Bank-sovereign risk spillovers in EMU

Marta Gomez-Puig[a], Manish K. Singh[b], Simon Sosvilla-Rivero[c]
[a]Department of Economics & Riskcenter, Universitat de Barcelona, Spain
[b]Department of Economics & Riskcenter, Universitat de Barcelona, Spain
[c]Complutense Institute for Economic Analysis, Universidad Complutense de Marid, Spain

January 2019

Abstract

This paper investigates the cross-sectional spillovers between banking and sovereign risk in the European Economic and Monetary Union (EMU) countries. Average 'distance-to-default' based on all publicly listed banks headquartered in a particular country is used as an indicator of banking risk, while 10-year sovereign yield as the measure of sovereign risk. Using spillover measure proposed by Diebold and Yilmaz (2014), we find evidence of clustering among banks and sovereigns in peripheral and central countries. Except for peripheral countries banks, rest of the clusters are well isolated from each other.

Keywords: yield spreads, bank risk, spillover, vector autoregression
JEL: G13, G21, C58

1. Introduction

The theoretical literature on risk spillover and/or contagion can be classified into two broad categories. When the fundamentals of different countries are connected by the cross-border flow of capital, goods, and services, shocks to one economy gets transmitted to the other via direct linkages. This effect is known as *fundamental-based contagion* (Eichengreen et al. (1996), Kaminsky and Reinhart (2000)). However, at times, financial crises in one country can trigger a crisis elsewhere for reasons unexplained by macroeconomic fundamentals - perhaps because they lead to shifts in market sentiment or changes the interpretation given to existing information. This is known as *wake-up call* or *pure contagion* (Goldstein (1998)).

Sidestepping this contentious issue associated with the definition and existence of episodes of *fundamentals-based* or *pure contagion*, in this paper, we analyse the cross-sectional risk spillover between EMU countries banking and sovereign risk, using the connectedness measure proposed by Diebold and Yilmaz (2014). Based on the directional quantification of risk spillover across risk measures, we try to answer the following questions: (1) how much of the risk premium in the euro-area can be assigned to the domestic market conditions?; and (2) did markets' degree of connectedness play the significant role in cross-market deterioration?

2. Data and methodology

2.1. Assessing banking sector risk

To assess the bank risk, we use a standard forward-looking market-based measure. Based on contingent claim literature, we use 'distance-to-default (DtD)' as the bank risk indicator. Its foundation lies in the isomorphic relationship between equity and call option. Since equity

is a junior claim to debt, it can be modelled as a European call option on the firms' assets (A) with the exercise price equal to the face value of debt (D).

Consider a bank having a simple capital structure with N shares of common stock (market capital E) and all debt denominated as zero coupon bonds (market value F, maturity T). Using value conservation equation:

$$A = E + F \tag{1}$$

Assuming that the assets returns follow the Generalized Brownian Motion, the Black-Scholes option pricing formula yields:

$$E = AN(d_1) - e^{-rT}DN(d_2) \tag{2}$$

where, $N(*)$ is the cumulative normal distribution, r is the risk-free rate, $d_1 = \{ln(\frac{A}{D}) + (r + 0.5\sigma_A^2)T\}/\{\sigma_A\sqrt{T}\}$; and $d_2 = d_1 - \sigma_A\sqrt{T}$.

Applying Ito's Lemma, the asset volatility (σ_A) can be linked with equity volatility (σ_E) as:

$$\sigma_E = N(d_1)\frac{A}{E}\sigma_A \tag{3}$$

Inverting Eqs. 2 and 3 and numerically solving for A and σ_A, yields the T periods ahead DtD as:

$$DtD = \frac{A - D}{\sigma_A A} \tag{4}$$

Once individual banks' DtD are calculated, we consider the banking sector risk as the simple average of individual DtD of all banks headquartered in a particular country. DtD can be interpreted as how many standard deviations the asset value of the bank is away from the debt threshold. The closer it is to zero, the closer the firm is to distress. For detailed calculation methodology, see Singh et al. (2015).

