. A Johansen trace statistic[5] with unrestricted intercepts and restricted trend coefficients is used to account for the number of cointegration relations among the variables in the VARX models. The trace test indicate a rank order of 6 for both, the USA and the euro area. However, due to the instability of a system with so many cointegration relationships, I reduce the ranks until the model becomes stable in terms of eigenvalues and persistent profiles. A rank of 3 for each country yields stable results. The lag orders of the domestic and foreign variables for the VARX models are determined by the AIC subject to a maximum lag order of 4 across models.[6] The VARX models for the euro area and the USA are estimated both with 4 lags of the domestic variables and respectively with 3 and 1 lags of the 'star' variables.

Model stability The global model must be dynamically stable. Specifically, the eigenvalues λ of the GVAR must be either on or inside the unit circle. The eigenvalues of a kp x kp coefficient matrix G of a GVAR(1), where p is the number of lags in a GVAR(p), are computed by solving the equation

$$|I_{kp}\lambda - G| = 0. \tag{8}$$

[5]The trace test is prefered to the maximum eigenvalue, because it is more robust concerning non-normal residuals.

[6]Due to the inclusion of the housing variables, the lag-order of the GVAR is increased as house price residuals from the VECM equations are serially correlated if only two lags are included. Housing demand adjusts more sluggish to the new information set due to information asymmetries, high transaction costs and long investment horizons.

Table 1: Unit root tests for the domestic variables at the 5% significance level

Variables	Statistic	Crit	Euro	USA	Variables	Statistic	Crit	Euro	USA
y (trend)	WS	-3.24	-2.81	-2.59	lr (trend)	WS	-3.24	-1.71	-3.93
y	WS	-2.55	0.44	0.64	lr	WS	-2.55	-0.93	-0.95
y (trend)	PP	-3.46	-2.35	-1.77	lr (trend)	PP	-3.46	-2.48	-3.50
y (trend)	KPSS	0.15	0.09	0.12	lr (trend)	KPSS	0.15	0.13	0.08
Δy	WS	-2.55	-3.76	-4.28	Δlr	WS	-2.55	-5.49	-5.77
Δy	PP	-2.90	-6.60	-7.37	Δlr	PP	-2.90	-5.45	-7.40
Δy	KPSS	0.46	0.15	0.09	Δlr	KPSS	0.46	0.11	0.07
$\Delta\Delta y$	WS	-2.55	-8.12	-7.11	$\Delta\Delta lr$	WS	-2.55	-6.78	-10.74
$\Delta\Delta y$	PP	-2.90	-18.54	-39.64	$\Delta\Delta lr$	PP	-2.90	-13.83	-23.27
$\Delta\Delta y$	KPSS	0.46	0.29	0.19	$\Delta\Delta lr$	KPSS	0.46	0.06	0.05
Δp (trend)	WS	-3.24	-1.58	-3.29	hp (trend)	WS	-3.24	-4.01	-1.84
Δp	WS	-2.55	-1.90	-3.09	hp	WS	-2.55	-0.65	-0.90
Δp (trend)	PP	-3.46	-5.23	-6.91	hp (trend)	PP	-3.46	-1.57	-0.85
Δp (trend)	KPSS	0.15	0.14	0.21	hp (trend)	KPSS	0.15	0.17	0.29
$\Delta\Delta p$	WS	-2.55	-12.97	-13.27	Δhp	WS	-2.55	-1.86	-2.09
$\Delta\Delta p$	PP	-2.90	-13.09	-13.29	Δhp	PP	-2.90	-2.69	-4.35
$\Delta\Delta p$	KPSS	0.46	0.12	0.12	Δhp	KPSS	0.46	0.20	0.57
$\Delta\Delta\Delta p$	WS	-2.55	-7.92	-6.95	$\Delta\Delta hp$	WS	-2.55	-9.29	-5.96
$\Delta\Delta\Delta p$	PP	-2.90	-24.37	-31.43	$\Delta\Delta hp$	PP	-2.90	-16.13	-14.80
$\Delta\Delta\Delta p$	KPSS	0.46	0.14	0.10	$\Delta\Delta hp$	KPSS	0.46	0.13	0.14
r (trend)	WS	-3.24	-2.38	-3.36	di (trend)	WS	-3.24	-2.71	-1.70
r	WS	-2.55	-1.28	-2.42	di	WS	-2.55	2.05	0.90
r (trend)	PP	-3.46	-1.83	-2.31	di (trend)	PP	-3.46	-2.54	-2.02
r (trend)	KPSS	0.15	0.13	0.06	di (trend)	KPSS	0.15	0.09	0.25
Δr	WS	-2.55	-5.01	-3.65	Δdi	WS	-2.55	-4.43	-5.95
Δr	PP	-2.90	-4.66	-4.06	Δdi	PP	-2.90	-9.30	-11.04
Δr	KPSS	0.46	0.12	0.05	Δdi	KPSS	0.46	0.12	0.17
$\Delta\Delta r$	WS	-2.55	-6.72	-7.92	$\Delta\Delta di$	WS	-2.55	-6.47	-7.45
$\Delta\Delta r$	PP	-2.90	-13.93	-10.80	$\Delta\Delta di$	PP	-2.90	-47.51	-100.02
$\Delta\Delta r$	KPSS	0.46	0.07	0.05	$\Delta\Delta di$	KPSS	0.46	0.11	0.19

