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Concentration risk and internal rate of return: Evidence from the infrastructure equity market

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Abstract

Although an adequate risk sharing is considered essential for the value for money of Private Finance Initiatives (PFIs), research has not yet considered if the market concentration of equity holders influences the return of projects in which they invest.

Basing on a comprehensive dataset of 706 UK PFIs, our analysis suggests that the equity market concentration influences the return on projects and, therefore, the price paid by the public sector to remunerate its private partners. Furthermore, the return on PFIs is correlated to the power exercised by the central lobby investors, mainly financial ones.

Since the recent evolution of the PFI policy requires a greater involvement of equity holders, policymakers should take into consideration the market concentration risk that can significantly impact on the value for money of such projects.

Keywords: Private finance initiatives; PFI; Internal rate of return; Concentration risk; Equity holders

1. Introduction

Public Private Partnerships are a public procurement model to provide infrastructures and services through a consortium of private investors (Hellowell and Vecchi, 2012). Governments rely on these partnerships to build, transform and modernize non-traded public services and infrastructures, shifting the burden of infrastructure from capital expenditures to future current expenditures (Shaoul, 2005). Among different partnership-types, Private Finance Initiative (PFI) is based on a fee-type reimbursement of the private partner by the sponsoring public body (Winch and Schmidt, 2016). In other words, "the public sector pays a unitary charge which includes payments for ongoing maintenance of the asset, as well as repayment of, and interest on, debt used to finance the capital costs. The unitary charge, therefore, represents the whole life cost associated with the asset" (HM Treasury, 2016, p. 3).

In PFI contracts, an appropriate risk allocation between the public and private partners is essential to achieve value for money (Khan et al., 2014; Khadaroo, 2014). Since the private sector is in a better position to manage risks at lower costs, the more risks are transferred to the private partner, the more the public partner can extract value from PFIs (Grout, 2005). Nonetheless, finding an optimal and workable risk-balance is not easy and it depends also on the bargaining power of partners (Broadbent and Laughlin, 2003; Broadbent et al., 2008) and on the efforts of partners to negotiate and transfer risks elsewhere (Demirag et al., 2012). Since value for money is linked to risk transferred away from the public partner, it is difficult to assess whether PFIs represent good value for money.

As a result, PFI projects are often perceived as a relatively low risk investment for equity investors, being backed by government support with a stable long-term yield and with many of the major risks shifted from investors to subcontractors (Akintoye et al., 2003; Shaoul, 2011).

Chiang et al. (2010) suggest that the internal rate of return (IRR) is the preferred method to evaluate the return on PFI

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projects and the IRR of PFI projects can be also seen as the price paid by the public sector to repay and remunerate its private partners (HM Treasury, 2006). Overall, the literature suggests the presence of high returns for the private partners if compared to the risk they actually borne (Shaoul, 2005) and poorly designed procurement processes and anti-competitive practices among bidders can actually allow equity investors to extract profits (Hellowell and Vecchi, 2012).

An under-investigated topic concerns whether the returns for shareholders can relate also to the equity market structure. On the one hand, a limited number of bidders can actually distort the degree of competition on the market and can affect the IRR of projects. PFIs introduce statutory financial performance obligations, creating barriers to entry and potentially increasing the equity market concentration (Froud et al., 1998). Barriers to entry are inevitably created for smaller firms and/or firms without a recognized track record. On the other hand, some shareholders tend to cooperate rather than compete on capital markets, thus creating a central lobby to exploit the profitability of PFI projects (Asenova and Beck, 2010; Toms et al., 2011).

Although the potential influence of the equity market concentration on the projects' IRR has been postulated in literature, the topic remains surprisingly unexplored. This is even more relevant in light of the current evolution of the PFI policy where the PF2 model requires a greater involvement of equity holders (HM Treasury, 2012).

Building on this premise, this study analyses the impact of the equity market concentration on projects' IRR and, as a consequence, on the price paid by the public sector to repay and remunerate its partners. Our analysis accounts also for the level of control and the co-investment strategies among shareholders to provide a more comprehensive picture of the actual equity market concentration.

Basing on a comprehensive dataset of 706 UK PFIs over a time period of 17 years, our analysis suggests that the equity market concentration influences the price paid by the public partner. Furthermore, the influence of the equity market concentration on IRR is more evident for the central investment lobby, mainly represented by financial shareholders.

In the next sections we present the relevant literature. We then describe the source of data and the method. We present the results and discuss them in light of the current evolution of the PFI policy.

2. The infrastructure equity market structure

One of the potential determinants of the IRR of PFI projects is the market structure, where few investors can influence the price paid by the public partners on contracts. Vecchi et al. (2013) suggest that the most likely source of "excess" return is the lack of competition in the PFI market. The market concentration represents the degree to which a small number of firms account for a relatively large percentage of market shares. Concentration in market share leads to a reduction in the competition for contracts, which may give substantial advantages to the main market players. High market concentration can allow a firm to influence the trading pricing power and vary the quality of products or services if compared to perfect competition (Baumol, 1982).

Even if equity represents a small percentage of the PFI capital value, the control over the project is actually determined by equity holders (Chinyere and Xu, 2012). For example, shareholders usually exercise control over all changes of PFI contracts and strongly control the company's behavior. If investments in the PFI market were to be competitive, companies investing in PFI projects would have a low degree of concentration. On the other hand, a situation of market concentration shows a high degree of ascendancy of equity holders on the market.

Furthermore, firms tend to combine into bigger groups when competing on the market to exploit scale economies and to reach a greater level of ascendancy (Demsetz, 1973). Businesses can be also tactically divided into medium or small firms at their operative level, but strategically cohesive when it comes to larger issues of economic policy (Laeven and Levine, 2008). Large-scale groups are expected to enjoy a greater ascendancy on the public sector than smaller ones. This ascendancy is exercised in terms of concentrated industrial, commercial and financial resources. As such, to investigate the equity market concentration in PFIs it is necessary to account for the holding structure of firms thus considering the parent companies or groups rather than the companies that directly invest in the project.

2.1. Level of control and co-investment pattern

Equity investors exercise different degree of control over decisions taken by the project company, ranging from absolute control to zero control, as specified in the funding agreement of the project (EPEC, 2010).

