Rev Ind Organ (2017) 51:25–42
DOI 10.1007/s11151-016-9540-1

How Much Vertical Integration? Contractual Choice and Public–Private Partnerships in the United States

Daniel Albalate[1] · Germà Bel[2] · R. Richard Geddes[3]

Published online: 20 August 2016

Abstract Efficiency gains in public–private partnerships (PPP) derive from risk transfer and the bundling of different tasks. We study the factors that explain bundling in single contracts. We focus on the choice between integrating operational tasks alone or construction tasks alone, versus vertically integrating both operational and construction tasks. We analyze a new data set that includes 553 PPPs that were concluded in the United States. We find evidence that some financial variables play a role in bundling decisions. In addition, market size and the type of economic sectors involved, are also important drivers of contract choice and bundling decisions.

Keywords Privatization · Public–private partnerships · Contracting · Vertical integration

JEL Classification L14 · L33 · L51 · L88

✉ Daniel Albalate
albalate@ub.edu

Germà Bel
gbel@ub.edu

R. Richard Geddes
rrg24@cornell.edu

[1] Department of Applied Economics, University of Barcelona, John Maynard Keynes 1-11, 08034 Barcelona, Spain

[2] Department of Applied Economics, University of Barcelona, John Maynard Keynes 1-11, Office 6034, 08034 Barcelona, Spain

[3] Department of Policy Analysis and Management College of Human Ecology, Cornell University, 251 Martha Van Rensselaer Hall, Ithaca, NY 14853, USA

1 Introduction

The term *public–private partnership*, or PPP, is often used to describe long-term, relational contracts between a public-sector sponsor and a private partner that are created to deliver large infrastructure projects across a range of economic sectors. PPPs have been used for decades in many countries. Popular sectors include water, transport, and energy.[1] PPP use in the United States is rising rapidly, with many U.S. states' passing laws that facilitate such a contractual approach.

We here focus on the structure of PPPs and the bundling of various aspects of project delivery. We do so because bundling, together with risk transfer, is the critical characteristic that distinguishes PPPs from traditional procurement (Albalate 2014).[2] We examine the combining (or vertical integration) of construction and operational elements of project delivery versus bundling within each element separately. Vertical integration in PPPs is important because many anticipated benefits from PPPs rely on synergies between construction and operation. Understanding why governments that engage in PPPs choose to bundle construction and operations—or to deliver them separately—is important for understanding the social benefits of PPPs more broadly.

We have assembled a large data set on PPP projects with the use of the International Major Projects database that is collected by the *Public Works Financing (PWF)* monthly newsletter. The *PWF* database includes the universe of North American PPP projects. *PWF* requests detailed PPP project information once per year from the major PPP project developers active in the North American market.[3] These companies have strong incentives to comply with that request because the influential annual PWF ranking of the world's top transportation infrastructure developers is based on information reported in the database.[4] *PWF* then cross checks that information with the Transportation Infrastructure Financing and Innovation Act (TIFIA) loan database, as well as several other sources to ensure completeness and accuracy.

We use data on 553 U.S. PPP projects that were authorized between 1985 and 2013.[5] We model the determinants of vertical integration decisions in PPPs with the use of multinomial logistic regression. We include financial, economic and political variables. We find that certain financial variables are important drivers of that

[1] See Chong et al. (2006) and Cruz et al. (2014) for recent papers on PPP's experiences in different sectors.

[2] Traditional procurement refers to a design–bid–build (DBB) contract. Project design is placed out for bid, and construction of that design is bid out separately. The public sector finances operation and maintenance of the project over its life. Smaller traditionally delivered projects may not be bid out at all. DBB projects thus incorporate no bundling, and are not considered to be PPPs.

[3] Project developers are companies that take transportation improvements from concept through the design and construction phases. Examples include ACS Group/Hochtief (Spain), Macquarie Group (Australia), Vinci (France), and Flour (U.S.).

[4] *PWF* is the only newsletter to conduct such regular rankings. Numerous testimonials as to its influence and respect in the industry are available upon request.

[5] The *PWF* database includes information on PPP projects only. There are many more projects that are completed under traditional (i.e., DBB, or non-PPP) delivery. Obtaining comprehensive data on traditionally delivered projects is very difficult. See, e.g., Flyvbjerg et al. (2003).

choice, while political variables have little influence. Economic-sector variables help predict the bundling decision and serve as proxies for transaction costs, externalities, and commercial risk.

2 Related Literature

The PPP concept is broad (Hodge et al. 2010) with the European Commission (2003, p. 96) defining PPPs as, “the transfer to the private sector of investment projects that traditionally have been executed or financed by the public sector.” At their core, PPPs are contractual frameworks that are designed to facilitate cooperation between the public-sector project sponsor and private-sector partners that provide a variety of services, including project design, construction, financing, operation, and maintenance. A key PPP element includes shifting risks from taxpayers to private partners (Engel et al. 2014), which requires that the public sponsor pay a risk premium, or price, for transferring that risk.

PPPs include a variety of contract types. The Asian Development Bank (2008, p. 28) identifies five basic types of PPPs: service contracts, management contracts, lease contracts, concessions, and build–operate–transfer (or BOT) contracts. Those are distinguished by differences in commercial (or market) risk and the overall risk level that is assumed by the private sector.[6] The PPP contract thus typically bundles various tasks while transferring significant risk to the private sector.