Note: Crit stands for the critical values of a t-test, taken from MacKinnon et al. (1999). WS - weighted symmetric Augmented Duckey Fuller test, PP: Phillips-Perron test; KPSS test; (trend) stands for a unit root test including additionally a trend. All unit root tests are conducted with an intercept. y: output, Δp: inflation rate, r: short-term interest rate, lr: long-term interest rate, hp: house prices, di: per capital disposable income.

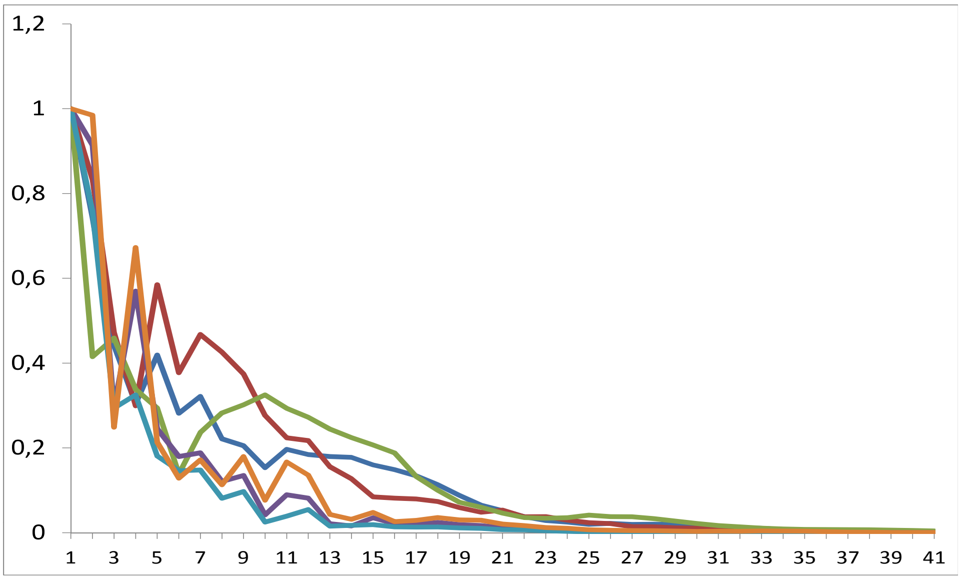
The G matrix is derived from (7) so that