The concentration based on market shares does not account for the level of control that shareholders have over the projects in which they invest. The major equity holder can indeed have greater decisional power over the project profitability, having more influence over any refinancing decisions (Asenova and Beck, 2003), thus making the level of control an important aspect in the analysis of the market concentration.

Asenova and Beck (2010) also point out that some equity holders can cooperate rather than compete on capital markets, so that the financed projects can meet their profitability expectations. Since the dependence on private capital is an intrinsic characteristic of PFI schemes, it is likely that investors tend to cooperate to increase their power.

Khan et al. (2014) evidence that the creation of PFI contracts requires a strong degree of co-operation between two or more public and private entities. In this regard, not only companies tend to acquire other companies in order to increase their ascendancy on the market, but also investors cooperate with each other, co-investing in the same projects (D'Errico et al., 2009). As a matter of facts, financiers can combine to exploit PFI opportunities and produce lobbying pressures (Demirag et al., 2011; Toms et al., 2011; Asenova and Beck, 2010). Therefore, market concentration can increase if considering the co-investment strategies among investors.

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In the next sections we combine market share, level of control and co-investment pattern to provide a more comprehensive figure of the competitive environment in the PFI market, analyzing whether equity market concentration influences the IRR of projects.

3. Method

3.1. Source of data

The main source of data is the HM Treasury database on UK partnerships from 1997 to 2014[1] (HM Treasury, 2014). All data are provided by the central government departments and administrations. The database contains information, not audited by HM Treasury, about PFI projects that reached financial close by 31 March 2014, excluding expired or terminated projects.

Data include the projects' commissioning body, date of financial close, period of contract, sector (hospitals and acute health, social care, schools, roads and highway, military facility, housing, courts, offices and waste), capital value (total funding requirement at the date of financial close of individual contracts including the aggregate debt and equity finance, plus any capital contributions made by the public sector), unitary charge payments by financial year across the life of the project, ownership information with details on shareholders and their equity stake (i.e., percentage of ownership).

For the upcoming analysis 22 projects were dropped from the initial database of 728 PFI projects due to incomplete data. The final dataset comprises 706 PFI projects. We further cluster the projects according to their market segment, defining a super market segment (Table 1).

We completed the database with a classification of shareholders (financial and industrial) and the identification of their parent company or belonging group. The information is retrieved from the companies' website and/or company reports.

3.2. Dependent variable

To test the influence of market concentration on the returns of PFI projects we carried out an econometric analysis, studying the relationship between yearly average IRR (aIRR) of PFIs and independent variables, including the market concentration.

The IRR of projects indicates the return on the overall project and it proxies the price paid by the public sector to remunerate PFIs. We first computed each project's IRR as the discount rate of the stream of the yearly unitary charges equal to the total capital value at the date of financial close for the project j:

$$Capital\ value_{j,t} = \sum_t \frac{Unitary\ charges_{j,t}}{\left(1 + IRR_j\right)^t}. \quad (1)$$

[1] Private Finance Initiative projects: 2014 summary data, 2014.

Table 1
Most relevant market segments and super market segments.

Market segments	Segment dimension	Super market segments	Super segment dimension
Hospitals and Acute Health	13,536.58 £m	*Healthcare sector*	13,787.56 £m
Social Care	250.98 £mln		
Schools (Non-BSF)	7478.551 £m	*Schools sector*	11,160.36 £m
Schools (BSF)	3543.205 £m		
University	138.6 £m		
Military facility	6109.83 £m	*Military facilities sector*	6109.83 £m
Roads and Highway Maintenance	4825.87 £m	*Roads and Highway Maintenance sector*	4825.87 £m

We then constructed the dependent variable as a yearly average IRR (aIRR), weighted by the capital value of the projects. This proxy indicates the yearly remuneration of all the operational PFI contracts in year t to be paid by the public sector.

$$aIRR_t = \frac{\sum_j Capital\ value_{j,t} * IRR_j}{\sum_j Capital\ value_{j,t}} \quad (2)$$

As we considered all the PFI projects that reached financial close by end of March 2014, the final time series of yearly aIRR consists of 17 observations from 1997 to 2013.

3.3. Independent variables

Acar and Sankaran (1999) suggest using Herfindahl index as a measure of market concentration. According to Jacquemin and Berry (1979), it is preferable both to the Concentration Ratios that simply measure the sum of the market shares of the biggest companies and to the Entropy Index that is more suitable to measure firm diversity. The Herfindahl index considers the squares of the market shares of the n shareholders operating in the market:

$$Herfindahl\ index = \sum_{i=1}^{n} Market\ share_i^2. \quad (3)$$

The index varies from a minimum value of 1/n to a maximum of 1. The former limit refers to a perfectly competitive market, while the latter indicates a condition of monopoly.

Our analysis considers the market share of the holding group rather than of the companies that directly invest in the project. The market share for each shareholder i is computed considering the capital invested by each shareholder in any project j and the overall market dimension (i.e. capital value of all projects in the market).

$$Market\ share_i = \frac{\sum_j Capital\ value_{j,i} * Equity\ stake_{j,i}}{\sum_j Capital\ value_j} \quad (4)$$

However, we modified the market share (and thus the Herfindahl index) to take into account the level of control and the co-investment pattern.

The level of control indicates if a shareholder has the full control over a project, if it is a minor investor or if it shares

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Table 2
Variables explained.