2.2. Assessing sovereign risk

Ten-year benchmark sovereign bond yield (Source: Datastream) is used as the sovereign risk measure. The sample contains eleven EMU countries, six central (Austria, Belgium, Finland, France, Germany and the Netherlands) and five peripheral (Greece, Ireland, Italy, Portugal and Spain). Figure 1 display the evolution of both sovereign and banking risk for individual countries.

[Figure 1 about here.]

2.3. Assessing spillover

Following Diebold and Yilmaz (2014), we first fit a standard vector autoregressive model to the multivariate time series. Secondly, using series data up to, and including, time t, we estimate the H period ahead forecast ($t + H$). Finally, we decompose the forecast error variance for each component with respect to shocks from the same or other components at

time t. Let d_{ij}^H be the fraction of variable i's H-step forecast error variance due to shocks in variable j (*direct spillover*).[1] We define the *Net directional spillover* as,

$$N_{ij} = d_{ij}^H - d_{ji}^H.$$

3. Empirical estimation

As the sample size is small (35 observations), we study the spillover by estimating four separate *direct spillover* tables based on the combination of peripheral and central countries banking and sovereign risk indices (Table 1-2). Estimates are based on the six-month forward forecast, along with the non-parametrically bootstrapped standard errors. The red and yellow cells (grey and light grey when viewed in greyscale) represent the first and second quartiles respectively.

On average, 36.55% of forecast error variances of peripheral countries banking sector can be explained by their own conditions, while this reduces to 29.8% for central countries. Risk spillovers among peripheral countries banks suggest the following uni-directional linkages: Portugal to Greece, Ireland, and Italy; Italy to Spain and Ireland; and Spain to Ireland. Among central countries banking sector, we find high spillover effect from banks in Austria and Finland. German, French, the Netherlands and Belgian banks suggest very balanced cross-sectional spillover. In peripheral sovereigns, we observe a high level of risk spillover from Greece, Italy, and Ireland, while moderate spillover from Portugal. Spanish yield remains isolated and suggests direct linkage only with Ireland. Among central sovereigns, we find well balanced cross-sectional spillovers.

Banks in peripheral sovereigns are mainly affected by Irish and Greek sovereign yields. Banks in Ireland are also moderately affected by yields of central European countries. For central countries banks, we find weak spillover effect from peripheral or central sovereigns.

For sovereigns in the periphery, Ireland is the net recipient of bank risk originated from Spain, Italy, and Ireland. Irish sovereign is also the net shock receiver from French, Austrian and the Netherlands banks. Rest of the peripheral sovereign receive very limited risk spillover from other country's banking sector. For central sovereign, we find moderate risk spillover from the Netherlands banks towards rest of the sovereigns.

Based on *net directional spillover* (Figure 2) among peripheral banks and sovereigns, we find net risk spillover from Greek, Irish and Portuguese sovereign towards Greek banking. Greek yields also have a weak spillover effect on Portuguese banks. Form central sovereigns, Irish banks are the net shock receiver from all countries, except Belgium while Portuguese banks receive shocks from French and Belgian yields.

[Figure 2 about here.]

[1] Since VAR methodologies are sensitive to ordering in case of non-orthogonal shocks, following Diebold and Yilmaz (2014), Koop et al. (1996) and Pesaran and Shin (1998), a generalized VAR decomposition, invariant to ordering, is employed. The methodology allows detection and directional quantification of spillover.

Net directional spillover from central banks to central sovereign suggest that banks in the Netherlands are the biggest risk transmitter. Except for Belgium and France, all sovereign yields are affected. Austrian and Belgian sovereigns transfer risk towards German banks. The interconnection between central banks and peripheral sovereign suggest Ireland as the only linkage. Irish sovereign is the net shock receiver from French, Austrian and the Netherlands banks.

Our main findings are robust to asset-weighted average DtD as the banking sector risk measure, sovereign yield spread (10-year benchmark sovereign bond yield over Germany) as the sovereign risk measure, and spillover based on the decomposition of longer-horizon forecasts (1 or 2 years).