$$X_t = h_0 + h_1 t + G X_{t-1} + V_t, \tag{9}$$

with $X_t = (x_t', x_{t-1}')'$, $X_{t-1} = (x_{t-1}', x_{t-2}')'$, $G = (G_1, G_2|I_k, 0)$ and $V_t = (v_t', 0')'$ for a GVAR(2). The estimated GVAR model is dynamically stable when the moduli of the 56 eigenvalues[7] of the G matrix are all on or within the unit circle with the number of eigenvalues lying on the unit circle (e.g. the number of unit roots) equal to the number of stochastic trends. The GVAR contains 14 endogenous variables and 6 cointegration relationships among the VARX models, thus G must have at least $14 - 6 = 8$ eigenvalues that fall on the unit circle. The estimated model is dynamically stable as there are exactly 8 eigenvalues which take the value 1. The three largest eigenvalues (in moduli) after the unit roots are 0.9297, 0.9297 and 0.9281, implying a rapid rate of convergence of the model to its steady state once shocked. Besides the eigenvalues, the persistent profiles of the system also give an insight about the model stability. They provide information on the speed with which the cointegrating relationships $\beta_i' z_{it}$ given in (3) return to their equilibrium states following a shock in the system. The persistence profiles in Figure 2 behave well, which is again reassuring for the choice of the long-run relations.

[7]Since the GVAR has 14 endogenous variables and 4 lags, the G matrix has $14 * 4 = 56$ eigenvalues.

Figure 2: Persistent profiles of the cointegration relations in the US and euro area VARX



Testing weak exogeneity The weak exogeneity assumption of the country-specific foreign variables is tested by examining the joint significance of the estimated error-correction terms of the individual country VECMX models in the marginal error correcting model of x^*_{it}. I conduct the test setting a lag order of 4 and 2 for the lagged changes for the domestic and foreign variables, respectively. Dees et al. (2007) argue that it is common to set the lag order for the domestic variables in the marginal model to equal their lag order in the conditional model given in (1) and the lag order of the foreign variables in the marginal model to 1 or 2. The weak exogeneity hypothesis is not rejected for any of the variables in both countries as is shown in Table 2.

Table 2: Test for weak exogeneity of the foreign variables at the 5% significance level

Country	Crit	ys	Δps	rs	lrs	hps	dis	$poil$	bd
Euro area	3.41	0.86	1.01	0.66	0.53	1.69	2.86	1.75	0.76
USA	3.86	0.38	0.69						

Note: 's' at the end of the variable abbreviation denotes the foreign or 'star' counterpart. Crit stays for the 5% critical value of an F-test.

3.4 Framework for a counterfactual experiment

Estimated GVAR coefficients from (7) were used to conduct a counterfactual experiment which imposes restrictions on the endogenous variables. The purpose is to calculate simultaneously new x_t values and compare them to the GVAR forecast values. The latter present the baseline counterfactual scenario, in which no restrictions on the endogenous variables are imposed. Standard counterfactual exercises compare the simulated values to what actually happened. However, counterfactuals might be subject to significant forecasts errors, "thus making it difficult to distinguish the effects of the restrictions (the counterfactuals) from the forecasts errors associated with the econometric model" (Pesaran et al. (2007)). Therefore, instead to the actual values, I compare the outcome of the restricted counterfactual scenario to the one without the restrictions (i.e. the forecasts).

In order to account for the change in regulatory capital requirements of investment banks, a restriction, that broker-dealer assets remain constant from 2004:2 onwards, has been imposed. Broker-dealer balance-sheets would then remain to their value prior to the SEC reform in April 2004, this is the value in the first quarter of 2004. Furthermore, a counterfactual scenario with a constant quarterly growth rate of 0.615% has been also conducted. This value is chosen so as to represent an exponential growth of the 2004:1-value of broker-dealer assets, so that it equals the asset value in the first quarter of 2009. Thereby, it can be assumed that the balance-sheet bubble since 2004 has not taken place. The both counterfactuals are calculated from 2004:2 onwards, using the actual values of the variables in the 4 quarters prior to the regulation change as the initial values.

Lucas critique It is also assumed that the parameters of the model remain constant at the values estimated from the historical sample. Therefore, some might argue that such a counterfactual experiment may be a subject to the Lucas critique, meaning that the parameters of the model would not remain the same following a regime change. However, there is an issue about what is considered as a regime change, as policy changes constantly. A change in the SEC regulation is not associated with a major policy change, as it is relevant only for a small number of individuals – the broker-dealer sector. It has been argued that most policy changes can be treated as realizations of a random variable, whose distribution has constant parameters. Moreover, the impact of this policy change might be cast as less clear-cut as is shown that the SEC regulation change had unanticipated consequences, which become obvious during the global financial crisis. Therefore, decision makers might need time to anticipate the new structure in order to adjust the parameters of the model. The Lucas critique, however, assumes that agents know the true model of the economy and learn fast the implications associated with policy changes. Finally, despite the Lucas critique, counterfactual experiments are still widely used for market judgement by central banks and other decision makers.

