Perverse incentives and invisible tradeoffs in subway construction in China: a case study of Hangzhou subway collapse

Ma Yongchi, Martin de Jong, Joop Koppenjan, Xi Bao

Paper presentat at the Next Generation Infrastructures Conference, Systems of Eco Cities, Shenzhen, China. 11-13 November 2010

***Abstract*—Hangzhou subway collapse is the most serious subway construction disaster to date in China. In this article, the management and regulatory questions the collapse raised are focused and a case study of Hangzhou subway collapse is given. By regarding the contractual arrangement as an outcome of a power game of principal-agent, the social causes and the perverse incentives to strategic behaviors of the key players are investigated to explain the particular project outcomes. In the end, some policy suggestions are given for improving the safety performance of subway construction.**

I. Introduction

November November 15, 2008 at 3:20 pm. A major accident occurs at Line 1 of the Hangzhou City Subway Network under construction in the Xiaoshan district. A 100 meter-long and 50 meter-wide section of a tunnel under construction collapses. The immediate death-toll is 21, while 24 persons are found seriously injured, and the direct economic loss is about 4961 million Yuan [1].

This event traumatized China not long ago and was the most serious subway construction disaster to date, which emerges in the context of public sector financial stringencies where private sector funding and other resources are tapped, leading to sometimes highly complex client-contractor relations. This tragedy begs the question what factors underlie this serious accident in Hangzhou, and what lessons can be drawn from it for other projects? More generally, what mechanisms must be held responsible for them and what can be done to improve their solidity in future occasions?

Many different types of safety lessons exist, because many different factors contribute in essential ways to safety performance [2]. Depending on one's perspective, safety can be viewed as a composite effect of technical factors, organizational factors and social factors; latent factors and active factors; technical deficiencies and human errors. Generally, the latent factors are always hidden in the organization (poor design, gaps in the supervision) and difficult to detect, but they are said to have a deep and persistent influence on safety performance. Reference [3] claims that with the growing complexity of infrastructure construction, technology and the social environment in which it is embedded have become more intertwined and giving clear-cut practical recommendations to fix things has become harder and less helpful. Meanwhile, the significance of more implicit features of organization and work coordination has increased, making it more meaningful to look at safety at several levels of abstraction, as for instance Rasmussen and Hellstrom have done[4], [5].

In this article, we will focus primarily on the contractual arrangements between the client, normally a public authority, and the contractor, often a private firm or consortium of firms responsible for the project management. The relationship between these two players can be seen as a principal-agent relation. In our analysis, we will describe this relationship as an active tradeoff of values between two partners in accordance with how they see their self-interest, leading to particular project outcomes.

II. Trading public values in principal agent relations

Modern contractual arrangements in which construction and project management is in multiple hands often take the shape of Public-Private Partnerships (PPP) or Public-Public Partnerships (PUPs). These novel approaches to infrastructure delivery are known to have advantages as well as disadvantages, the balance between both being either positive or negative, depending on a wide range of factors, including the eye of the beholder [6]-[9]. Their composite impact is complex and one of their more obvious features is that as more actors get involved, the existence of multiple and partly conflicting values becomes apparent [10]. Public values are known to be essential aspects of service delivery in infrastructures to which citizens and/or consumers are attached, such as mobility, universal access, safety, sustainability, efficiency and transparency [11]-[12]. These are often defined at a relatively high level of abstraction by policy-makers, and at that level they all seem equally crucial and essential. However, when it comes to their implementation, they turn out to be partly contradictory,

Yongchi Ma is with the Harbin Institute of Technology, Harbin, 15001 PRC (corresponding author: 86-451-86400502; e-mail: frigo8341@163.com).

Martin de Jong is with Delft University of Technology, 2600 AA Delft, NL (e-mail: W.M.deJong@tudelft.nl).

Joop Koppenjan is with Delft University of Technology, 2600 AA Delft, NL (e-mail: J.F.M.Koppenjan@tudelft.nl).