Industrial organization has adopted a restrictive view of bundling in PPPs relative to the broader literature. It generally requires a PPP to combine construction and operations within one contract, so that the same private sector firm (or consortium) that designs and builds the asset also operates and maintains it (Martimort and Pouyet 2008, p. 394; Engel et al. 2014, p. 11; Bennett and Iossa 2006). Together with taxpayer/private partner risk sharing, bundling emerges as the second distinctive feature of PPPs (Iossa and Martimort 2015, pp. 6–7).

Theoretical contributions have examined the conditions under which contracts are likely to include the bundling of construction with operation and maintenance. Bentz et al. (2004) link the government’s choice of PPP to service provision costs. They conclude that a more vertically integrated contract is chosen when such costs are low and the required investment is small. Alternatively, conventional procurement is chosen when service provision costs are high and the investment required is large. However, when those costs are small, the transaction costs that are associated with PPP contracts can dominate and make conventional procurement or public production more likely, as stressed by Iossa and Martimort (2015).[7]

[6] In a BOT contract, a private entity receives a concession from the public sector to finance, design, construct, and operate a facility for an agreed-upon period. Operation is transferred back to the public sector at the end of the concession period. Close relatives of the BOT contract are the Build–Own–Operate (BOO), in which the private partner owns the facility for a time, and the Build–Transfer–Operate (BTO), in which the private partner owns the facility for the construction phase only, transfers ownership to the public sponsor, and commences operation.

[7] PPP tendering periods can be long and the contracting process costly. Procurement costs can be between 5 and 10 % of total capital costs (Yescombe 2007). Moreover, the relative impact of

Bennett and Iossa (2006) analyze synergies between different project phases. They distinguish positive externalities (i.e., when quality-enhancing investment in building reduces operational costs) from negative externalities (i.e. when quality-enhancing investment increases operational costs).[8] They predict that construction-operational bundling will be more frequent with positive externalities because the builder is able to internalize the benefits of quality-enhancing investment on operational costs.[9] In contrast, greater vertical integration generates underinvestment in the case of negative externalities because added investment increases operational costs. That discourages the private partner from undertaking those investments if it is also responsible for operations.[10]

The theory of incomplete contracts provides a useful analytical framework for studying complex contracting as in a PPP. Using that framework, Hart (2003) and Hart et al. (1997) show that private production creates incentives to reduce costs by means of reducing quality. The contracting firm may thus sacrifice quality to reduce total costs (e.g., Bennett and Iossa 2006) unless quality is clearly defined and highly specified. Building on those insights, theory implies that greater vertical integration is preferable when quality is contractible (i.e. Martimort and Pouyet 2008; Iossa and Martimort 2015), which implies that outcomes are easy to measure.

Regarding risk-related characteristics, Iossa and Martimort (2012) show that PPP benefits are higher when demand and operational risks are low. PPPs on existing motorways or toll roads therefore benefit from well-documented traffic information, which improves revenue forecasts. Traditional procurement may thus be preferable for new toll roads, where traffic and demand risk is considerably more difficult to predict.

Bennett and Iossa (2006) study the relationship between vertical integration and intrinsic asset characteristics. They show that reduced specificity for public use at contract's end generates higher PPP benefits. Investments with strong network characteristics and the attendant high sunk costs are less appropriate for PPP than are facilities with multifunctional traits.

The PPP-choice literature also emphasizes the role of financial incentives. Auriol and Picard (2013) stress restrictions on government spending as a motivation for PPP use, arguing that greater vertical integration is more frequent during financial crises.

Based on our review of the theoretical literature, we emphasize several theoretical hypotheses that can be tested empirically, which will be used in our

Footnote 7 continued
procurement costs rises as the project's capital value declines. High transaction costs are thus a significant barrier to greater vertical integration for low capital-value projects. Overall, the relationship between capital value and the probability of choosing a PPP is likely to be non-linear.

8 A more general term for positive externalities would be that of 'complementarities', which imply that the marginal profitability of one action increases with the level of another (Lafontaine and Slade 2012, p. 1001).

9 This occurs in prison provision, for example, where a better infrastructure design may reduce operational costs for a given safety level (Martimort and Pouyet 2008).

10 Airports offer an example: The complexity that is created by innovation requires that new procedures and sophisticated management tools be learned and adopted (Martimort and Pouyet 2008).

empirical analysis. First, vertical integration will be more frequent when procurement costs are high and required investment is small (Bentz et al. 2004). Second, vertical integration will be more frequent when positive externalities exist between the building phase and facility operation (Bennett and Iossa 2006), such as in prisons (Martimort and Pouyet 2008). Third, greater vertical integration is preferable when quality can be clearly defined and specified (Hart et al. 1997) and it is contractible (Martimort and Pouyet 2008; Iossa and Martimort 2015). This requires that outcomes be easy to measure. Furthermore, investments with strong network characteristics and high sunk costs, which involve high asset specificity, are less preferable for vertical integration (Bennett and Iossa 2006). Our empirical analysis tests these core hypotheses.

Most prior empirical work on contract design has focused on the compensation scheme, financial terms, or control rights (see, e.g., Lafontaine and Slade 2012). To our knowledge, we are the first to analyze empirically the degree of vertical integration in contract design. We next describe the data that we use to study the vertical integration choice in U.S. PPPs.