4 Structural impulse response analysis

In order to assess the effects of a deregulation shock, the true economic model for the USA is assumed to have a recursive structure. Moreover, the US variables are not supposed to depend upon euro area economic information within the same quarter. As is common for financial variables, broker-dealer assets are ordered at last in order to react to news about economic activity in the USA without a lag.[8]

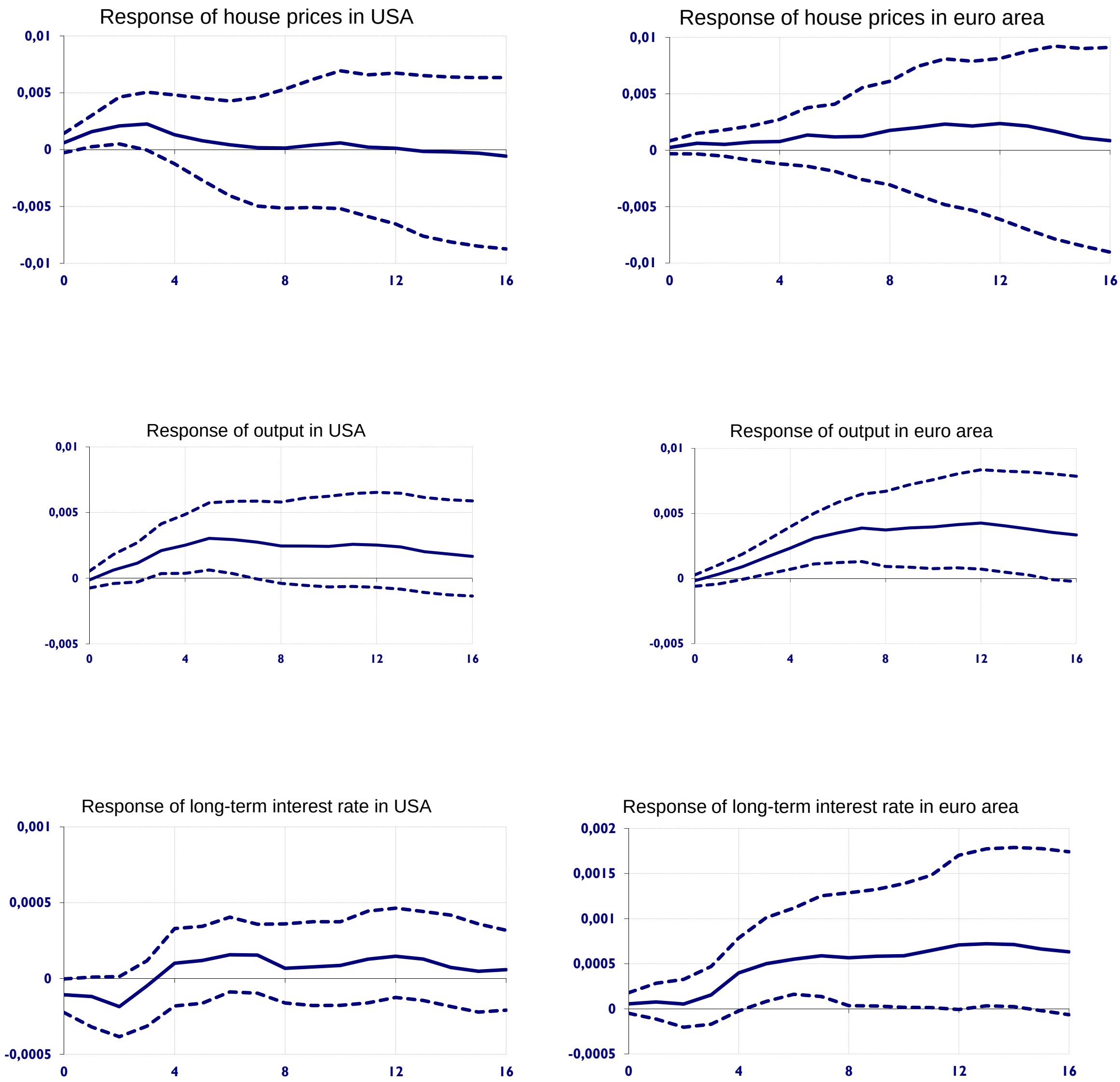
[8]Assuming that broker-dealer assets depend also on euro-specific variables, e.g. calculating the GRIFs, does not change the results.