Bao Xi is with the Harbin Institute of Technology, Harbin, 15001 PRC (e-mail: xibao@yeah.net)

making a trading off process among them necessary [13]. Reference [8] and Reference[14] show that there is a gap between public values as defined in the abstract and public values as they are realized in the daily practice of service delivery. For instance, in the Australian construction industry, all stakeholders perceive worker safety as a vital public value, yet it is not highly rated in the assessment criteria, nor does it become manifest in the generally poor safety records on the work-floor. Reference [8] suggests the gap between 'abstract value' and 'practical value' is the main reason why other public values overshadow safety. In addition, 'a culture of cost cutting' is also an important underlying cause. It seems that in practice, cost-reduction is a hard public value protected by strong incentives and powerful actors, whereas safety is a soft public value the safeguarding of which has much weaker supporters and the institutionalization is also less secured. Reference [15] state that 'hard' values are firmly institutionalized in formal objectives and performance indicators, while 'soft' ones remain far more elusive and intangible when it comes down to it, because they tend to lose out in the trading off process towards project implementation.

To clarify how public values are exactly traded off against each other during the implementation process, it is helpful to see how abstract values find their way into concrete project management benchmarks and are thus enforced. Reference [16] argue that the four 'classical' project management benchmarks, *time*, *cost*, *scope* and *quality*, can be seen as concretizations at the lower tactical and operational level of construction projects of values imposed upon the project by various public and private parties (compare [17]).

Reference [18] has argued that these values are chiefly encouraged by the client, particularly in situations where the client controls the initial budget and is most sensitive to signals from citizens and customers to uphold public values. In theory, the client strives to maximize scope with the highest quality for the least money and within the shortest possible time, while the constructor has an interest in spending the least effort for the highest possible budget and over the longest period of time [16]. What does it mean in practice? In practice, the public client will be keen to minimize contract uncertainty to avoid and deflect possible political blame. This normally implies minimizing time and costs and maximizing the scope of projects (in terms of what it can do for mobility, sustainability etc.) to please fellow politicians, citizens and customers and increase the attractiveness of the project to gather and sustain support. Officially quality issues as defined above are also part and parcel of what public clients should uphold, but in practice they know far less about them and they are also far less conspicuous before and during construction. As a consequence, this protection often remains limited to paying lip-service, unless protected by strong and enforceable benchmarks. Contractors, on the other hand, are less dependent on political support and keep out of the limelight. They are more profit-oriented and focus on the minimization of time and cost spending. With regard to scope, they accommodate the wishes of their client which may fluctuate over time due to political pressures, but consider them an external obligation or requirement imposed on them. Their concern with quality is the least strong, especially there where no legal or contractual liability exists for them, because they are mostly a cost. Moreover, as general project managers they tend not to know enough about them and therefore delegate technical details to subcontractors whose concerns equally reside with minimizing (their own) time and costs and otherwise complying with their contract obligations (with the main contractor). Scope and especially quality for them are merely side considerations that are (hopefully) accommodated, without excitement.

Situations grow particularly risky when contractors have agreed to tight budgets and time schedules with their clients, when afterwards these clients keep meddling with the actual decision-making and place novel scope demands on the table (derived from political pressure or expediency) which the contractor has to incorporate in the package without (sufficient) compensation. In most cases, expanding 'scope' puts safety at risk, because the constructor, with his back against the wall, will keep up his profit levels while cutting corners and redressing 'quality' if he feels he has to do so. This can come in various forms such as economizing on construction materials, cutting back and/or saving time on quality checks or ignoring geological risks. In any of the above cases, the safety boundary is shifted to grey areas where you may not want to have them.

To sum up, although the causes of the Hangzhou subway collapse can be attributed to technical reasons and the human errors, just like the official investigations do [1], the underlying conditions can be found in management and regulatory sides, such as contractual arrangements and the way these play out in the way involved actors (clients, contractors, subcontractors) trade off values against each other and behave strategically in ways to serve their own interest even if this goes to the detriment of certain public values (see figure 1).