4. Summary

Using spillover measure proposed by Diebold and Yilmaz (2014), we find evidence of clustering among peripheral countries banks, peripheral countries sovereigns, central countries banks, and central countries sovereigns. The spillover effects are very balanced, especially among central countries banks and sovereigns. Bank-sovereign spillover suggests that central and peripheral sovereigns (except Ireland) receive limited risk spillover from peripheral or central countries banks. While central countries banks are well isolated from all sovereign risk, the peripheral countries banks are net receivers from pre-dominantly peripheral, but also from central sovereigns.

Acknowledgement

We are very grateful to the seminar participants at the University of Barcelona for helpful comments and suggestions, and to Fernando Fernandez-Rodriguez for his assistance with the research. One of the authors thanks the Department of Economics at the University of Barcelona for their hospitality. The opinions expressed in this paper are those of the authors, and they do not reflect in any way those of the institutions to which they are affiliated. Responsibility for any remaining errors rests with the authors.

Funding

This work was supported by the Instituto de Estudios Fiscales [grant IEF 151/2017] and the Spanish Ministry of Economy and Competitiveness [grant ECO2016-76203-C2-2-P].

References

Diebold, F. X., Yilmaz, K., 2014. On the network topology of variance decompositions: Measuring the connectedness of financial firms. Journal of Econometrics 182 (1), 119–134.

Eichengreen, B., Rose, A. K., Wyplosz, C., 1996. Contagious currency crises: First tests. Scandinavian Journal of Economics 98, 463–484.

Goldstein, M., 1998. The Asian financial crisis causes, cures, and systematic implications. Institute for International Economics, June 1998, Washington D.C.

Kaminsky, G. L., Reinhart, C. M., 2000. On crises, contagion, and confusion. Journal of International Economics 51, 145–168.

Koop, G., Pesaran, M. H., Potter, S. M., 1996. Impulse response analysis in non-linear multivariate models. Journal of Econometrics 74, 119–147.

Pesaran, M. H., Shin, Y., 1998. Generalized impulse response analysis in linear multivariate models. Economic Letters 58, 17–29.

Singh, M. K., Gómez-Puig, M., Sosvilla-Rivero, S., 2015. Bank risk behavior and connectedness in EMU countries. Journal of International Money and Finance 57, 161–184.

Table 1: Spillovers - I

Among peripheral countries banking and sovereign risk

	Banks-Spain	Banks-Greece	Banks-Ireland	Banks-Italy	Banks-Portugal	Sov-Spain	Sov-Greece	Sov-Ireland	Sov-Italy	Sov-Portugal
Banks-Spain	46.05	2.45	4.64	27.85	4.62	3.95	0.91	9.00	0.25	0.29
Banks-Greece	2.97	38.31	2.36	5.30	22.55	2.42	8.50	6.72	5.54	5.32
Banks-Ireland	18.95	5.77	32.95	18.20	12.92	1.37	0.60	3.75	4.09	1.41
Banks-Italy	23.36	4.10	4.24	34.06	19.05	0.49	4.91	5.48	2.14	2.19
Banks-Portugal	3.28	6.39	1.38	9.45	55.04	1.01	10.84	6.80	1.73	4.07
Sov-Spain	2.74	3.22	0.29	3.14	0.55	62.53	4.87	12.97	4.37	5.32
Sov-Greece	2.06	0.93	0.22	1.65	6.18	0.97	36.20	7.02	29.83	14.94
Sov-Ireland	8.01	2.58	6.10	5.72	2.92	12.92	3.12	49.26	3.03	6.35
Sov-Italy	1.05	3.04	0.44	1.51	1.69	0.75	26.42	4.02	51.39	9.71
Sov-Portugal	0.38	0.27	0.87	0.25	1.64	1.56	28.48	21.53	21.12	23.90

