EX-POST ANALYSIS OF AN INFRASTRUCTURE PROJECT IN THE PORT OF ANTWERP

Vergauwen Britt
University of Antwerp
Department of Transport and Regional Economics
Prinsstraat 13
2000 Antwerp (Belgium)
tel +32 3 265 46 08
fax +32 3 265 43 95
e-mail: britt.vergauwen@ua.ac.be
http://www.ua.ac.be/tpr

ABSTRACT

A social cost-benefit analysis is a good and common method to evaluate large investments in infrastructure projects in an economic way. The purpose of such an analysis is to examine whether the project will benefit to social wealth or not. If the social costs turn out to be larger than the social benefits, then the project should be abandoned. Otherwise, if social benefits are higher than social costs, it would be advisable to proceed with the infrastructure investments. However, cost-benefit analyses are based on forecast figures, which can be different from the real costs and benefits. Forecasts are subject to uncertainty and should be considered with care. Therefore, an ex-post analysis is interesting to make a comparison between forecast and real values.

In this paper, an ex-post analysis will be made of the 'Deurganckdock', a Flemish infrastructure project in the port of Antwerp (Belgium). A cost-benefit analysis of this project was carried out in 1996. The paper will have a close look at this analysis, it will compare the original to the actual, ex-post costs and benefits and it will examine the most influencing variables on costs and benefits in particular, such as investment expenses and maintenance costs of the government, environmental costs, traffic forecasts, cost savings for port users, employment during construction and maintenance.

Lessons can be drawn with respect to the caution that is needed when estimating ex-ante costs and benefits, and with respect to the cost and benefit elements that are of highest importance in port investment analysis. As such, the results are beneficial to academics as well as business practitioners.

Keywords: investments, infrastructure, cost-benefit analysis, ex-post analysis, Deurganckdok

BACKGROUND OF THE 'DEURGANCKDOCK'

The case of the Deurganckdock (also known as 'Containerkade West') concerns an investment project in the port of Antwerp between 1995-2006. It is located on the left bank of the river Scheldt, south of the village Doel (figure 1).