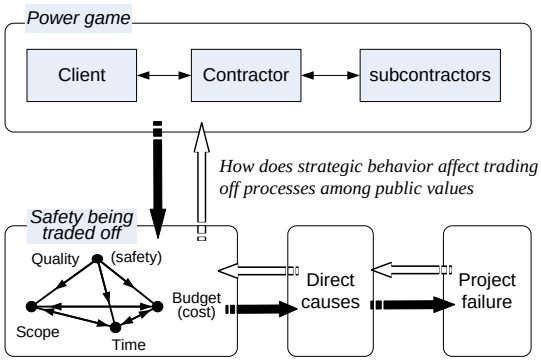

Figure 1 The game of trading off public values

III. THE CASE OF THE HANGZHOU SUBWAY COLLAPSE

The Hangzhou subway system was first conceived in 1984 and is the largest investment with the longest construction

period in the history of the city. Eight subway lines are projected, with a total length of 278 km, requiring a total investment of at least 100 billion Yuan (over 10 billion euros). The first phase of the construction will consist of lines 1, 2 and part of line 4 and is estimated at approximately 45 billion Yuan. Currently, subway line 1 is under construction. It will be 47.97 kilometers long, with 30 stations, 41.36 km underground, 6.14 km elevated, and 0.47 km at the ground level. In 2004, the initial total estimated project costs were of 15.2 billion Yuan provided by both the city government (10.2 billion Yuan) and private banks (5 billion), but this number has increased to 22.08 billion Yuan since 2007. It was hoped that line 1 could become the backbone of the New Hangzhou in the urban space structure [19] and was well-known for being the longest trajectory of almost 48 km, about three times the average length of single lines in China. The Hangzhou city government aimed to transfer the Hong Kong pattern of subway development (Build-Develop-Operate- Transfer, BDOT) to Hangzhou, where subway construction was linked to and dependent on real estate development. Consequently, real estate developers were attracted to support urban expansion. These developers regularly lobbied for changes in the route to increase their profits and found a sympathetic ear with the city government which realized that such changes also generated additional income for the city.

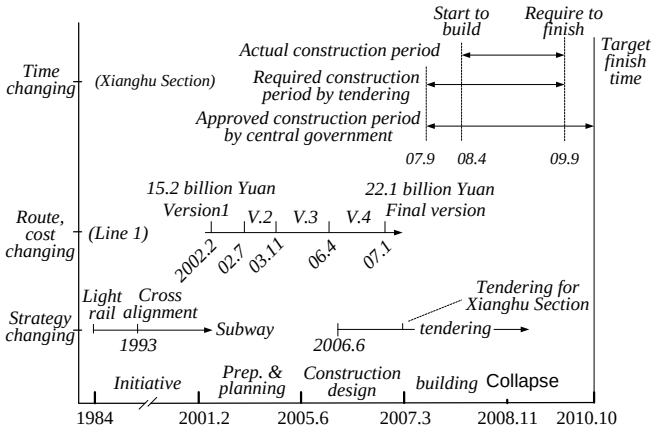

Figure 2 Time schedule of the development of Hangzhou subway line 1

June 6, 2002, the Hangzhou Subway Group Co. Ltd was founded, a so-called Special Project Vehicle (SPV) with the aim to build and operate the metro system, accompanied by a remarkable change in policy intents from mitigating traffic congestion to supporting urban expansion [20]. A final notable fact are the weak geological conditions (soft soil layers, high underground water levels and extensive sludgy layers) against which experts in charge of the line 1 planning review warned in advance. To accommodate this caveat a section of the subway about 260 meters long (named Qiutao experimental section for 0.17 billion Yuan) was built for exploration, testing and learning on December 26, 2003. These tests were apparently successful, since the construction of subway line 1 was officially approved by the central government January 17, 2007.

As to the financial arrangement, the main constitution of the funds for subway line 1 is Hangzhou government and Districts governments (55%), Bank loans (23%) and private company (10%). Although financial responsibilities are distributed over the Hangzhou government, the district governments and the banks, actual decision-making power stays firmly in the hands of the Hangzhou government, implying that it can intervene without impunity at any time and in any decision-making phase (planning, building, operations and management).

On March 20 2007, the Hangzhou Subway Group launched an open tender for its construction, which is now divided up in no less than 40 contract sections. Here it should be noted that two big state-owned enterprises, the *China Railway Group Co. Ltd.* (CRG) and *the China Railway Construction Corporation Limited* (CRCC), together (including their various subsidinaries) won about 65% of the bids, while the 22.5% private winners are all from Zhejiang province itself. Both aspects indicate the high level of market concentration.