I follow the identification scheme of US shocks in GVARs conducted by Chen et al. (2010) and Beaton and Desroches (2011). The USA is placed as first in the GVAR model and the US-specific variables are ordered as follows: output, disposable income, inflation, oil prices, short-term interest rates, long-term interest rates, house prices and broker-dealer assets. The US-regulatory capital shock is identified assuming that broker-dealer assets react within a quarter only to domestic shocks. Indeed, their reaction to domestic macroeconomic, interest rate and house price variations is contemporaneous. This is a plausible assumption due to the fact that such financial intermediaries have short-term liabilities and long-term assets and react thus fast to variations in financial market conditions. Ordering broker-dealer assets, however, before all other variables yields highly similar results. The identification of the housing shocks is also common in the literature. The house price equation might be seen as a US housing demand function and is consistent with a theoretical housing model, in which housing depends on disposable income and the cost of borrowing, as approximated by the long-term interest rate (see McQuinn and O'Reilly (2006), Ortalo-Magne and Rady (2006) and Holly et al. (2010)).

4.1 Effect on house prices

Figure 3 shows that regulatory capital shocks increasing broker-dealer assets have significant positive effects on house prices in the USA in the first 3 quarters. A one standard deviation increase in broker-dealer assets is associated with a 0.23% increase in house prices in the USA after 3 quarters. This result underlines the important role played by the securities sector in propagating housing market growth in the USA. Unexpected increases in broker-dealer assets are related to a relaxation of capital requirements. Broker-dealer reserves freed by such deregulation can then be used to increase the purchase of securitized products by other financial borrowers. Banks and mortgage lenders can in turn increase the provision of mortgage loans. Under a limited number of mortgage borrowers who classify for a loan, higher credit supply is associated with easing collateral constraints in order to acquire new, subprime borrowers. Under short-term inelastic housing supply, when given access to the credit market, housing demand from such households may have stronger effects on house prices than demand from unconstrained individuals. Ortalo-Magne and Rady (2006) show in a life-cycle housing model that the ability of young households to afford the down-payment rate can cause house prices to overshoot. Furthermore, Iacoviello (2005) and later Song (2011) construct a dynamic stochastic general equilibrium (DSGE) model to analyze the responses of credit-constrained and unconstrained households to monetary policy and house price shocks. When allowing for collateral effects, the models match better the results from the VAR estimations. The authors find that credit-constrained households are substantially more responsive to both shocks than unconstrained individuals. This pattern might be explained by momentum effects for credit-constrained individuals, who are more optimistic about increases in house prices (see Piazzesi and Schneider (2009)) or by a leverage effect on mortgage borrowers (see Kiyotaki et al. (2011)).

Figure 3: Impulse responses to a shock in regulatory capital requirements



Note: 90% bootstrapped confidence bands with 2000 bootstrap replications. The shock in regulatory capital requirements is identified by a one SD unexpected increase in the assets of broker-dealers. The horizontal axis shows the time after the shock in quarterly terms.