Variable name	Variable description	Data source
Dependent variable		
$aIRR_t$	Yearly average IRR of each project with financial close in year t, weighted by the capital value of the projects.	Our estimation on data provided by HM Treasury, 2014 database (unitary charges and capital value)
Independent variable		
Herfindahl Index* Herfindahl Index	Concentration risk is measured through the Herfindahl index accounting for the level of control and the closeness centrality (Herfindahl Index*) or through the index accounting for the mere market shares (Herfindahl Index).	Our estimation on data provided by HM Treasury, 2014 database (capital value and equity stake)
Control variables		
Private credit	Private credit refers to financial resources provided to the private sector by monetary authorities. As the variable increases, the private sector finds itself in having higher chances to get higher debt, driving interest rate down. Therefore, unitary charges are expected to decrease and so are the internal returns. The annual percentage value is multiplied by the Gross Domestic Product.	World Bank
Corporate tax	Corporate tax refers to taxes on profits. If the tax rate increases, the aIRR decrease as well. The variable is expressed as percentage.	World Bank
Unemployment rate	Unemployment percentage rate creates a risky economy that leads to higher unitary charges and aIRR.	World Bank
Concession period	Concession period is defined as the length of the contract in years and, according to Shen and Wu (2005), it is directly related to the ability of the project to generate cash flows. For each year, concession period is estimated as the average concession period weighted by the capital value of the PFI contracts that result open.	HM Treasury, 2014 database
Time interval	Time interval is calculated as the years between the financial closure and the first unitary charge payment. For each year, time interval is estimated as the average time period weighted by the capital value of the PFI contracts that result open. The longer the time interval, the riskier the project, the greater the aIRR.	HM Treasury, 2014 database

control with other shareholders. It is a proxy of the influence that each shareholder has on the projects (see Technical Appendix A for details).

We measure the co-investment pattern among investors through a social network analysis (De Nooy et al., 2005), since shareholders may decide to repetitively co-invest with each other to strategically increase their combined ascendancy on the market. The PFI market is described through a one-mode network in which each shareholder is connected to other shareholders if they co-invest in the same projects (see Section 3.4). Central and dominant shareholders are detected through centrality indexes (D'Errico et al., 2009). In particular, closeness centrality indicates how many shareholders interact with the shareholder i (see Technical Appendix A for details) while K-core indicates the strength of the centrality index and identifies whether the most central shareholders are clustered, representing a cohesive group of co-investors creating a lobby of co-investments, or rather scattered all over the network (see Technical Appendix A for details).

The market share is therefore modified by the level of control and by the centrality indicator weighted by the power of the central lobby on the market (k), identified through the sum of the market shares of the investors belonging to the maximum k-core subgroup. The level of control has a unitary coefficient, since it already represents the relevance of owning of a certain market share:

$$Market\ share_i^{modified} = Market\ share_i (1 * Level\ of\ control_i + k_i * Closeness\ centrality_i) \quad (5)$$

In order to have a convergence to the unitary value, as by definition of the market share, we normalized the Market Share^{modified} (from now on, Market Share*). Finally, we computed the Herfindahl Index* as follows:

$$Herfindahl\ index^* = \sum_{i=1}^{n} Market\ share_i^{*2}. \quad (6)$$

Together with the Herfindahl index, we consider other independent variables to account for the risks borne by the private sector (Table 2).

3.4. Descriptive analyses

3.4.1. Co-investment pattern

To study the co-investment patterns among investors, we implemented a one-mode network in which vertices represent investors and edges represent the co-investment relationships. In a one-mode network, investors are connected in case they invest in the same projects.

The PFI one-mode network is characterized by a major subnetwork, some minor subnetworks, and many isolated investors having full control (100% stakes) of their projects, thus showing no co-investment patterns (Fig. 1).

We computed different centrality measures (degree centrality, betweenness centrality, and closeness centrality) for each shareholder to account for their centrality, thus their relevance, in the PFI market (see Table A1 in Technical Appendix A).

We carried out a scale-free analysis to verify the presence of hubs in the network. According to D'Errico et al. (2009), degree centrality indexes allow to test the presence of hubs in the network. Degree centrality coefficient of variation confirms

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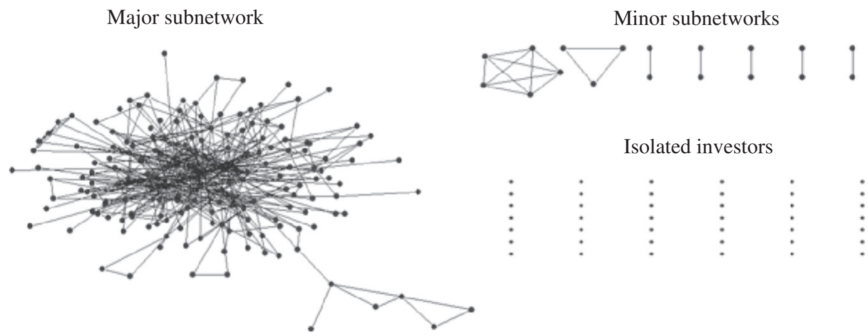

Fig. 1. One-mode network of the PFI market.
Source: our elaboration with Pajek on data from HM Treasury, 2014 database.

Table 3
Market share (2014), modified with control index and closeness centrality.

Shareholder	Market share	Level of control	Closeness centrality	Market share*	K-Core
InfraRed Capital Partners LLP	9.84%	0.71	0.356	11.20%	7
Semperian PPP Investment Partners Holdings LTD	8.32%	0.73	0.330	9.50%	7
Innisfree Group LTD	7.59%	0.62	0.301	7.50%	7
John Laing Group PLC	4.99%	0.58	0.317	4.71%	7
Balfour Beatty PLC	4.96%	0.78	0.294	5.86%	6
EADS Matra Datavision in Vereffening NV	4.49%	1.00	0.191	6.36%	3
3i Group PLC	4.41%	0.68	0.343	4.81%	7
Lend Lease Corp LTD	2.62%	0.74	0.292	2.98%	6
Veolia Environmental Services (UK) PLC	2.47%	0.78	0.233	2.86%	3
Skanska AB	2.34%	0.58	0.277	2.13%	6

Table 4
Investors with highest K-Core (2014).

Shareholder	K-Core	Market share
3i Group PLC	7	4.41%
Amber Infrastructure Group Holdings LTD	7	1.36%
Dalmore Capital Fund LP	7	0.80%
Equitix Holding LTD	7	1.99%
InfraRed Capital Partners LLP	7	9.84%
Innisfree Group LTD	7	7.59%
Interserve PLC	7	1.48%
John Laing Group PLC	7	4.99%
Lloyds Banking Group PLC	7	2.20%
Semperian PPP Investment Partners Holdings LTD	7	8.32%
Sodexo Investment Services LTD	7	0.86%
Most central k-core market power		43.85%

the hypothesis of the presence of scale-free property, and the consequent presence of hubs.[2]

Table 3 shows the control indicator, closeness centrality and K-core for investors with bigger markets shares in 2014. Results do not substantially differ in previous years.