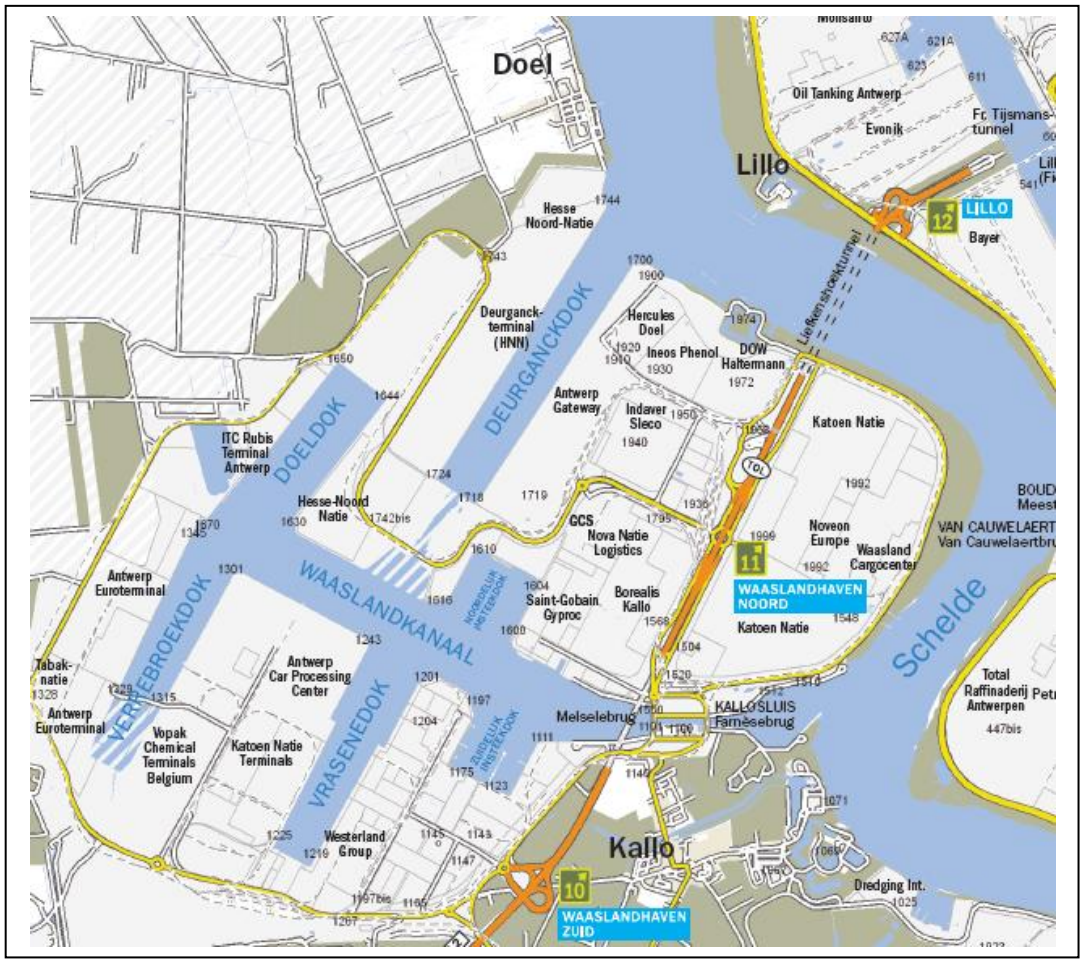


Figure 1 - Location of the Deurganckdock (Port of Antwerp, 2008a)

Several aims were set. The dock should anticipate on the increased growth in the container market. This would maintain and even improve the competitive position of the port of Antwerp. (Kloek 2009)

Moreover, a major objective of the project was to expand the capacity for transhipment with at least two million twenty-feat containers by building this tide dock next to the river Scheldt. This would almost double the existing capacity of the port. Because of an open connection to the river Scheldt there would be no need of any lock, which leads to faster treatment of ships. (Teurelincx et al. 1997)

The project was preceded by a number of studies among which a cost-benefit analysis, an environmental impact assessment, a ground physical study and a study concerning the quality of life of the village Doel. (Kloek 2009)

The plans for the Deurganckdock were prepared in the mid 90's by 'the Administration Waterways and Seaways'[1] as part of the ministry of the Flemish government on the one hand and the Port Authority of Antwerp ('Gemeentelijk Havenbedrijf Antwerpen') on the other hand. In 1997, the Flemish Port Commission ('Vlaamse Havencommissie') advised in favour of the project and the Flemish government approved the construction of the dock on January 20th, 1998. Therefore, a number of modifications of the district plans and licenses were needed in order to transform part of the residential area into industrial area. (Rekenhof 2005)

On July 24th , 1998, the 'social supervision plan Doel' was approved. This plan included concrete initiatives to help the residents of Doel in order to manage the desertion of the village in a financial and social well-considered way. (Rekenhof 2005)

Furthermore, the project was delayed by several suspensions due to procedural mistakes. Besides, a number of interest groups interrupted the progress of the project on legal grounds. Their complaints included the uncertainty about the need for further development of the port and their concerns about the residential area of Doel. In addition, the European Commission insisted on compensations for the loss of nature that was caused by the project. (Rekenhof 2005; Vlaamse Havencommissie 2003)

As a consequence, the work was suspended for over a year and the claims for the building contractors added up to 33,5 million EUR in 2004. In order to continue the building constructions and to validate the work, a special decree was issued which provided the required building licenses and environmental compensations. (Rekenhof 2005)

Eventually, the Deurganckdock was opened on July 6th, 2005. This resulted in the fact that the capacity for containers in the port of Antwerp doubled. According to the port alderman Leo baron Delwaide, Antwerp would be able to compete again with other European ports from this point on. (Rekenhof 2005; Vlaamse Havencommissie 2005)

FUNDING OF THE PROJECT

The construction of the dock was split into three phases in order to anticipate demand and to spread the total investment amount for the construction that was estimated in 1995 at 9,2 billion BEF. Respectively 4 billion BEF, 2,5 billion BEF and 2,7 billion BEF would be invested in the first (1997-2000), the second (2001-2005) and the third phase (2006-2010) of construction. The purpose of a planning in phases is to link the created capacity to the expected evolution of traffic over time. (Teurelincx et al. 1997)

Table 1 represents a comparison between the cost estimates of 1998 (price level 1994) and the cost estimates in 2004 at the point of realization of the project. Halfway 2004, the total cost of the project was estimated at approximately 600 million EUR, which is 39% higher than the initial estimate in 1998.