Among peripheral countries banking and central countries sovereign risk

	Banks-Spain	Banks-Greece	Banks-Ireland	Banks-Italy	Banks-Portugal	Sov-Austria	Sov-Belgium	Sov-Germany	Sov-Finland	Sov-France	Sov-Netherlands
Banks-Spain	41.25	5.67	4.50	28.41	8.93	0.70	1.40	2.38	1.50	3.44	1.81
Banks-Greece	6.37	41.31	5.89	11.23	20.30	2.28	2.92	1.13	1.65	5.22	1.69
Banks-Ireland	7.01	6.94	11.14	8.89	11.56	7.93	5.08	9.35	9.23	13.55	9.32
Banks-Italy	22.67	9.13	5.73	37.93	16.40	0.58	4.39	0.24	0.49	2.23	0.19
Banks-Portugal	10.22	10.28	3.94	15.27	27.45	3.82	8.59	2.55	4.35	9.68	3.84
Sov-Austria	1.52	1.49	1.49	2.84	0.94	17.88	8.90	13.93	15.62	20.40	15.00
Sov-Belgium	2.92	1.01	1.58	3.74	2.60	14.24	19.18	9.89	13.36	20.26	11.20
Sov-Germany	0.62	3.37	1.42	0.82	0.76	14.16	6.14	18.83	16.44	19.37	18.05
Sov-Finland	0.68	2.16	1.49	2.22	0.97	15.58	7.55	16.46	16.52	19.62	16.77
Sov-France	0.79	0.98	1.99	0.93	1.63	15.81	11.31	13.76	14.92	23.02	14.86
Sov-Netherlands	0.62	1.71	1.47	1.33	0.85	15.17	6.99	17.41	16.61	19.93	17.91

Table 2: Spillovers - II

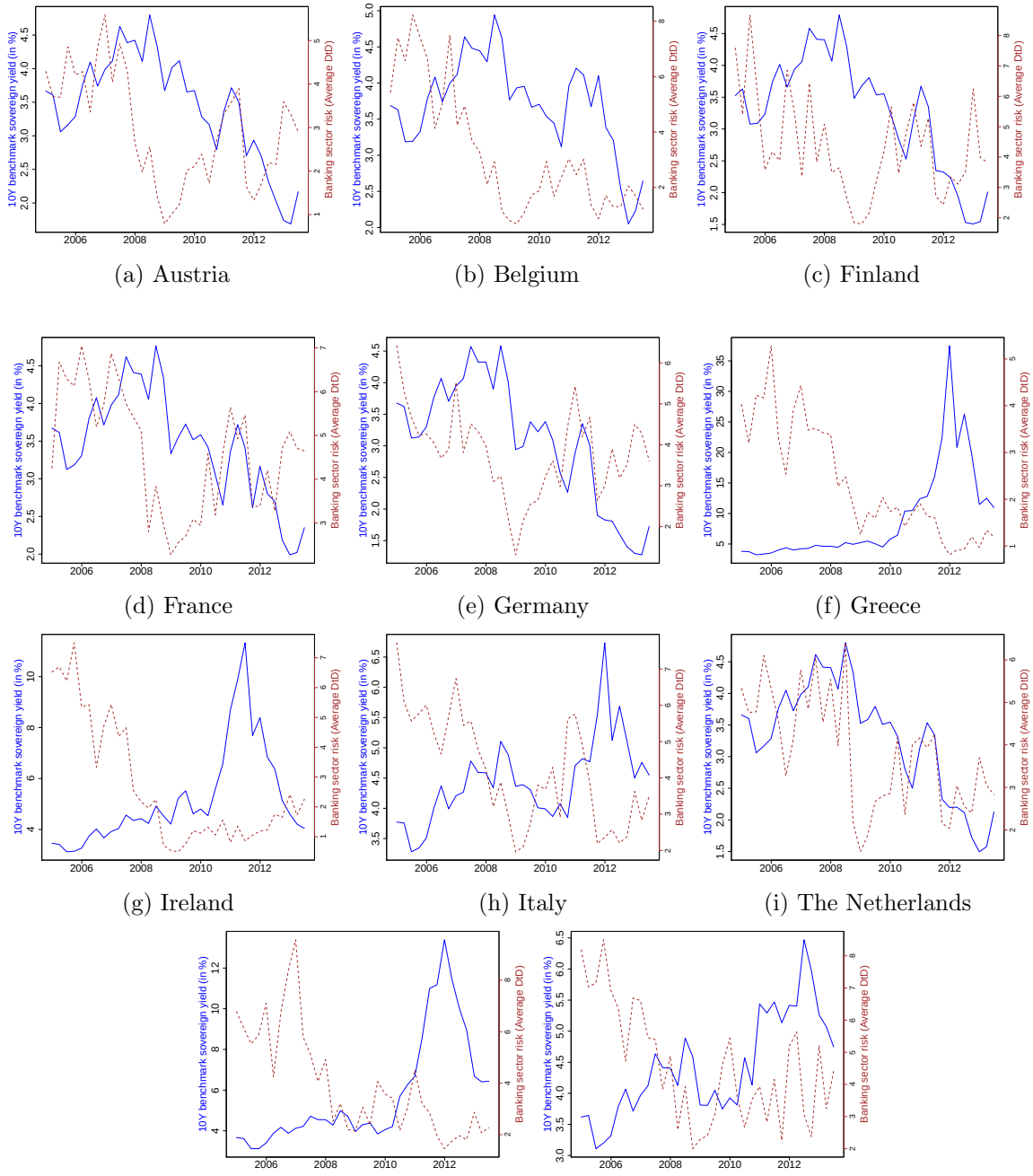
Among central countries banking and sovereign risk