In contrast, the US-specific deregulation shock does not affect significantly house prices in the euro area. One reason for this finding might be the more heterogenous housing markets across euro area countries, which difference in the ownership rates (43% in Germany versus 85% in Spain) or the type of mortgage rate contract (10-year fixed rate in Germany and flexible rate in Spain. Moreover, while Continental and Southern European countries, which outweigh in the euro area sample, have less flexible mortgage markets in terms of loan-to-value ratios, securitization and mortgage equity withdrawal, the latter are higher and widely used in the USA. Thus, the low flexibility of mortgage markets in the euro area, mainly due to low securitization and limited access to financing, can contribute to a low variation in house prices following a shock on financial markets. Another explanation of above result may stem from reallocation of capital away from the euro area and towards the US financial market through the securities sector. As Shin (2012) argues, European banks in the last decade increasingly engaged in the US wholesale market and served as providers of mortgage credit to US households through the shadow banking system. Thus, a shock easing capital requirements in the USA may align capital flows from Europe to the USA and thus affect stronger the US housing market instead of the euro area one.

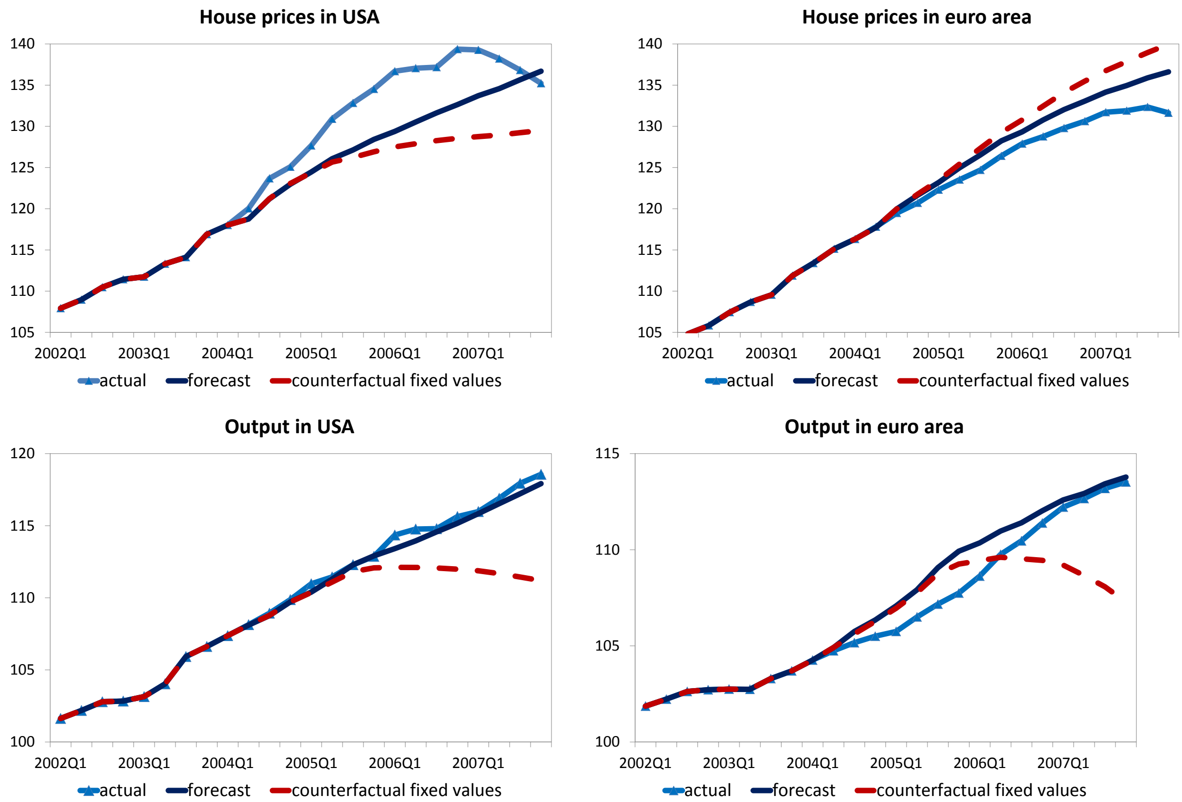
4.2 Effect on output

Interestingly, a US-deregulation shock affects, indeed, output in the euro area and in the USA to a similar extent and in the same direction, with a slightly more significant effect in the euro area (see Figure 3). A one standard deviation deregulation shock increases US GDP by around 0.33% at the end of the sixth quarter and then it starts to recover. In the euro area, the effect of the shock in the first 6 quarters is smaller than in the USA, however, in the next 6 quarters it impacts on euro area GDP twice as much as on the USA, increasing it by 0.45% after 12 quarters. This finding implies that US-specific changes in regulatory capital requirements are not only transmitted to the real economy of other developed countries, but have even stronger medium-term effects on their economic growth than in the USA. The impulse response results are consistent with the findings in Xu (2010) and Eickmeier and Ng (2011), that credit shocks impact significantly on GDP in the USA, the euro area, UK and Japan. Xu (2010) and Eickmeier and Ng (2011) find that a one standard deviation negative credit shock decreases output respectively by 0.5% and 0.3% in the USA and by 0.3% and 0.2% in the euro area. Following a deregulation shock, an 'international financial multiplier' may be set into force through the balance sheets of foreign leveraged financial institutions which expand credit provision and relax credit standards. According to economic theory, an increase in credit provision (through an easing in credit constraints) is accompanied by an increase in firm investments and output growth in the economy. Furthermore, the transmission to output may be also explained by collateral effects for credit-constrained mortgage borrowers who will increase consumption and residential investment following an increase in the value of their collateral – the house price. The subsequent spillover in the foreign economy could be thus, on the one side, a result of the strong trade linkages between the USA and the euro area. On the other side, the finding that the balance-sheet shock to broker-dealers leads to a similar output increase in both countries, might be due to the high integration of their financial markets (see Perri and Quadrini (2011) and van Wincoop (2011) for theoretical models).