When it comes to the specific contract section of Xianghu station where the accident occurred, it appears that the selected contractor is China Railway Group Co Ltd (CRG), the market leader, at a bidding price of 306.214 million Yuan for a scheduled construction time of 706 days. The quality requirement in this contract is ‘pass’, which is at the lower end of a two-level scale ‘pass-good’ set by the client (Hangzhou Subway Group) for line 1. In reality, choosing market leader CRG actually entails hiring a number of fairly unknown and interdependent subcontractors doing the job (more details in later), because it already has too many construction projects to deal with. What you see is not always what you get.

IV. An Analysis of the Hangzhou Subway Collapse

A. Results from the official investigations

The Hangzhou City government set up an examination immediately after the accident. On February 9, 2010, the outcomes of this investigation were released by the Hangzhou government [1]. These focused mostly on technical reasons and causes, such as the violation of construction rules, problems in the support systems for the roof, failures in the project monitoring and the problematical effectiveness of the rescue operations. The only organizational reason mentioned in the report was that the project monitoring company, Zhejiang Dahe Engineering Monitoring Co. Ltd. was an ‘attached’ one, meaning that it was actually a subcontractor which was part of the Design Institute of China Railway No 4 Engineering Group Co. Ltd, but in a different guise. This implies that the monitoring organization is effectively the same as the actual constructor.

B. Continuous revisions in the route due to real estate profit motives

The BDOT procurement model in which subway development and real estate development were combined and

where the Hangzhou government could intervene at any time to secure its income from real estate development made regular adjustments in the route line 1 a key phenomenon to understand the outcome of the events. All along the way, the Hangzhou government has promoted this innovative procurement model and failed to see possible downsides. As a result, the itinerary underwent countless changes.

Figure 3 Changes in the route of subway line 1 from 2002 to 2007

In figure 3, we can see how the original line 1 underwent three major changes (apart from countless small ones not mentioned here) in the period 2002 to 2007 [21]-[24]. In this process, universal access and reduction of traffic congestion (connecting densely populated areas) increasingly gave way to urban expansion and commercial development of residential areas and shopping malls. Xianghu, the location of the later subway station and accident can be found between the Binjiang and Xiaoshan areas and is famous for its beautiful hilly landscape and its lake and was therefore considered an excellent location to develop real estate. But the geological conditions there are far less propitious for subway construction than elsewhere, and the risk of accidents accordingly higher (apart from the fact that the line will no longer serve the Chengxiang area in Xiaoshan district, where it could have helped solving traffic problems). Moreover, sudden changes increased the likelihood of irresponsibly high work pressure imposed on the contractor and subcontractors. In March 2004, the opportunistic and profit-driven changes in the planning scheme were subject to strong citizen protest. In the end, in order to alleviate public anger, the Hangzhou City government promised to build another subway line (line 2) which would call at the center of Xiaoshan district to accommodate the traffic demand there. This was less easy than it seems at first sight, because it implied that the route for line 2 would almost certainly also be subjected to adjustments too.

Another notable thing is that the continuous revisions in the route until January 2007 inevitably had a negative impact on the work of detailed construction design which began in September 2006 (see Figure 2).

C. Permanent time compression to save money

Time compression can be seen as an implicit way to save money at the expense of caution. Since subway line 1 is set up as a BDOT/SPV + TOT, the sooner the construction process is accomplished, the sooner the Hangzhou City government can get its cash back by leasing out the developed real estate. Furthermore, the contractor pays the salaries of workers by counting their working days. So to accelerate the construction the number of work hours per day can be increased while leaving the wages unchanged. Given the fact there is a growing demand for infrastructure construction in China, the sooner contractors can finish a project, the sooner they can begin the next one.

In the case of the Xianghu station, the winning bid mentioned a completion of the construction time in September 2009. However, in the official request for approval submitted to the State Council, completion had been forecasted for October 2010, which followed the official industry standards required for approval by the central government. Apparently, the actual construction schedule had been tightened by 13 months compared to what was legally required. Worse even, the actual construction began in April 2008 rather than September 2007, as there had been a 6-month backlog because of delays in the demolition works [25]. To make up for this 19-month gap (see figure 8), laborers indeed had to work 16 hours or more per day and many safety regulations were violated [26], [27].

Due to the enormous time pressure effective tracking and monitoring of the effects of environmental variations at the site were neglected, such as the influence of rainfall and the dynamics resulting in variations in the load on the roof due to passing automobiles, as well as regulations regarding the excavation width and exposure time for materials and the order in which construction layers had to be laid before workers could move on to the next section [28].