	Banks-Austria	Banks-Belgium	Banks-Germany	Banks-Finland	Banks-France	Banks-Netherlands	Sov-Austria	Sov-Belgium	Sov-Germany	Sov-Finland	Sov-France	Sov-Netherlands
Banks-Austria	23.80	7.10	9.04	28.53	9.21	8.52	1.42	5.10	1.07	1.79	3.26	1.16
Banks-Belgium	14.94	16.57	9.44	24.76	11.36	19.08	0.27	2.82	0.18	0.06	0.42	0.11
Banks-Germany	12.08	6.96	26.00	15.45	7.59	4.50	4.28	10.23	1.50	2.71	6.16	2.53
Banks-Finland	20.38	6.80	11.66	43.34	4.44	6.79	1.08	1.85	0.53	0.75	1.56	0.81
Banks-France	16.04	9.90	10.00	18.34	27.24	10.62	0.74	4.88	0.11	0.28	1.59	0.27
Banks-Netherlands	9.52	7.67	4.68	11.68	11.10	41.89	2.46	1.49	2.76	2.55	1.51	2.68
Sov-Austria	2.58	0.99	0.84	2.50	3.71	6.95	16.62	10.79	12.05	13.92	16.14	12.91
Sov-Belgium	8.22	1.89	5.33	3.56	3.39	2.19	12.64	21.16	7.52	10.83	15.01	8.24
Sov-Germany	2.17	0.51	2.62	0.87	1.59	7.84	12.23	6.06	17.88	15.23	16.03	16.97
Sov-Finland	2.95	0.67	1.06	1.35	2.69	7.30	14.19	8.49	15.09	15.08	16.02	15.10
Sov-France	4.11	0.57	4.67	1.42	2.13	2.60	13.80	12.76	12.18	13.3	19.36	13.11
Sov-Netherlands	1.93	0.47	1.19	0.96	2.29	7.47	13.37	7.40	16.44	15.21	16.46	16.81

Among central countries banking and peripheral sovereign risk

	Banks-Austria	Banks-Belgium	Banks-Germany	Banks-Finland	Banks-France	Banks-Netherlands	Sov-Spain	Sov-Greece	Sov-Ireland	Sov-Italy	Sov-Portugal
Banks-Austria	27.46	7.47	13.69	26.58	7.96	12.32	0.85	0.41	0.14	2.93	0.18
Banks-Belgium	15.26	14.68	15.09	22.38	10.80	15.33	0.26	2.80	1.22	1.80	0.38
Banks-Germany	7.48	3.53	40.57	19.62	5.96	10.08	1.01	4.55	0.90	5.44	0.87
Banks-Finland	16.53	3.99	22.88	35.30	2.40	10.06	0.85	2.33	1.18	3.90	0.58
Banks-France	10.59	6.58	15.20	15.36	16.41	14.53	1.79	6.55	3.52	7.91	1.55
Banks-Netherlands	8.73	4.21	13.05	8.87	10.55	44.24	1.09	3.30	2.28	3.60	0.08
Sov-Spain	3.99	0.23	4.66	0.40	3.50	6.48	42.53	9.25	13.37	8.46	7.13
Sov-Greece	0.33	0.14	1.55	0.29	0.40	2.11	2.02	38.36	14.09	26.06	14.64
Sov-Ireland	7.26	3.26	4.40	2.21	15.12	13.37	4.14	8.40	23.62	11.27	6.95
Sov-Italy	1.72	0.25	4.65	0.71	2.92	1.55	1.93	26.98	7.07	43.87	8.33
Sov-Portugal	0.23	0.28	1.42	0.30	2.30	0.65	2.65	26.26	28.52	17.29	20.11