[1] Administratie Waterwegen en Zeewezen (AWZ)

Table 1 - Cost estimates of the Deurganckdock (EUR) (Rekenhof, 2005)

EUR	**Cost estimates in 1998 (price level 1994)**	**Estimates in 2004 of total costs at realization**
Preliminary studies	1.561.729,19	2.327.526,62
Additional studies	-	1.518.036,00
Wall quays (incl.insurance claims	197.893.399,84	276.184.794,67
Dredging operations	137.880.051,76	174.238.364,38
Other construction works	12.394.676,24	20.606.229,84
Road works	14.997.558,25	34.637.085,95
Expropriations MIDA[2]	14.687.691,34	14.849.252,65
Social supervision plan Doel	51.357.622,97	45.855.415,28
Nature compensations	-	24.099.379,54
Total	**430.772.729,59**	**594.316.085,62**

This table reflects a significant difference between the actual costs at realization and the cost estimates in 1998. The difference can be attributed to a number of factors, although the main reason for the increase in costs is due to the impact of inflation, which was initially not taken into consideration. Besides the impact of inflation, the increase in costs is also caused by many changes and new decisions during the progress of the project, among which: (Rekenhof 2005)

- a number of additional studies
- the construction of a bank in the 'Doeldok' in order to get rid of the dredgings
- a number of other construction works that were not foreseen such as additional costs for the raising of the terminal areas
- many additional road works for the opening up of the Deurganckdock
- the nature compensations that were disregarded in the initial estimates

However, in spite of these underestimations, the forecasts related to the expropriations were well-considered.

Though the construction of the project took place after the Port Decree of 1999, the funding occurred following the rules of the period before the Decree and thus bilateral agreements concerning the financing were made. These agreements implied that the financing was divided between the Flemish Region and the Port authority of Antwerp[3] according to the 60/40 investment rule. The decree of November 10th, 1993 of the Flemish government stipulates that the Flemish Region has the possibility to support equipment infrastructure and dredging operations for respectively 60 and 100 percent. (Rekenhof 2005)

As a consequence, 60 percent of all costs related to the construction works of quay walls and potential additional charges are supported by the Flemish Region against 40 percent supported by the Port authority of Antwerp. However, all dredging operations and additional costs are 100 percent funded by the Flemish Region. (Kloek 2009; Rekenhof 2005)

Table 2 represents an overview of the cost segmentation between the Flemish Region and the other authorities.

[2] Maritime Industrial Development Area
[3] Havenbedrijf Antwerpen

Table 2 - Cost segmentation of Deurganckdock (EUR) (Rekenhof, 2008)

Description	Total	Flemish Region	%	Other authorities	%
Preliminary studies	2.500.181,62	2.200.840,37	88%	299.341,25	12%
Additional studies	1.535.807,09	654.961,76	43%	880.845,33	57%
Quay walls	259.326.485,47	155.595.891,28	60%	103.730.593,72	40%
Insurance claims	27.218.121,57	16.330.872,94	60%	10.887.248,63	40%
Dredging operations	235.062.785,39	235.062.785,39	100%	-	0%
Other construction works	11.949.602,07	11.751.290,07	98%	198.312,00	2%
Road works	32.627.521,49	22.957.060,33	70%	9.870.461,16	30%
Expropriations MIDA	12.845.868,39	12.845.868,39	100%	-	0%
Social supervision plan Doel	48.794.462,20	46.002.613,16	94%	2.791.849,04	6%
Nature compensations	41.004.102,3	25.681.801,20	63%	15.322.301,10	37%
Total	**672.864.937,60**	**529.083.984,89**	**78%**	**146.692.320,82**	**22%**

COST-BENEFIT ANALYSIS OF THE 'DEURGANCKDOCK'

In 1997, Teurelincx, Verbeke and Declercq carried out the cost-benefit analysis of the Deurganckdock. On the one hand, the analysis considers the costs and benefits from an international point of view (represented in table 3) and thus takes into account all costs and benefits related to the international community. On the other hand, the analysis pays attention to the Belgian point of view and regards all costs and benefits related to the Belgian community. (Teurelincx et al. 1997)

Table 3 - Costs and benefits from the international point of view (Teurelincx et al, 1997)

Costs	Benefits
Investment expenses of the government	Cost savings for the port users
Maintenance expenses of the government	Employment during construction and maintenance
Environmental costs	Additional port revenues
Inefficient use of capacity in other ports caused by the project	Contribution to other port projects

With a view to the ex-post analysis in the next part of this paper, only the international point of view will be discussed, because the required and detailed data are hard to obtain on a national level.