3 Empirical Strategy

3.1 Data

Data on PPP projects were gleaned from the International Major Projects Survey that is collected by *Public Works Financing*, which contains information on all PPP projects since 1985. We use information on 553 U.S. PPP projects that were approved between 1985 and 2013 and that covered several economic sectors, including Water, Roads, Rail, Airports, Ports, Prisons, and other Facilities (e.g., sport stadiums, schools, street lights, post offices, and parking, among others). The PPPs are governed by different contract types, including Management Contracts, Design and Build, Leases (with or without improvements), Joint Development Agreements,[11] Concessions, and other relatively complex arrangements. This contract information is included in the PWF database and will serve to define the degree of vertical integration. Contracts include different specific tasks, such as Design, Build, Finance, Maintain, or Operate. We omit military housing projects (which are sponsored by the Federal government) and those implying full privatization (i.e., asset sales) because they do not meet our definition of PPPs. This leaves 475 projects in the database that were approved by local and State authorities in the United States between 1985 and 2013.

Table 1 displays information on the major economic sectors that are included in our sample and on contract type. Most PPPs in the sample involve water/wastewater and road projects, followed by rail, airports, prisons, bridges and tunnels, ports, and other facility projects.

[11] Lease contracts with improvements imply that the lease included a commitment to undertake new investments in the existing facility. Joint development agreements refer to PPPs that were undertaken by joint venture companies with equity contributed by the private and public sectors (see Moszoro and Gasiorowski 2008).

Table 1 U.S. Major Projects Survey (as of 2013) *Source* Public Works Financing (PWF) newsletter

Id	Economic sector	Number of PPPs in sample	Percentage in sample	Percentage that integrate both construction and management
1	Roads	115	24 %	39 %
2	Bridge and tunnels	23	5	70
3	Rail	32	7	47
4	Airports	29	6	38
5	Ports	8	2	63.5
6	Water	92	19	43.5
7	Wastewater	103	22	44
8	Prisons	28	6	89
9	Facilities	31	7	71
10	Other	14	3	36
		475	100 %	48 %

We consider the degree of vertical integration in PPP contracts. Greater vertical integration includes the combination of construction and operational tasks, while less integration combines specific tasks on either the construction or the operational side only. The last column in Table 1 offers information on the percentage of highly bundled PPPs in each economic sector in the sample. Our sample includes 246 (52 %) less integrated PPPs and 229 (48 %) more integrated PPPs. Table 2 indicates how we divide contract types into more-versus-less vertically integrated PPP categories.

Table 2 Classification of PPP contract types by degree of vertical integration

Contract type	Less vertical integration		More vertical integration
	Construction phase	Management phase	
Design and build	X		
Design, build and finance	X		
Management contract		X	
Lease		X	
Operate and maintain		X	
Lease and improve			X
Design build and maintain			X
Design build and operate			X
Design build finance and maintain			X
Design build finance and operate			X
Design build operate and maintain			X
Joint development			X
BOT/BOO/BTO			X

See footnote 4 above for an explanation of these contract types

3.2 Variables

We focus on the choice between alternative contract types. Our dependent variable is categorical: it takes different (unordered) values that identify alternative contract types. If PPP contracts exhibit greater vertical integration (i.e., bundling together construction and operational tasks) we group them into Category 1, our reference category. We group contracts that bundle only design-build tasks into Category 2. Category 3 represents bundling within management-related contracts only.[12] This categorization allows us to compare the drivers of more-versus-less vertical integration in PPP contracts.

We considered alternative groupings to obtain a better model fit. Categories 2 and 3 were retained while Category 1 was split by creating new Categories 4 and 5. Category 4 includes those PPPs that combine construction and management but exclude design tasks. Category 5 includes vertically integrated PPPs that exclude operational tasks. These more granular definitions allow examination of how externalities and synergies that are associated with design tasks, along with demand risk, affect PPP contract decisions.

Independent variables include: (1) financial variables to account for fiscal constraints; (2) binary variables that identify various economic sectors to capture the intrinsic characteristics of different infrastructure types; (3) variables that proxy for political preferences; and (4) other controls. We estimate the likelihood of greater vertical integration in PPPs as affected by financial, economic, and political factors. Bundling is present to some extent by construction in all PPPs examined. We do not address the determinants of PPP use *per se*, as have other authors.

Table 3 lists our variables and data sources. Financial variables are likely to impact PPP bundling with a lag. We thus utilize prior-year financial data. We designate *facilities* as the (dropped) reference economic sector to avoid co-linearity.[13] *Facilities* are delivered through highly integrated PPPs 71 % of the time (see Table 1); this is one of the highest percentages in our sample.

3.2.1 Financial Predictors[14]

Tax Income: State and local tax revenues per capita (thousands of constant dollars) in the state where the project was signed, year prior to the agreement. This variable is a proxy for fiscal pressure and the ability of state governments to raise tax revenue. *Tax income* is likely to be negatively correlated with vertical integration in PPPs since states with larger per-capita revenues will rely less on private infrastructure investment if public and private investment are substitutes.

Expenditures: State and local government expenditures per capita (thousands of constant dollars) in the state where the project was signed, year prior to the

[12] We define the management of an infrastructure facility as including both operation and maintenance.

[13] Recall that this category includes sport stadiums, schools, street lights, post offices, and parking, among others.