D. The opaque phenomenon called sub-contracting

Accordint to the bidding requirements [24] released by the Hangzhou Subway group, it is evident that these requirements are extremely high for general construction firms, leading to a situation where only the largest companies can obtain contracts, provided their relations (‘guanxi’) with the client are good and they accept the fact that their bids should be very low to stand a chance in the competition. For this reason, the contractor is often willing to accept certain jobs at a loss to maintain a good relationship with their client. The smaller ones, on the other hand, are weak and often strapped for cash, and have little or no chance to become the (main) contractor In practice, the contractor winning the bid charges 5% management fees and then passes on the actual work to small private firms that do the actual physical construction work

which they need in order to survive. Their weak position puts them in a subservient role and they are far removed from any opportunities to communicate directly with the client. The combination of factors is a dangerous admixture of high risk delegations without checks and balances: the lowest bids are the winning ones, leading to high financial and time pressures and evasion of regulatory safeguards against accidents, while these pressures are shifted to a great variety of nearly invisible, badly qualified (and sometimes illegal) subcontractors and sub-subcontractors acting on behalf of the main contractor [27], [29], [30]. These subcontractors are not independently monitored and have no incentive to send bad news or warning down.

In the case of Xianghu station, the bid winner was the large *China Railway Group Ltd.* (CRG) which was mentioned before. Its first subcontractor was *China Railway No.4 Engineering Group Co., Ltd* (CREG4), one of CRG's 47 subsidiaries (CRG has most shares). At its turn, CREG4 has 13 branch companies and 19 subsidiary companies and it used *the Sixth Civil Engineering Co. Ltd. of the CTCE Group* (CE6-CTCE), one of these 19 subsidiaries, as a sub-subcontractor. However, the actual builder of the fatal section of Xianghu station was the 'Project Department of Hangzhou subway line 1', a sub-sub-subcontractor temporarily founded by CE6-CTCE. As we can see, transparency and effective project oversight are not easy in such circumstances, making it not completely unlikely that safety problems arise and remain undetected for a long time.

E. The invisible but pernicious process of trading off public values

In the above subsections, we have given quite of a bit of evidence on how the trading off process among various values between client and contractor, and between contractor and subcontractor evolves in the case of the Hangzhou subway line 1. The figure below succinctly summarizes these findings. The client (Hangzhou City government) formulated certain quality requirements (regarding safety and durability of the construction, partly in compliance with official regulations) and otherwise focused primarily on minimizing costs and time, while maximizing scope, such as maximizing income from real estate and servicing various areas or responding to pressure from pressure groups, the public and other players. The contractor (CRG) attempted to maximize its profits and goodwill with the client through accommodating the changes in scope (at least in appearance) while minimizing time and costs and maximizing extra income from real estate development. For CRG, quality was obviously a cost and therefore not very attractive to safeguard. In order to achieve all of this, it was deemed acceptable even to by-pass national legal procedures, requirements and safeguards aimed to promote caution.

Fortunately for Hangzhou and CRG, there was a way to dissimulate these quality flaws. They were re-delegated to obedient and deprived subcontractors and sub-subcontractors whose time-pressured operations were not seriously monitored and which could (be trusted to) deliver what they promised. Because of the weak positions these unknown and sometimes ephemeral subcontractors had and the fact that CRG owned a majority of their shares, it could over-demand, push subcontractors against the wall and thus please its client by promising golden pie in the sky. However, there was a price to pay. Although often such half-legal and illegal practices of strategic behavior [31] and safety risks remain undetected and client and contractor get away with them, every now and then serious accidents occur casting a doubtful light on the contractual arrangements in place for some subway projects. Although the Hangzhou case seems exceptional in terms of the severity with which safety aspects were sacrificed for private economic gain and political convenience, the incentives for downplaying soft values when they do not appear to generate income need special consideration. This is true not only when they are not protected through legislation, but even when such regulations exist but are not (sufficiently) enforced.