4.3 Effect on long-term interest rates

While a US-deregulation shock increases significantly the long-term interest rates in the euro area in the second year after the shock, its effect on the US counterpart is insignificant (see Figure 3). A one

Figure 4: Actual and forecast values of house prices and output compared to a counterfactual of fixed asset values



Note: The counterfactual sets the values of broker-dealer assets from 2004:2 onwards to be equal to their value in 2004:1. The forecasts are conducted based on the estimated GVAR coefficients.

standard deviation shock to broker-dealer assets leads to an increase in 10-year government bond yields in the euro area by 0.07% after 12 quarters. This result is indicative of either stronger effects on expected inflation in the euro area than in the USA or of an anti-cyclical monetary policy in the euro area, which aims to offset the effects associated with the US-deregulatory shock. Such effects might include an increase in credit supply and output. As a consequence, according to the expectations theory of the term structure, expectations of higher future nominal short-term interest rates lead to an increase in long-term interest rates. In contrast, in the USA, a shock to broker-dealer assets is not associated with higher long term interest rates. This finding has also been observed in the data and discussed by Bernanke (2005), Caballero et al. (2008) and Borio and Disyatat (2011).

5 Results from a counterfactual experiment

The results of the counterfactual experiment are presented in Figures 4 and 5. I calculate counterfactual house prices and output setting the values of broker-dealer assets from 2004:2 onwards to either be equal to their value in 2004:1 or assuming that they grow quarterly by 0.615%. These results are then compared to the forecasts from 2004:2 onwards, which are conducted using the estimated model parameters. By using the forecast values instead of the actual values (which are also displayed in the figures), it is assured that the difference from the counterfactual scenario is not due to model forecast errors. The difference between both scenarios will be then a proxy for the effect of the SEC net capital rule reform and thus for the effect of shocks in regulatory capital requirements.

Figure 5: Actual and forecast values of house prices and output compared to a counterfactual of constant asset growth

Note: The counterfactual assumes a constant quarterly growth rate of broker-dealer assets of 0.615% from 2004:2 onwards. The forecasts are conducted based on the estimated GVAR coefficients.

If broker-dealer assets had remained fixed at their 2004:1-value, house prices in the USA would have been about 5.3% lower by the fourth quarter of 2007 (see Figure 4). I refer to the difference between the counterfactual value without the reform and the forecasted value with the reform as the 'deregulation effect'. Without the reform, house prices in the USA would have grown at a lower pace, increasing only by 3% from 2005:2 to 2007:4, instead of by 9% as forecasted[9]. This finding is consistent with the impulse response results for the USA in Section 4. Thus, the role of financial deregulation as a driver of house prices in the USA should not be underrated. As discussed above, the US-specific deregulation shock does not affect significantly the housing market in the euro area and, therefore, no notable 'deregulation effect' has been observed in the euro area. This finding might be due to either the more heterogenous and less flexible mortgage markets in the euro area countries or to redistribution effects of capital towards the US financial market through the securities sector.