Investors with bigger market shares tend to have a high average control indicator meaning that they can exercise considerable influence as majority shareholders.

Through components analysis and k-core method it is possible to identify and to extract cohesive subnetworks from the whole network. From this analysis, we noticed the presence of a central core of eleven shareholders representing a strongly connected subnetwork investing in the same projects. These shareholders are even those with bigger market shares, establishing more connections with others through co-investments strategies (Table 4). Fig. 2 provides a graphic representation of the biggest k-cores. The biggest sub-connected k-core network is characterized by firms investing with at least other seven investors, therefore leading to a maximum k-core value of seven. The market shares of the investors inside this network amount to 43.85% and the coefficient for the closeness centrality index in the final market shares value is 0.44. With the confirmation of the scale-free and consequently of the hub existence[2], there is the certainty that the k-core analysis identifies the most central investors in the network.

Further, the central lobby identified through this method is entirely constituted by financial investors despite the number of financial and industrial investors in the entire equity market is almost the same. Therefore, financial investors play a central role on the market, constituting the central lobby in co-investment strategies.

3.4.2. Market concentration and aIRR

The time series of yearly aIRR evidences that from 1997 to 2000 the aIRR of projects exceeded the 20% (Fig. 3). During years, a considerable number of projects reached financial close, dragging the yearly aIRR to lower levels.

3.4.3. Equity market concentration

The time series of the Herfindahl index suggests that market concentration has decreased over time. In the first years, the market was characterized only by the presence of big investors, creating high market pressure (Fig. 4). During years, the market concentration decreased until the actual situation close to perfect competition with no market leaders emerging.[3]

[2] Analyses not showed, available upon request to the authors.

[3] The Entropy Index and Concentration Ratio show the same result. Analyses not showed, available upon request to the authors.

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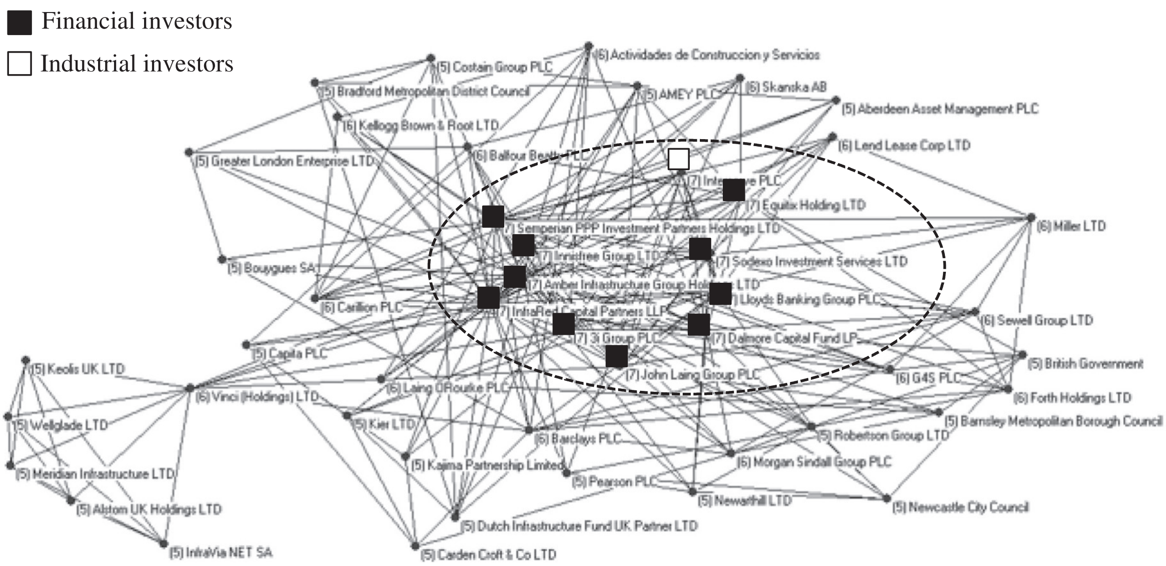

The figure includes shareholders with the highest K-Core (5, 6, 7). The circle includes only the investors with a K-Core of 7, thus representing the central lobby.

Fig. 2. Co-investment pattern (2014).

4. Results

To test the relation between market concentration and aIRR we use a linear regression model accounting for all the variables:

$$aIRR = \beta_0 + \beta_1 Herfindahl\_Index^* + \beta_2 Private\_Credit + +\beta_3 Corporate\_Tax + \beta_4 Unemployment\_Rate + \beta_5 Concession\_Period + \beta_6 Time\_Interval + \varepsilon. \quad (7)$$

The OLS regression model takes into account all the independent variables. Results are shown in Table 5. T-value and P-value tests statistics reject the null hypothesis of non-significance of the parameters' estimation at a level of confidence of 10% for all the variables, except for the unemployment rate and concession period. However, the model presents problems of multicollinearity for the variables presenting high Variance Inflation Factor.

To better deal with potential multicollinearity problems, reducing the number of variables in the model, we used a stepwise selection procedure. Stepwise selection constructs a sequence of regression models by adding or removing variables at each step on a partial F-Fisher test, selecting variables with the highest correlation with the response (Montgomery and Runger, 2003). Results of the second linear regression model are shown in Table 6.

Stepwise selection inserts in the model only the most relevant variables in explaining the variability of the aIRR. T-value and P-value statistics for all regressors reject the null hypothesis of non-significance of the coefficient estimated at a significance level of of 5%. Herfindahl index* and time interval show a positive effect on aIRR, while private credit shows a negative effect.