V. CONCLUSION

The analysis of the Hangzhou subway case has shown how institutional practices may create conditions for strategic behaviour, resulting in safety being traded off against 'hard' values like time and money, thus generating conditions for direct causes for failure to occur. Unfortunately the Hangzhou case is hardly unique as far as safety outcomes are concerned, and neither is it in terms of the institutional practices identified: continuous revisions by the client, time compression, playing the 'real estate card' and subcontracting. As such, the conditions underlying the occurrence of incidents and casualties are deeper and more persistent than merely technical failures, and widely spread over the country. Attempts at improving the safety performance therefore require measures at the institutional and regulatory level, not all of which can be immediately realized.

More specifically, the analysis of the Hangzhou casus provides us with the following adaptations of institutional practices to enhance checks and balances in the Chinese context of subway construction.

1) Real estate interests should be prevented from dominating the decision making. The Hangzhou case illustrates that if the client has immediate financial stakes in real estate development, this is a perverse incentive, which may result in risky trade-offs. On the other hand establishing a fire wall between subway construction and real estate development diminishes the opportunities to use the latter as a source of income [32]. Therefore the challenge regarding the playing of the real estate card is how the relationship between both activities can be arranged adequately. One solution might be to establish the infrastructure route before real estate is developed. Another is to prevent capture of government by real estate developers as happened in the Hangzhou case, by making

real estate development part of the project scope, as is being done in what can be called the 'Shenzhen model'. In Shenzhen a public-private arrangement was used, requiring the contractor to co-finance the subway construction by reinvesting the profits of real estate development. Nevertheless this model is not without problems either: in one of the Shenzhen projects contractors delayed their investment in the subway once the real estate had been realized [33].

2) The client's interference with the professional planning of construction projects should be restricted. Ongoing revisions of the project will jeopardize its realization and create risks for failure, including safety risks. In this respect the procurement model used may be considered less fortunate, giving the Hangzhou government the opportunity to keep on interfering in the planning process. Worldwide BOT and DBFO contracts are renowned for their ability to reduce the number of scope changes by government during the realization phase [7], [34]. As long as the client bears the financial risks, it will hard to limit the client's strategic attempts to increase its gains by interfering in the planning and realization phase.

In addition, the Hangzhou government's autonomy in making decisions on the project, despite the fact that financial responsibilities are distributed over various parties, might be seen as a cause of the whimsical behavior of the Hangzhou government. A greater accountability of the Hangzhou governments towards the district governments and banks might mitigate its inclination to intervene.

REFERENCES

[1] Hangzhou Government. Announcement of the investigation results on Hangzhou Nov. 15th subway collapse, 2010-02-10 (in Chinese).

[2] Harms-Ringdahl, L. "Analysis of safety functions and barriers in accidents." Safety Science 2009, 47(3): 353-363.

[3] Reiman, T. and P. Oedewald. "Assessment of complex sociotechnical systems - Theoretical issues concerning the use of organizational culture and organizational core task concepts." Safety Science, 2007, 45(7): 745-768

[4] Rasmussen, J. "Risk management in a dynamic society: a modelling problem." Safety Science, 1997, 27(2-3): 183-213.

[5] Hellström, T. "Critical infrastructure and systemic vulnerability: Towards a planning framework." Safety Science, 2007, 45(3): 415-430.

[6] Van Ham, H. J. Koppenjan. 'Building Public-Private Partnerships: Assessing and Managing Risk in Port Development.' Public Management Review, 2001, 3(4):593–616.

[7] Hodge, G. C. Greve, eds. 2005. The Challenge of Public-Private Partnerships: Learning from International Experience. Cheltenham: Edward Elgar.

[8] Charles, M. B., R. Ryan, et al. "Safe and Sound? The Public Value Trade-Off in Worker Safety and Public Infrastructure Procurement." Public Money & Management, 2008, 28(3): 159 - 166.

[9] de Jong, M., R. Mu, et al. "Introducing public-private partnerships for metropolitan subways in China: what is the evidence?" Journal of Transport Geography, 2010, 18(2): 301-313.

[10] Thacher, D., and Rein, M. Managing value conflict in public policy. Governance, 2004, 17(4), pp. 457-86.

[11] de Bruijn, H. & Dicke, W. Strategies for Safeguarding Public Values in Liberalized Utility Sectors. Public Administration, 2006, 84(3): 717-735.

[12] Koppenjan, J., M. B. Charles, et al. "Editorial: Managing Competing Public Values in Public Infrastructure Projects." Public Money & Management, 2008, 28(3): 131-134.