[14] All financial variables are in constant US$. We deflate to 1984 as the base year for the regional CPI estimates. Because there is not official estimation of CPI for many states we use regional CPI 1982–1984 and apply it to the states in the region.

Table 3 Variable description and source for the full U.S. PPP database

Variable	Description	Source
Financial		
Tax_Income (000's)	State and local tax revenues (thousand constant US$ of 1984) divided by the state population in the state where the PPP is signed in the year prior to the agreement	State and Local Tax Burdens: All Years, One State
Expenditures (000's)	State and local expenditures (thousand constant US$ of 1984) divided by the state population in the state where the PPP is signed in the year prior to the agreement	United States Census Bureau
Debt (000's)	State debt outstanding (thousand constant U.S.$ of 1984) divided by the state population (thousands inhabitants), in the year prior to the agreement	Statistical Abstract of the United States
Contract_size (000,000's)	Project size (i.e. capital cost) in constant US$ millions of 1984	PWF
Economic sector		
Roads	Binary variable that takes the value 1 when the PPP affects a Network Road; 0 otherwise	PWF
Bridge and tunnel	Binary variable that takes the value 1 when the PPP affects a Bridge or a Tunnel, 0 otherwise	PWF
Rail	Binary variable that takes the value 1 when the PPP affects a Railway; 0 otherwise	PWF
Airports	Binary variable that takes the value 1 when the PPP affects an Airport; 0 otherwise	PWF
Ports	Binary variable that takes the value 1 when the PPP affects a Port; 0 otherwise	PWF
Water	Binary variable that takes the value 1 when the PPP affects a Water project; 0 otherwise	PWF
Wastewater	Binary variable that takes the value 1 when the PPP affects a Wastewater project; 0 otherwise	PWF
Prison	Binary variable that takes the value 1 when the PPP affects a Prison project; 0 otherwise	PWF
Other	Binary variable that takes the value 1 when the PPP affects other sectors/services; 0 otherwise	PWF
Political		
Repub_Governor	Binary variable that takes the value 1 if the governor of the state is a Republican; 0 otherwise	Almanac American Politics (Barone); Politics in America
Control		
Sponsor	Binary variable that takes the value 0 if the Sponsor signing the PPP is local, and 1 if it is the State Government.	PWF
Population (000,000's)	Population (in millions) living in the state in the year prior to the agreement	U.S. Census for State Population
PPP legislation	Synthetic index of how favorable to PPPs is each state's PPP legislation in the year the PPP was signed	Geddes and Wagner (2013)
Year	Year in which the PPP was signed	PWF

agreement. This measures the government's fiscal burden and the need for private financing. We expect a positive correlation between this variable and vertical integration in PPPs because states with greater per-capita spending are likely to rely more on private investment and to engage in greater bundling of PPP contracts.

Debt: State debt outstanding (thousands of constant dollars) per capita, year prior to the PPP agreement. This captures states that face fiscal stress from high debt levels. We predict a positive relationship between this variable and vertical integration in PPPs since a larger debt burden encourages greater reliance on private partners.

Contract Size: Project size, measured by capital cost in millions of constant U.S. dollars. Consistent with extant literature, we expect a non-linear relationship between capital value and vertical integration in PPPs. We use a logarithmic transformation of this variable.

3.2.2 Economic-Sector Predictors

We include 10 sector-specific binary variables to indicate which sector each project most closely represents. Each is relative to *facilities*, which is the reference sector. Our literature review reveals that facilities exhibit more vertical integration because their quality is contractible, easy to measure, and transaction costs are lower. In contrast, road and rail projects face large commercial risks, which may frustrate vertical integration. This leads to less vertically integrated PPPs overall but to more vertical integration within the project's management or construction phases.

Network infrastructure creates greater asset specificity relative to *facilities*. This suggests that roads, rail, and water PPPs will be negatively correlated with vertical integration, except in the case of Bridges and Tunnels, which are similar to facilities. Moreover, Ports, Airports and Prisons bear less commercial risk despite their asset specificity. Their economic cost—limiting the hold-up problem—is lower than for network infrastructure. Although we expect significant differences between network infrastructure and facilities, we do not expect large differences between stand-alone infrastructure and facilities.

Economic sector indicators reflect the degree of asset specificity and ease of quality measurement, which are drivers of transaction costs. However, it is useful to account directly for those factors with the use of specific indicators of asset specificity and ease of measurement. We use the average specificity and ease-of-measurement ratings in Brown et al. (2005) for services contracted out by U.S. municipalities. Brown et al. (2005, pp. 329–330) define asset specificity as a characteristic of those services that require large specialized investments that cannot be used for other alternative purposes, and are likely to have few providers. Ease of measurement refers to the ability of the contracting organization to assess the provider's performance or to observe how the service is delivered. They conduct a survey of 75 public managers about the transaction costs involved in 64 local government services.

Answers to that survey give each service a rank of one to five according to ease of measurement, and also according to asset specificity. Based on the answers obtained, they build a ranking of those 64 services according to their respective ease of measurement, and asset specificity (Brown et al. 2005, pp. 336–341). We incorporate this ranking to examine the role of transaction costs in explaining vertical integration in alternative models.

3.2.3 Political Predictors

Republican Governor: A dummy variable that is set to one (when the project is signed) if the governor is Republican, zero otherwise. To the extent that Republican governors are more business friendly and more market-oriented than their Democratic counterparts, they will employ more vertically integrated PPPs.