Overall, an increase of 0.1 in market concentration would determine an absolute increase of the percentage rate of return of investments of 5.56%. Private credit values show an opposite effect on aIRR values, evidencing that the price paid by the public

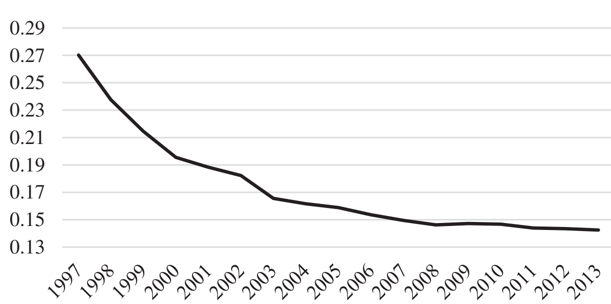

Fig. 3. Time series of yearly aIRR.

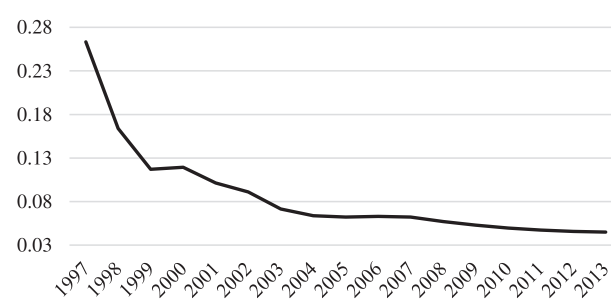

Fig. 4. Time series of Herfindahl Index.

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Table 5
OLS using observations from 1997 to 2013 (T = 17).

Parameter	Coefficient		Std error	T-value	P-value	VIF
Constant	0.132		0.080	1.65	0.129	–
Herfindahl Index*	0.441	***	0.053	8.24	0.000	12.46
Private Credit	−9.41e−06	*	4.74e−06	−1.99	0.075	16.15
Corporate Tax	0.160	*	0.082	1.95	0.080	5.21
Unemployment Rate	0.325		0.189	1.72	0.116	7.32
Concession Period	−0.003		0.003	−1.25	0.239	13.56
Time Interval	0.031	**	0.010	3.07	0.012	2.81
R-squared	99.48%					
R-squared adjusted	99.17%					
F-value (6, 10)	318.88					
P-value (F)	0.0000					

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

partner depends on the actual availability of private finance. With maximum VIF of 4.5, there are not multicollinearity problems.

The final hypotheses consist in the verification of the randomness and normality distribution of residuals of regression. With a P-Value of 98.54% of the Chi-squared Shapiro–Wilk normality test, the null hypothesis of normality distribution cannot be rejected at a level of confidence of 5%. Concerning the randomness of residuals, the non-parametric run test does not reject the null hypothesis of data independently distributed at a level of confidence of 5%.

For this reason, aIRR and Herfindahl index* accounting for co-investment patterns are analyzed in a time series analysis. Any time series model would need to include the study of autocorrelations among variables and eventually the analysis of first differences and the consequent construction of a Vector Autoregression model, whose parameters would be impossible to estimate due to the length of time series. To solve this problem, only aIRR and Herfindahl index* are analyzed in a time series analysis. The presence of only two variables grants not to run out of degree of freedom, which would have occurred in the estimation of a Vector Autoregression model, as well as the study of the two variables separately from the other sources of risk:

$$aIRR_t = \theta * Herfindahl\_Index^*_t + \varepsilon_t. \quad (6)$$

According to Greene (2002), the assumption is the disturbances ε_t to be a stationary white noise time series. If the two time series are both integrated of the same order, then there might be a value of θ such that the disturbance is stationary, which can be assessed through the Engle and Granger method with the application of the Dickey-Fuller test. Two series are cointegrated if they satisfy this requirement. If cointegration is verified, the estimator of θ happens to be superconsistent and it asymptotically tends to the real value of the coefficient faster than any other OLS estimations.

Table 6
Stepwise selection and OLS using observations from 1997 to 2013 (T = 17).

Parameter	Coefficient		Std error	T-value	P-value	VIF
Constant	0.073	***	0.020	3.696	0.003	–
Time interval	0.044	***	0.009	4.650	0.001	1.99
Private credit	−6.12e−06	**	2.790	−2.194	0.047	4.51
Herfindahl Index *	0.556	***	0.029	19.09	0.000	2.98
R-squared	99.16%					
R-squared adjusted	98.97%					
F-value (3, 13)	512.46					
P-value (F)	9.63 e−14					

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 7
Time series analysis using observations from 1997 to 2013 (T = 17).

Parameter	Coefficient	Std error	T-value	P-value
Constant	0.209 ***	0.010	20.69	0.000
Herfindahl Index*	0.278 ***	0.041	6.736	0.000
Linear trend	−0.011 ***	0.001	−7.899	0.000
Quadratic trend	0.001 ***	0.000	6.561	0.000
R-squared	99.34%			
R-squared adjusted	99.19%			

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

The autocorrelation and partial autocorrelation functions suggest the presence of one degree of autocorrelation and one degree of non-stationariety for both variables. Variables are tested under the Engle-Granger test. Dickey-Fuller test is executed under the hypothesis of the existence of one order of autocorrelation, a drift, a linear and a quadratic trend. The null hypothesis of the existence of a unitary root cannot be rejected for the Herfindahl index* time series as well as for the aIRR time series at a significance level of 5%, due to P-values of 8.87% and 26.12% respectively. Therefore, the two time series are integrated. Since the null hypothesis of unitary root for the residuals of linear regression is rejected at significance level of 5%, with a P-value of 1.81%, cointegration is verified (Table 7).

The regression confirms the presence of a parabolic trend for the aIRR with a direct linear relationship with the Herfindahl index*.

4.1. Additional analyses

4.1.1. Central lobby of investors and aIRR

We test the impact of the co-investment pattern and there is an evidence of the relevance of a positive correlation existing between the aIRR and the global market power exercised by the

Table 8
OLS using observations from 1997 to 2013 (T = 17).

Parameter	Coefficient	Std error	T-value	P-value	VIF
Constant	0.087 ***	0.009	9.72	0.000	–
Max K-Core market power	0.079 ***	0.022	3.59	0.003	3.17
Herfindahl Index	0.484 ***	0.054	8.93	0.000	3.17
R-squared	97.06%				
R-squared adjusted	96.64%				
F-value (2, 14)	230.76				
P-value (F)	1.92 e−11				

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

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most central investors on the market. Herfindahl index and co-investment pattern do not show multicollinearity (Table 8).