[9]Similar growth is observed for the actual values.

The counterfactual path of house prices is sensible to the underlying assumptions about the development of the counterfactual broker-dealer assets. When it is accounted for growth in their assets, the 'regulation effect' in the USA reduces to the half (2.7%) and in the euro area there is no positive effect anymore. Interestingly, under the scenario with fixed balance sheets, the counterfactual house prices in the euro area was even by 2.4% higher than the forecasted. Therefore, a reduction in the negative 'deregulation effect' for the euro area may explain the reduction of the positive 'deregulation effect' in the USA. Actually, about the half of the 'deregulation effect' on US house prices can be related to the 'deregulation effect' on house prices in the euro area. As argued above, this result can be associated with a capital reallocation towards the US financial market through the shadow banking system. This finding may thus endorse the 'global banking glut' hypothesis, in which Shin (2012) argues that European global banks were strongly engaged in the US credit market prior the the global financial crisis of 2007-09.

Under the counterfactual of no rule change, output would be equally lower in both regions. Had broker-dealer assets remained constant since 2004:2, would output have been about by 6% lower in both areas than its forecast for 2007:4 (see Figure 4).[10] These results do not change when the experiment is conducted assuming constant growth of broker-dealer assets (see Figure 5). Indeed, under the counterfactual scenario, output in the USA would have remained constant between 2005:3 and 2007:4, while in the euro area it would have even decreased by 2% between 2006:2 and 2007:4. These findings reveal that deregulation related to capital requirements for broker-dealers might have boosted output through the provision of credit during the bubble period in the last decade in both, the USA and the euro area. The transmission to output can be proceeded by variations in credit-intensive sectors of the economy such as durable consumption and investment. The finding that the euro area GDP decreases to the same extent as the US one can be associated with the strong trade linkages between both regions.

6 Conclusion

It has been widely argued that deregulation of financial markets in developed economies is among the reasons for the global financial crisis of 2007-09. Due to the globalization of trade and financial markets, variations in regulatory capital requirements in one country may affect not only the domestic economy but also spread to other economies. This paper assess empirically the effects of a US-specific financial deregulation shock on housing markets and economic activity, and its transmission to the euro area using a GVAR. Shocks in regulatory capital requirements are measured by variations in broker-dealer assets which serve as a channel of the securitized credit supply to the real economy. Moreover, the GVAR model is used to conduct a counterfactual path of house prices and output in the USA and the euro area under the presumption that the SEC had not changed the existing net capital regulation for broker-dealers

[10] The forecasted and actual values in 2007:4 are almost equal.

in April 2004. Indeed, it has been argued that the reform removed capital requirements on investment banks and enabled them to more than double their leverage, what can have as a consequence an increase in credit supply and trigger a housing bubble.

It was found that deregulation shocks to the securities sector play an important role in propagating housing market growth in the USA. Instead, house prices in the euro area do not respond to the US regulatory capital shock. This finding might be due to either the more heterogenous and less flexible mortgage markets in the euro area countries or to redistribution effects of capital towards the US financial market through the securities sector. However, a US-deregulation shock affects output in both the USA and the euro area in the same direction and to a similar extent which may be due to the strong trade and financial linkages between the two regions. Indeed, the counterfactual results show that if broker-dealer assets had grown to a lower pace from the second quarter of 2004 onwards, output would have stagnated since the third quarter of 2005 in both countries. The counterfactual path of house prices depends on the underlying assumption about the development of broker-dealer assets since 2004. If broker-dealer assets remain unchanged, house prices in the USA would decrease by a similar share as US output, while euro area house prices would increase by the half of this share. This finding may be associated with an increasing engagement of European banks in the US mortgage market through the shadow banking sector.

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