3.2.4 Control Predictors

Population: State population. This is a measure of market size. Private investors are likely to find facilities in populated markets more attractive, since larger markets are likely to have a greater demand for the services from PPP projects and thus investment recovery should be easier. Based on extant literature, we expect a non-linear relationship between population and vertical integration in PPPs. We thus use a logarithmic transformation to this variable.

Sponsor: Categorical variable that is set to zero if the project sponsor is a local government; one if a state government. Because higher levels of government typically receive more public resources, we expect this variable to reduce vertical integration.

Year: Variable that indicates the year in which the PPP was approved. This captures a time trend and thus long-run policy changes. It is important to control for time because economic crises may affect PPP design. We expect *Year* to affect vertical integration positively.

PPP Legislation: Variable indicating the favorability of a State's PPP legislation to private investment in the year and State in which the PPP is consummated. This variable, described in Geddes and Wagner (2013), allows assessment of the impact of PPP legislation on private infrastructure investment. It is a synthetic indicator of how experts view the impact of various PPP enabling law provisions in attracting investment. Higher values indicate a better institutional framework that stems from reduced uncertainty and regulatory risks, which are essential to engaging in long-term relationships and large sunk investments, as required when PPPs bundle construction and operational tasks. Table 4 reports descriptive statistics.

3.3 Methods

We use multinomial logistic regression to model the PPP contract-type decision with regard to the degree of vertical integration. Equation (1) contains the four variable groups that we use to estimate determinants of vertical integration in U.S. PPPs[15]:

[15] Model (1) includes a time-trend variable (Year). We also considered models with year dummy variables. These show consistent results for financial, economic sector, and control regressors. Such models, however, return negative values in the McFadden Pseudo-R^2, which suggests a poor fit. We thus report models with time trends.

Table 4 Descriptive statistics

	Variable	Mean	Std.Dev.	Min	Max
Financial	Tax_Income	2.08	0.74	0.98	5.58
	Expenditures	3.81	0.77	2.29	7.37
	Debt	1.81	1.39	0.32	6.94
	Contract_size	238.03	397.18	1.21	3431
Economic sector	Network roads	0.24	0.43	0	1
	Bridge and tunnels	0.05	0.21	0	1
	Rail	0.07	0.25	0	1
	Airports	0.06	0.24	0	1
	Ports	0.02	0.13	0	1
	Water	0.19	0.39	0	1
	Wastewater	0.22	0.41	0	1
	Prisons	0.06	0.24	0	1
	Other	0.03	0.17	0	1
Political control	Repub_Governor	0.39	0.49	0	1
	Sponsor	0.26	0.44	0	1
	Population	13.64	10.80	0.53	38.43
	PPP legislation	2.54	2.32	0	7
	Year	2003	5.87	1985	2013

$$
\begin{aligned}
Y_i = {} & \alpha_0 + \beta_1 Tax\_Income_i + \beta_2 Expenditures_i + \beta_3 Debt_i + \beta_4 Log(Contract\_Size)_i \\
& + \partial_1 D_i^{Water} + \partial_2 D_i^{Wastewater} + \partial_3 D_i^{Network\_Roads} + \partial_4 D_i^{Bridge\_Tunnel} \\
& + \partial_5 D_i^{Rail} + \partial_6 D_i^{Ports} + \partial_7 D_i^{Airports} + \partial_8 D_i^{Prisons} \partial_9 D_i^{Others} \\
& + \gamma_1 D_i^{Repub\_Governor} + \mu_1 Sponsor_i \\
& + \mu_2 Log(Population)_i + \mu_3 PPP\_legislation_i + \mu_4 Year_i + \varepsilon_i
\end{aligned}
$$

where Y_i takes the value 1 for highly integrated PPPs (i.e., bundling construction and management tasks), 2 for integration within the construction phase only, and 3 for bundling within the operational phase only. The sector indicator *Facilities* is the omitted (or benchmark) category. The reference category for the dependent variable is highly integrated PPP contracts.

We use multinomial logistic regression because having discrete (unordered) values precludes ordinary least squares. The PPP contractual categorical dependent variable prohibits the use of binary-response models such probit or logit. Our model is analogous to a logistic regression model where the response variable's probability distribution is multinomial instead of binomial. Also, the $J - 1$ multinomial logit equations compare categories 1, 2,…, $J - 1$ to category J (the most integrated case), whereas the single logistic regression equation is a contrast between successes

Table 5 Multinomial categories: different groupings of contracts

	Benchmark Group	Group 2	Group 3	Group 4	Group 5
Multinomial 1	Bundling of construction and operation tasks	Bundling of construction tasks only	Bundling of operation tasks only		
Multinomial 2	Bundling of construction and operation tasks (including design tasks)	Bundling of construction and operation tasks (excluding design tasks)	Bundling of construction tasks only	Bundling of operation tasks only	
Multinomial 3	Bundling of construction and operation tasks (including design tasks)	Bundling of construction and operation tasks (excluding design tasks)	Bundling of construction and Maintenance tasks (including design)	Bundling of construction tasks only	Bundling of operation tasks only

We cannot provide models with more or other categories because the maximum likelihood procedure did not converge with the necessary further splitting