This substantiates the connection between the power of the central lobby and the aIRR in combination to the market power of the investors constituting it. Moreover, the central lobby is constituted by almost the same financial investors over years. Such investors tend to maintain their central position in the network and to increase their interconnectedness.

4.1.2. Sectorial analysis

The econometric analysis computed on the whole PFI market is replicated on the most relevant market infrastructural segments (Table 9), to verify their degree of competitiveness.

Regarding the healthcare sector, it is possible to estimate only the linear regression model, as a few variables emerge as significant. Corporate tax and the Herfindahl index* are positively correlated to the aIRR. Herfindahl index* has a coefficient of 0.16, showing a discrete influence of market concentration over the returns on investments. Moreover, concession period has a negative impact over aIRR, contrarily to what stated by the theoretical assumption, but accordingly to empirical results reached even by De Marco and Mangano (2013) on the same sector.

Regarding the roads and highway maintenance sector, a few variables emerge as significant. Herfindahl index* shows higher direct effect on the aIRR, with a coefficient of 0.67. Even unemployment rate shows a positive effect on the aIRR time series.

Time series analysis through Engle-Granger test of cointegration is possible on schools sector, probably due to the great number of projects on the market that leads to more consistent aIRR values. Herfindahl index* shows a lower direct marginal effect on the aIRR.

Table 9
Sectorial analysis.

Healthcare sector		Roads and highway maintenance sector	
Parameter	Coefficient	Parameter	Coefficient
Constant	0.380 ***	Constant	0.363 *
Herfindahl Index *	0.155 ***	Herfindahl Index *	0.665 ***
Private credit	−1.3 e−05 ***	Unemployment rate	0.940 ***
Corporate tax	0.103 ***	Concession period	−0.011
Concession period	−0.008 ***		
R-squared	99.51%	R-squared	91.65%
R-squared adjusted	99.34%	R-squared adjusted	89.56%

School sector

Parameter	Coefficient
Constant	0.113 ***
Herfindahl Index *	0.157 ***
R-squared	52.65%
R-squared adjusted	49.01%

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

5. Discussion and conclusions

Basing on the UK PFI market, the risk of equity market concentration emerges as an important determinant of projects' IRR, while it was previously unconsidered in the literature. The yearly average return on PFI projects in the UK has indeed declined over time following a reduced concentration of equity holders. An increasing number of investors entered the PFI market over years, attracted by high returns. The entrance of new investors has enhanced a greater competition leading to declining returns. Overall, a greater level of competition has clearly benefited the public sector in terms of lower price to be paid on projects, thus suggesting that market-driven policies can actually benefit the public sector.

Nonetheless, looking at the market structure of investors, the analysis shows the presence of a central lobby of investors and a correlation between the aIRR and the market power exercised by them. Despite a higher degree of competition, returns are influenced by the central lobby of investors that can affect the price paid by the public sector on PFIs. These investors maintained their central position in the network over time and they also increased their interconnections. There is therefore stability in the market structure of the most central lobby of investors despite they decreased their market shares due to the entry of new investors. The explanation can be twofold: on the one hand, first-mover investors who constitute the central lobby can increase their ascendancy by leveraging their past experience on the market if compared to the newcomers. On the other hand, the central lobby of interconnected investors can enjoy a greater level of ascendancy by concentrating industrial, commercial and financial resources. Finally, the central lobby is composed mainly by financial investors thus potentially being more focused on financial returns than industrial ones.

These results are significant in light of the current evolution of the PFI policy, with the PF2 model in England. On the one hand, PF2 requires the public sector to become a minority equity co-investor in the projects. This novel governance structure could indeed affect the IRR of projects since the public sector will share the investment returns, reducing the overall cost of projects to the public sector (HM Treasury, 2012). On the other hand, PF2 aims at attracting new long-term equity investors (such as pension funds) by introducing an equity funding competition, after the preferred bidder stage, for a portion of the private sector equity.

If this policy will result in an increased competition in the equity market, the public sector will benefit in terms of a lower price to be paid to remunerate projects. On the contrary, if this policy will favor existing shareholders increasing their market power, the benefits for the public partner are less clear.

Future research needs to consider whether the increase in market competition can impact the quality of the infrastructures and services delivered by the private sector in the partnerships. It could be indeed possible that a reduction in market concentration leads to a reduction in the degree of the quality of the services delivered. In this case, a certain degree of market concentration can grant the market leaders and most specialized investors an advantage to win the projects and deliver better quality services.

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Appendix A. Technical Appendix

A.1. Level of control

The level of control index is structured in two levels. The first level refers to each single project to indicate the level of control of shareholder *i* over the project *j*. In any project we can identify:

- Major shareholder: shareholder with the highest investment in the project. If there is a single major shareholder, his $Level\ of\ control_{i,j}$ ($LOC_{i,j}$) is equal to 1. If more than one shareholder has the same investment, i.e. the control is shared, both investors will have the same index, which will be equal to their percentage stake in the project.
- Minor shareholders: any minor shareholder will have a $Level\ of\ control_{i,j}$ equal to 0.

The second level refers to the control of each shareholder *i* on the overall portfolio of projects, without taking into account the dimension of the projects in which the control is established.

$$Level\ of\ control_i = \frac{\sum_{j=1\ldots M} Level\ of\ control_{i,j}}{M} \tag{a}$$

Considering the example above (Fig. A1), the level of control of the three shareholders over the projects financed in the market will be 0.17, 0.83 and 0 respectively. This measure is thus a proxy of the influence of each shareholder on the projects.

A.2. Closeness centrality

The Closeness Centrality of a vertex is the number of other vertices divided by the sum of all distances between the vertex and all others. Given $geodesic_{ki}$ the number of lines that connects *k* to *i* following the shortest path, the closeness centrality for an edge *i* assumes the following expression (Freeman, 1979):

$$Closeness\_Centrality_i = \frac{\sum_{k \neq i} k}{\sum_{k,i} geodesic_{ki}}. \tag{b}$$

If the network is separated in subnetworks, for each vertex the value of closeness centrality is weighted by the percentage of the reachable vertices in the subnetwork.