Figure 1: Country-wise evolution of banking sector and sovereign risk



(a) Austria (b) Belgium (c) Finland

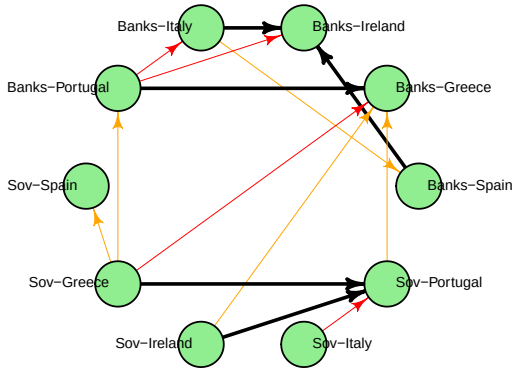
(d) France (e) Germany (f) Greece

(g) Ireland (h) Italy (i) The Netherlands

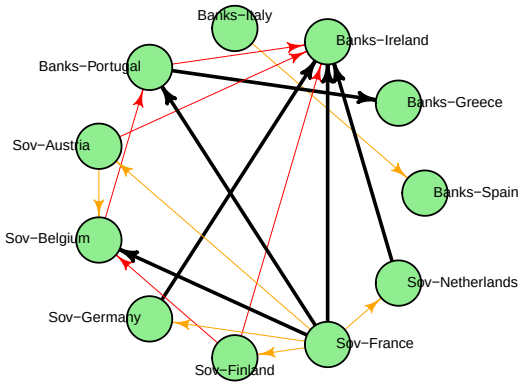
(j) Portugal (k) Spain

Notes: The blue solid and brown dotted line represent the sovereign and banking sector risk for individual countries from 2004Q4-2013Q2 using quarterly data.

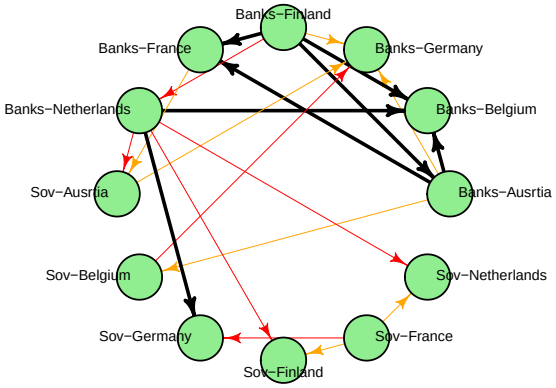
Figure 2: Net directional spillovers



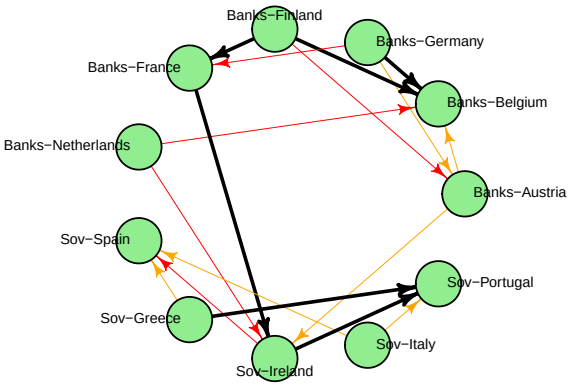
(a) Peripheral countries banking and sovereign risk



(b) Peripheral countries banking and central countries sovereign risk



(c) Central countries banking and sovereign risk



(d) Central countries banking and peripheral countries sovereign risk

Notes: Black, red and orange lines (black, grey and light grey when viewed in greyscale) represent the first, second and third deciles based on net directional spillover.