Table 6 Model fit of different multinomial models

	Multinomial 1	Multinomial 2	Multinomial 3	Logistic
LR χ^2 test	178.60***	231.39***	252.615***	27.661*
Log-like full model	−272.593	−353.179	−368.241	−224.327
McFadden Adj. R^2	0.142	0.125	0.102	0.022

Significance levels of 1, 5, and 10 % denoted by ***, **, and * respectively

and failures. Finally, standard errors are robust to arbitrary forms of heteroscedasticity while also clustered by State or by economic sector.[16]

We compared multinomial logistic regressions according to different contractual groupings, starting with a 3-category model. Table 5 displays the type of multinomial models compared, while Table 6 reports their joint-significance tests. Comparisons of model fit are possible through log-likelihood values and McFadden's pseudo-R^2. Our models are jointly significant according to likelihood-ratio χ^2 tests. Log-likelihood results and the adjusted pseudo-R^2 values suggest that the most restricted model (multinomial 1) is the best in terms of both fit and explanatory power. We used Category 1 as the reference category. The two remaining categories are those that combine only construction or operational tasks.[17]

[16] We considered State fixed effects (separately), but the maximum likelihood method did not converge.

[17] The Hausman test for the independence of irrelevant alternatives (IIA) supports the null hypothesis of Odds (Outcome-J vs. Outcome-K) being independent of other alternatives in all models with different categories.

We also compared multinomial and logistic regression models. The latter is a special case of the multinomial model where the dependent variable is dichotomous. We find support for the former and reject the use of logistic regression. The next section discusses estimates for the selected model (multinomial 1) only.

4 Estimates

Table 7 reports estimates for Multinomial 1, which is our main model. This model incorporates the full sample, in which all observations are included and standard errors are clustered by sector and State (I, II, III). Predicted marginal effects for each PPP contractual category are reported instead of coefficients. Coefficients would be difficult to interpret in multinomial logistic models and operationally irrelevant.

We report the predicted marginal effects associated with greater bundling in PPP contracts (i.e., bundling of construction and management) in column (I). Columns (II) and (III) report predicted marginal effects for less vertically integrated contracts (i.e., those within the construction and the operational phases only, respectively).

4.1 Financial Variables

Marginal effects in Columns (II) and (III) indicate that the (lagged) level of expenditures per capita is an important determinant of vertical integration. It is positively related to vertical integration in the construction phase only and negatively related to integration within operational tasks only. Therefore, PPPs with only less vertical integration within the construction phase are more prone to be signed than are PPPs with vertical integration that involve both construction and operation tasks in states with higher government expenditures. To the contrary, state and local governments' expenditures make PPPs with less vertical integration within the operational phase less likely than PPPs with greater vertical integration, which involve construction tasks as well. Vertical integration is more likely in the construction phase than in the operation phase. PPPs in construction likely have major financial implications, which is consistent with predictions from Auriol and Picard (2013), although we would have expected more integration overall with greater state and local expenditure.

Our estimates do not reveal a significant impact of contract size on the choice among alternative vertical integration contracts. This suggests that project size does not make a difference between less versus more vertical integration. Viewing contract size as a proxy for provision costs, we do not find evidence of the relationship between bundling in PPPs and service provision costs (Bentz et al. 2004). Similarly, *tax income* is statistically insignificant for all contract types, while *State indebtedness* per capita increases the likelihood of less vertical integration PPPs only in the operational phase case.

Table 7 Multinomial logistic regression

	Variables	Greater vertical integration (I)	Less vertical integration construction phase (II)	Less vertical integration operation phase (III)
Financial	Tax_Income (000's)	0.0157	0.0030	−0.0188
		(0.0512)	(0.0303)	(0.0451)
	Expenditures (000's)	0.0728	0.0641*	−0.1369***
		(0.0631)	(0.0355)	(0.0487)
	Debt (000's)	−0.0371	−0.0180	0.0551**
		(0.0260)	(0.0143)	(0.0236)
	Log Contract_size	0.0301	−0.0074	−0.0226
		(0.0208)	(0.0109)	(0.0168)
Economic Sector	Network roads	−0.1372	0.1559	−0.0186
		(0.1114)	(0.0978)	(0.0868)
	Bridge and tunnels	0.1438	0.0820	−0.2258***
		(0.1497)	(0.1477)	(0.0329)
	Rail	−0.1336	0.2173	−0.0836
		(0.1585)	(0.1631)	(0.0774)
	Airports	0.1438	−0.1323***	−0.0115
		(0.0952)	(0.0307)	(0.1211)
	Ports	−0.1706	−0.1317***	0.3023
		(0.2877)	(0.0304)	(0.2836)
	Water	−0.1446	−0.0640	0.2087*
		(0.1240)	(0.0483)	(0.1269)
	Wastewater	−0.0638	−0.1624***	0.2262**
		(0.1064)	(0.0404)	(0.1167)
	Prisons	0.1722*	−0.0138	−0.1583***
		(0.1026)	(0.0993)	(0.0250)
	Other	−0.3953	0.01374	0.3815**
		(0.2574)	(0.1041)	(0.2011)
Political control	Repub_Governor	−0.0051	0.0066	−0.0015
		(0.0435)	(0.0299)	(0.0332)
	Sponsor	−0.0309	0.0358*	−0.0049
		(0.0415)	(0.0207)	(0.0328)
	Log population	0.0386	−0.0475**	0.0090
		(0.0393)	(0.0234)	(0.0319)
	PPP legislation	−0.0104	0.0121	−0.0016
		(0.0123)	(0.0096)	(0.0098)
	Year	0.0041	−0.0031	−0.0010
		(0.0062)	(0.0052)	(0.0050)
	Log likelihood	−272.593		
	LR χ^2	178.60***		
	Pseudo-R^2	0.25		
	Adjusted pseudo-R^2	0.142		