Applying it to our case, as in Eq. (c), for every shareholder in the network, we account for both how many investors interact with the shareholder *i* and how central is the shareholder in respect to the subnetwork in which it operates, and the dimension of the subnetwork in respect to the whole market:

$$Closeness\ centrality_i = \frac{Number\ of\ reachable\ vertices}{Sum\ of\ shortest\ paths\ in\ the\ subnetwork} * \frac{Number\ of\ vertices\ of\ the\ subnetwork}{Total\ vertices\ of\ the\ network} \tag{c}$$

Values of closeness centrality vary between 0 (highly disconnected network in which nodes have no connections one with the others) and 1 (central node in a non-divided network).

A.3. Degree centrality

Degree Centrality is based on the idea that information easily reaches people who are central in the network and more connected to the others (Freeman, 1979). A first estimation is the number of other vertices to which one is connected. According to D'Errico et al. (2009), inside a graph *G(V,E)*, the degree of a vertex $i \in V$ is defined as the number of edges incident to *i*, or as its number of neighbors. The more interconnected the vertex, the higher the degree value.

A.4. Betweeness centrality

Betweenness Centrality of a vertex is the portion of all geodesics between pairs of other vertices that include this vertex. Given two edges *i* and *j*, with $i \neq j$, $geodesic_{ij}$ the number of geodesic from *i* to *j* and *geodesicij(k)* the number of geodesics between *i* and *j* passing through *k*, the betweenness centrality for an edge *k* assumes the expression of:

$$Betweenness\_Centrality_k = \sum_{i,j \neq k} \frac{geodesic_{ij}(k)}{geodesic_{ij}} \tag{d}$$

A.5. K-core

The K-Core method allows the identification of coefficient weights for the closeness centrality index.

The presence of hubs that hold the network together is a test of the strength of centrality indexes, which can be verified through the detection of power law distribution in the degree measures (Barabasi and Albert, 1999). According to De Nooy et al. (2005), a k-core is the maximal subnetwork in which each investor has at least degree k within the subnetwork. The index identifies whether vertices with the highest degree are clustered or scattered all over the network and the existence of the most cohesive group of co-investors creating a lobby of co-investments.

A proxy of the power of such investors is the sum of the market shares of investors being in the subnetwork with the highest k-core *p*.

$$k_i = \sum_{i \in \max_p \{k-core_p\}} Market\ share_i \tag{e}$$

Table A1
Centrality measures for the most relevant shareholders (2014).

Parent company or group	Closeness centrality	Degree centrality	Betweenness centrality	Market share
InfraRed Capital Partners LLP	0.356	46	0.087	9.84%
Semperian PPP Investment Partners Holdings LTD	0.330	35	0.042	8.32%

(continued on next page)

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Table A1 (*continued*)

Parent company or group	Closeness centrality	Degree centrality	Betweenness centrality	Market share
Innisfree Group LTD	0.301	20	0.016	7.59%
John Laing Group PLC	0.317	25	0.043	4.99%
Balfour Beatty PLC	0.294	16	0.025	4.96%
EADS Matra Datavision in vereffening NV	0.191	3	0.000	4.49%
3i Group PLC	0.343	38	0.085	4.41%
Lend Lease Corp LTD	0.292	17	0.021	2.62%
Veolia Environmental Services (UK) PLC	0.233	3	0.000	2.47%
Skanska AB	0.277	11	0.005	2.34%
Lloyds Banking Group PLC	0.325	29	0.039	2.20%
Equitix Holding LTD	0.325	27	0.056	1.99%
Cobham PLC	0.241	8	0.005	1.85%
Carillion PLC	0.284	18	0.010	1.77%
Interserve PLC	0.304	19	0.014	1.48%
Kellogg Brown & Root LTD	0.267	8	0.002	1.46%
Amber Infrastructure Group Holdings LTD	0.370	62	0.128	1.36%
Aberdeen Asset Management PLC	0.262	9	0.014	1.25%
AMEY PLC	0.299	15	0.048	1.16%
GDF Suez Cofley & Uberior LTD	0.251	8	0.005	1.12%

Table A2
Equity investors with the highest values of k-core (2014).

Equity holder owner	K-Core	Equity holder owner	K-Core
3i Group PLC	7	Lend Lease Corp LTD	6
Amber Infrastructure Group Holdings LTD	7	Miller LTD	6
Dalmore Capital Fund LP	7	Morgan Sindall Group PLC	6
Equitix Holding LTD	7	Sewell Group LTD	6
InfraRed Capital Partners LLP	7	Skanska AB	6
Innisfree Group LTD	7	Vinci (Holdings) LTD	6
Interserve PLC	7	Aberdeen Asset Management PLC	5
John Laing Group PLC	7	Alstom UK Holdings LTD	5
Lloyds Banking Group PLC	7	AMEY PLC	5
Semperian PPP Investment Partners Holdings LTD	7	Barnsley Metropolitan Borough Council	5
Sodexo Investment Services LTD	7	Bouygues SA	5
Actividades de Construccion y Servicios	6	Bradford Metropolitan District Council	5
Balfour Beatty PLC	6	British Government	5
Barclays PLC	6	Capita PLC	5
Carillion PLC	6	Carden Croft & Co LTD	5
Forth Holdings LTD	6	Costain Group PLC	5
G4S PLC	6	Dutch Infrastructure Fund UK Partner LTD	5
Kellogg Brown & Root LTD	6	Greater London Enterprise LTD	5
Laing O'Rourke PLC	6	InfraVia NET SA	5

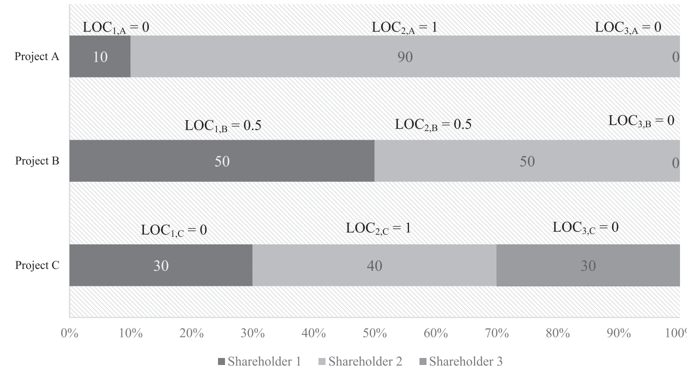

Fig. A1. Examples of level of control.