[13] Pandy, S.K., and Wright, B.E. Connecting the dots in public management: political environment, organizational goal ambiguity, and the public manager's role ambiguity. Journal of Public Administration Research and Theory, 2006, 16, pp. 511-32.

[14] Steenhuisen, B., W. Dicke, et al. ""Soft" Public Values in Jeopardy: Reflecting on the Institutionally Fragmented Situation in Utility Sectors." International Journal of Public Administration, .2009, 32(6): 491 - 507.

[15] Steenhuisen, B. and M. van Eeten. "Invisible Trade-Offs of Public Values: Inside Dutch Railways." Public Money & Management, 2008, 28(3): 147-152.

[16] Leijten, Koppenjan, ten Heuvelhof, Veeneman and van der Voort. Dealing with Competing Project Management Values under Uncertainty: the Case of RandstadRail. European Journal of Transport and Infrastructure Research, 2010, 10(1), pp. 63-76

[17] Turner, R. (ed.) Handbook of Project-Based Management (2008/1999), berkshire: Mc-Graw-Hill

[18] Yip, S. L. J. New directions of environmental management in construction: Accepted levels of Pollution. Structural Survey, 2000, 18(2): 89-98.

[19] HUPB-Hangzhou Urban Planning Bureau, Hangzhou Urban General Planning: 2001~ 2020. 2002 (in Chinese). URL: http://map.hangzhou.gov.cn/hzupo/hangzhou2020/index.jsp (URL)

[20] Hong, M. and J. Wan. "Why Hanghou to built a subway (in Chinese)." Merchomts weekly, 2004, 4(5): 32.

[21] Xiaoshan government, 2002-02-04. Two of top 10 projects of Hangzhou will locate in Xiaoshan district (in Chinese).

[22] Xiaoshan government, 2002-07-16. The adjustment of planning scheme of Hangzhou subway line 1 (in Chinese). http://www.xiaoshan.gov.cn(URL)

[23] Xiaoshan government, 2003-11-27. The experimental section of Hangzhou subway will begin to build before spring festival (in Chinese). http://www.jt.xiaoshan.gov.cn/FL/editers/2003-11-27/000002.html

[24] Hangzhou Subway Group, 2007-03-21. Notice for tendering Zhejiang key construction project, Project No. 2007-010, (in Chinese). Zhejiang Daily.

[25] Xiaoshan Government, 2008-04-02. Xianghu station of subway line 1 begins to build (in Chinese). URL:http://www.xiaoshan.gov.cn/zw/zwdt/tpxw/t20080402_63027.htm

[26] Shao, G. "Warning of Collapse Accident of Construction Site in Hangzhou Metro (in Chinese)." Modern Urban Transit, 2009, 6(1): 1-3.

[27] Yan, G. "Reflections resulted from Hangzhou subway accident (in chinese)." Construction Safety, 2009, 24(2): 42-45.

[28] Xinhua News, 2008-11-19. The State Administration of Work Safety announced Hangzhou Nov. 15th subway collapse event (in Chinese). http://news.xinhuanet.com/newscenter/2008-11/19/content_10383212_1.htm (URL)

[29] Chen, Z. and L. Xiao. The chain of responsibility of Hangzhou subway accident (in Chinese). China Township Enterprises, 2009, 28(1): 11-13.

[30] Ji, X. "tendering four times disclosed in Hangzhou subway project (in Chinese)." China Economic Weekly, 2008, 5(45): p.13.

[31] Heuvelhof, Ernst ten, Martin de Jong, Mirjam Kars and Helen Stout: Strategic behaviour in network industries: A Multi-disciplinary approach, 2009, Edward Elgar, Cheltenham.

[32] Koppenjan, J.F.M., and E. Enserink. Public Private Partnerships in Urban Infrastructures: Reconciling Private Sector Participation and Sustainability: in Public Administration Review, 2009 (3/4) pp. 284-

[33] Mu, R., de Jong, M. and Koppenjan, J. The rise and fall of public-private partnerships in China: a path-dependent approach. Journal of Transport Geography. 2010, (forthcoming)

[34] National Audit Office. PFI Construction performance, HC 371, Parliamentary session 2002-3, London: The Stationary Office. 2003. www.nao.org.uk.publications/nao_reports/01-02/0102375/pdf (URL)