Predicted marginal effects for each category of PPP contract

***, **, * significance levels at 1, 5 and 10 % respectively. In parentheses standard errors clustered by state and economic sector

4.2 Economic Sectors

Road projects are not associated with any particular type of PPP vertical integration when compared to the project reference group (i.e., facilities). Rail projects follow a similar pattern, which suggests that rail is not associated with a particular PPP contract type. PPP contracts that involve network modes of transportation, therefore, are not related to any specific bundling choice.

This differs from other economic sectors. Bridges, and tunnels consistently rely less on PPPs that integrate tasks within the operational phase only (Column II). This implies that greater vertical integration (reference category 1) is more likely in these cases than integrating operational tasks alone. Alternatively, airports, ports, and wastewater rely less heavily on PPPs that integrate tasks within the construction phase only, as is indicated in column (II). Greater vertical integration PPPs are relatively more probable in these economic sectors than are less vertically integrated contracts within the construction phase alone. Nonetheless, wastewater provision is more likely to bundle operational tasks with respect to strong vertical integration PPPs only. This is similar to water provision contracts, as is indicated by the estimates that are reported in column (III).

With regard to prisons, we find a positive correlation with greater vertical integration contracts, but a negative correlation with contracts that integrate tasks within the operational phase only. Finally, activities in the *Others* group are more likely to rely on vertically integrated PPP project delivery when those PPPs integrate only operational tasks with respect to the reference category of greater vertical integration.

4.3 Political and Control Variables

The governor's political party is not associated with any particular type of vertical integration in PPP contracting. We reach similar conclusions for public sponsor type, except in the case of less vertical integration within the construction phase. That is more likely when the sponsor is a state government. Neither PPP legislation nor the time trend affect the PPP bundling decision. This relationship is statistically significant at the 10 % level only.

Population, however, affects contract choice. Populous states are less likely to rely on integration that only combines construction-phase tasks. We do not find any statistically significant difference, with respect the reference group, in the case of less vertical integration within the operational phase only.

4.4 The Role of Transaction Costs

Sector variables suggest that transaction costs are a key driver of the PPP bundling decision. Those variables capture differing project traits linked to transaction costs, including asset specificity and ease of quality measurement. We next consider asset specificity and measurement ease directly, although doing so greatly reduces sample size.

Table 8 Multinomial logistic regression estimates

Variables	Greater vertical integration (IV)	Less vertical integration construction phase (V)	Less vertical integration on operation phase (VI)
Asset specificity	0.4459	−0.2195*	−0.2264
	(0.6442)	(0.1167)	(0.6636)
Ease of measurement	0.8027**	0.0710	−0.8738**
	(0.3741)	(0.0571)	(0.3764)
Log likelihood	−117.552		
LR χ^2	36.926**		
Pseudo-R^2	0.14		

Predicted marginal effects for each category of PPP contract. Estimates for transaction costs as drivers of contract choice

***, **, * significance levels at 1, 5 and 10 % respectively. In parentheses, standard errors clustered by state and economic sector. We control for the same variables that were used in the previous models

We rely on the indicators of asset-specificity and of ease of measurement that are utilized in Brown et al. (2005) for services that are contracted out by U.S. cities. We identified those sectors that appear in our sample. Although most of the Brown et al. (2005) service list does not appear in our sample, we were able to utilize values for 163 projects. We applied the Multinomial 1 model, but replaced economic sectors with the associated asset specificity and ease of measurement variables. Table 8 reports the estimates.

The estimates indicate that both variables are relevant for the vertical integration choice. Contract choice is influenced by measurement ease, which increases the likelihood of greater-vertical-integration PPPs and decreases the likelihood of PPPs that involve only operational tasks. Given that ease of measurement is one of the key factors that facilitate contractibility, our estimates are consistent with the theoretical predictions in Martimort and Pouyet (2008) and Iossa and Martimort (2015). However, asset specificity affects only the PPP bundling choice in the case of less vertical integration within the construction phase only. We find a negative relationship between asset specificity and construction PPP contracts with respect to vertical integration. We find insignificant effects for other forms of reduced vertical integration within the operation phase only. In this regard, our estimates neither contradict nor support the theoretical predictions in Bennett and Iossa (2006), who establish that greater integration is negatively correlated with asset specificity. Our estimates do not suggest that asset specificity plays an important role in bundling decisions.

5 Conclusions

We report findings from the first empirical study of the vertical-integration choice in public–private partnership contracts. That choice is important in an assessment of the expected efficiency gains that can be realized from bundling-derived synergies.

Such synergies partly depend on whether bundling includes operational and construction tasks (creating the largest scope for such efficiencies) versus tasks that remain only within the operational or construction tasks, respectively.

We find that government expenditures per capita affects the likelihood of vertical integration: States with higher expenditures are more likely to sign PPP contracts that involve construction phase tasks only and less likely to sign PPP contracts that involve management tasks only (in the context that the reference category is greater-vertical-integration bundling of both operational and construction tasks). However, other financial variables, such as per capita debt, contract size and per capita taxes, do not play an important role.