References

Acar, W., Sankaran, K., 1999. The myth of unique decomposability: specializing the Herfindahl and entropy measures? Strateg. Manag. J. 20 (10), 969–975.

Akintoye, A., Beck, M., Hardcastle, C., 2003. Public–Private Partnerships: Managing Risks and Opportunities. Blackwell Science Ltd., Oxford, UK.

Asenova, D., Beck, M., 2003. The UK financial sector and risk management in PFI projects: a survey. Public Money Manag. 23 (3), 195–203.

Asenova, D., Beck, M., 2010. Crucial silences: when accountability met PFI and finance capital. Crit. Perspect. Account. 21, 1–13.

Barabasi, L., Albert, R., 1999. Emergence of scaling in random networks. Science 286, 509–512.

Baumol, W.J., 1982. Contestable markets: an uprising in the theory of industrial structure. Am. Econ. Rev. 72, 1–15.

Broadbent, J., Laughlin, R., 2003. Control and legitimation in government accountability processes: the private finance initiative in the UK. Crit. Perspect. Account. 14, 23–48.

Broadbent, J., Gill, J., Laughlin, R., 2008. Identifying and controlling risk: the problem of uncertainty in the private finance initiative in the UK's National Health Service. Crit. Perspect. Account. 19 (1), 40–78.

Chiang, Y., Cheng, E., Lam, P., 2010. Employing the net present value-consistent IRR methods for PFI contracts. J. Constr. Eng. Manag. 136 (7), 811–814.

Chinyere, I.I., Xu, X., 2012. Public–private partnerships: the underlining principles of infrastructure investment, finance and development projects. Int. J. Bus. Manag. 7 (1), 109–125.

De Marco, A., Mangano, G., 2013. Risk and value in privately financed health care projects. J. Constr. Eng. Manag. 139, 918–926.

De Nooy, W., Mrvar, A., Batagelj, V., 2005. Exploratory Network Analysis with Pajek.

Demirag, I., Khadaroo, I., Stampleton, P., Stevenson, C., 2011. Risks and the financing of PPP: perspectives from the financiers. Br. Account. Rev. 43 (4), 294–310.

Demirag, I., Khadaroo, I., Stapleton, P., Stevenson, C., 2012. The diffusion of risks in public private partnership contracts. Account. J. 16 (3), 332–341.

Demsetz, H., 1973. Industry structure, market rivalry, and public policy. J. Law Econ. 16 (1), 1–9.

D'Errico, M., Grassi, R., Stefani, S., Torriero, A., 2009. Shareholding networks and centrality: an application to the Italian financial market. In: Ahmad (Ed.), Networks, Topology and Dynamics. Springer, pp. 215–228.

EPEC, 2010. Capital Markets in PPP Financing. Where We Were and Where Are We Going? Luxembourg.

Freeman, L.C., 1979. Centrality in social networks conceptual clarification. Soc. Networks 1, 215–239.

Froud, J., Haslam, C., Johal, S., Shaoul, J., Williams, K., 1998. Persuasion without numbers? Account. Audit. Account. J. 11 (1), 99–125.

Greene, W.H., 2002. Econometric Analysis. Prentice Hall.

Grout, P.A., 2005. Value-for-money measurements in public-private partnerships. EIB Pap. 10 (2), 33–56 (ISSN 0257–7755).

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Hellowell, M., Vecchi, V., 2012. An evaluation of the projected returns to investors on 10 PFI projects commissioned by the National Health Service. Financ. Account. Manag. 28 (1), 77–100.

HM Treasury, 2006. Value for Money Assessment Guidance. The Stationery Office, London.

HM Treasury, 2012. A New Approach To Public Private Partnerships. The Stationery Office, London.

HM Treasury, 2014. Private Finance Initiative Projects: 2014 Summary Data. The Stationery Office, London.

HM Treasury, 2016. Private Finance Initiatives and Private Finance 2 Projects: 2015 Summary Data. The Stationery Office, London.

Jacquemin, A.P., Berry, C.H., 1979. Entropy measure of diversification and corporate growth. J. Ind. Econ. 27 (4), 359–369.

Khadaroo, I., 2014. The valuation of risk transfer in UK school public private partnership contracts. Br. Account. Rev. 46 (2), 154–165.

Khan, I.A., Ghalib, A., Hossain, F., 2014. Stakeholders involvement or public subsidy of private interests? Appraising the case of public private partnerships in Pakistan. Public Organ. Rev. 15, 281–296.

Laeven, L., Levine, R., 2008. Complex ownership structures and corporate valuations. Rev. Financ. Stud. 21 (2), 579–604.

Montgomery, D.C., Runger, G.C., 2003. Applied Statistics and Probability for Engineers. John Wiley & Sons, Inc., United States of America.

Shaoul, J., 2005. A critical financial analysis of the private finance initiative: selecting a financing method or allocating economic wealth? Crit. Perspect. Account. 16, 441–471.

Shaoul, J., 2011. 'sharing' political authority with finance capital: the case of Britain's public private partnerships. Polic. Soc. 30 (3), 209–220.

Shen, L.Y., Wu, Y.Z., 2005. Risk concession model for build-operate-transfer contract projects. J. Constr. Eng. Manag. 131 (2), 211–220.

Toms, S., Beck, M., Asenova, D., 2011. Accounting, regulation and profitability: the case of PFI hospital refinancing. Crit. Perspect. Account. 22 (7), 668–681.

Vecchi, V., Hellowell, M., Gatti, S., 2013. Does the private sector receive an excessive return from investments in health care infrastructure projects? Evidence from the UK. Health Policy 110, 243–270.

Winch, G.M., Schmidt, S.E., 2016. Public private partnerships: a review of the UK private finance initiative. In: Jefferies, M.C., Rowlinson, S. (Eds.), New Forms of Procurement: Public Private Partnerships and Relational Contracting in the 21st Century. Taylor and Francis, London, pp. 35–50 (ISBN: 9781138796126).