We also find that the economic sector under consideration strongly influences bundling. That may be due to transaction costs, commercial risk, and initial investment. Indeed, economic-sector dummy variables may be serving as proxies for transaction costs. However, we explored that possibility through the use of a reduced sample that includes asset specificity and ease-of-measurement variables. Although we do not find a meaningful effect of asset specificity, ease of measurement (as a proxy of contractibility) is important, and is positively related to greater vertical integration.

Our investigation suggests that PPP design may be a pragmatic rather than a political decision. The decision to undertake a PPP (which necessarily implies private-sector participation in project delivery) may include political considerations, while the vertical-integration choice, given that the decision has been made to use a PPP, does not. With regard to controls, population is positively correlated with greater vertical integration in PPPs. Other variables that were considered are generally unrelated to the extent of vertical integration.

We view our conclusions as preliminary since this is the first empirical examination of PPP vertical integration. Although we focus on the United States, we anticipate that different regulations, contracting practices, legal origins, and legal traditions will produce different PPP designs. They may also influence the factors that lead to decisions about combining operational and construction tasks, as with decisions with regard to risk transfer via PPPs. Our estimates suggest that bundling in PPPs is neither random nor arbitrary. We view our contribution as identifying an initial set of statistically significant factors that help explain policy makers' PPP contract bundling choices.

Acknowledgments This work was supported by the Spanish Government (ECO2012-38004); the Catalan Government (SGR2014-325), and the ICREA-Academia program of the Catalan Government. We are grateful to Bill Reinhardt, the editor of *Public Works Financing Newsletter*, for providing us with access to his database, and also for his detailed information on how the data base is built.

References

Albalate, D. (2014). *Privatisation and nationalisation of European roads. Success and failure of public–private partnerships*. Cheltenham: Edward Elgar.

Asian Development Bank. (2008). *Public–private partnerships handbook*. Manila: ADB.

Auriol, E., & Picard, P. M. (2013). A theory of BOT concession contracts. *Journal of Economic Behavior & Organization, 89*, 187–209.

Bennett, J., & Iossa, E. (2006). Building and managing facilities for public services. *Journal of Public Economics, 90*(10–11), 2143–2160.

Bentz, A., Grout, P. A., & Halonen, M. L. (2004). *What should governments buy from the private sector—Assets or services?* Mimeo.

Brown, T., Potoski, M., & Van Slyke, D. (2005). Transaction costs and contracting: The practitioner perspective. *Public Performance & Management Review, 28*(3), 326–351.

Chong, E., Huet, F., Saussier, S., & Steiner, F. (2006). Public–private partnerships and prices: Evidence from water distribution in France. *Review of Industrial Organization, 29*(1–2), 149–169.

Commission, European. (2003). *Public finances in EMU 2003*. Brussels: European Commission.

Cruz, C., Marques, R. C., & Cardoso, P. (2014). Empirical evidence for renegotiation of PPP contracts in the road sector. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 7*(2), 05014003.

Engel, E., Fischer, R., & Galetovic, A. (2014). *The economics of public–private partnerships. A basic guide*. Cambridge: Cambridge University Press.

Flyvbjerg, Bent, Bruzelius, Nils, & Rothengatter, Werner. (2003). *Megaprojects and risk: An anatomy of ambition*. Cambridge: Cambridge University Press.

Geddes, R. R., & Wagner, B. L. (2013). Why do states adopt public–private partnership enabling legislation? *Journal of Urban Economics, 78*, 30–41.

Hart, O. (2003). Incomplete contracts and public ownership: Remarks, and an application to public–private partnerships. *Economic Journal, 113*(486), C69–76.

Hart, O., Shleifer, A., & Vishny, R. W. (1997). The proper scope of government: Theory and an application to prisons. *Quarterly Journal of Economics, 112*(4), 1127–1161.

Hodge, G. A., Greve, C., & Boardman, A. E. (2010). Introduction: the PPP phenomenon and its evaluation. In G. A. Hodge, C. Greve, & A. E. Boardman (Eds.), *International handbook of public–private partnerships* (pp. 3–16). Cheltenham: Edward Elgar.

Iossa, E., & Martimort, D. (2012). Risk allocation and the costs and benefits of public–private partnerships. *RAND Journal of Economics, 43*(3), 442–474.

Iossa, E., & Martimort, D. (2015). The simple microeconomics of public–private partnerships. *Journal of Public Economic Theory, 17*(1), 4–48.

Lafontaine, F., & Slade, M. E. (2012). Interfirm contracts: Evidence. In R. Gibbons & J. Roberts (Eds.), *Handbook of organizational economics* (pp. 958–1013). Princeton: Princeton University Press.

Martimort, D., & Pouyet, J. (2008). To build or not to build: Normative and positive theories of public–private partnerships. *International Journal of Industrial Organization, 26*(2), 393–411.

Moszoro, M., & Gasiorowski, P. (2008). *Optimal capital structure of public–private partnerships*. IMF Working Paper 1/2008. Washington, DC: International Monetary Fund.

Yescombe, E. (2007). *Public–private partnerships principles of policy and finance*. Burlington, MA: Butterworth-Heinemann, Elsevier.