Besides the difference between the international and Belgian point of view, a second distinction is part of the cost-benefit analysis. In particular, two different work strategies are used. A first work strategy concerns conventional techniques for cost-benefit analyses and a second work strategy takes improvements of the conventional techniques into account. (Teurelincx et al. 1997)

As table 4 indicates, both strategies have a significant outcome in the cost-benefit analysis. The difference is due to a number of aspects: (Teurelincx et al. 1997)

- The first work strategy assumes linear demand curves unlike the second strategy were non-linear demand curves are used. As a consequence, the induced traffic is

subject to effects of agglomeration, effects related to psychological inertia and transaction costs in the second strategy. This is not the case in the first strategy.

- The estimations concerning traffic over different terminals are based on linear and capacity related criteria in the first work strategy. The second strategy estimates these figures based on congestion levels and time costs through locks.
- The concept of congestion is different for both methods. If congestion occurs in the first strategy, growth of traffic has been halved. The second method on the other hand calculates congestion levels on each terminal, depending on parameters as the vessel portfolio, the average waiting time, the efficient use of quays and the terminal productivity. Growth of traffic on the congested terminals can also be determined, applying these parameters.
- Whereas the first work strategy halves the growth when the existing capacity is no longer sufficient to deal with the traffic growth (without the construction of the dock), the second work strategy determines the annual congestion level and integrates a gradual deterioration in productivity.

Table 4 - Cost-benefit analysis of the Deurganckdock (EUR, prices of 1995) (Teurelincx et al, 1997)

	1st work strategy	**2nd work strategy**
Costs		
Investment expenses of the government	215.392.124	
Maintenance expenses of the government	132.193.685	
Environmental costs	0	
Inefficient use of capacity in other ports caused by the project	0	
Total costs	**347.585.809**	
Benefits		
Cost savings for the port users	1.285.054.185	1.623.577.695
Time benefits	*712.091.292*	*783.995.354*
Savings in congestion	*572.962.893*	*839.582.341*
Employment during construction and maintenance	154.724.864	
Additional port revenues	316.197.578	407.725.633
Concessions	*154.258.026*	*154.258.026*
Port charges	*161.939.552*	*253.467.607*
Contribution to other port projects	84.199.611	
Total benefits	**1.840.176.238**	**2.270.227.803**

Moreover, a number of remarks about the cost-benefit analysis in table X should be highlighted: (Kloek 2009; Teurelincx et al. 1997)

- The investment expenses of the government enclose the total construction costs of the project.
- Costs related to expropriations and measures that are inevitable to keep the quality of life of Doel safe are left out of the analysis. Teurelincx, Verbeke and Declercq (1997) state that the expropriations are attributed to a cause other than the construction of the Deurganckdock. In their opinion, the expropriations result from a previous decision to build out the left bank of the river Scheldt as part of the port area.
- Concerning the inefficient use of capacity in other ports caused by the project, these costs are left out of the analysis based on the principle of reciprocity and analogous

to the common use in previous cost-benefit analyses. This principle will be discussed later on in the section about 'inefficient use of capacity in other ports caused by the project' of this paper.

- The cost savings for the port users can be subdivided between the time benefits (for the ship, as well as for the goods) and the savings in congestion.
- The benefits related to the creation of employment only consider construction and maintenance. The employment during the handling of containers and repairing containers is left out of the analysis. From the international point of view, there are no additional benefits for the international community, because the project only causes a shift in traffic flows. This is also the case concerning a rise in industrial activity that can be created in the direct environment because of the project. These factors are only considered in the Belgian point of view.
- The additional port revenues comprise the concessions as well as the port charges.
- The contribution to other port projects refers to the amount of dredgings that becomes available to raise industrial areas in the environment of the container dock. These terrains are classified as 'Maritime Industrial Development Area' (MIDA).
- All figures in the cost-benefit analysis are expressed in prices of 1995 and have been discounted against a rate of 4%.

Based on table 4, the cost-benefit ratio can be calculated:

$$\text{Cost benefit ratio} = \frac{(\text{Total of discounted benefits} - \text{Total of discounted costs})}{\text{Non discounted investment expenses}}$$

$$\text{Cost benefit ratio}_{\text{work strat.1}} = \frac{(1.840.176.238\ \text{EUR} - 347.585.809\ \text{EUR})}{287.178.451\ \text{EUR}} = 5{,}20$$

$$\text{Cost benefit ratio}_{\text{work strat.2}} = \frac{(2.270.227.803\ \text{EUR} - 347.585.809\ \text{EUR})}{287.178.451\ \text{EUR}} = 6.69$$

These figures can be interpreted as follows: 5,20 EUR for the first work strategy and 6,69 EUR for the second work strategy will be the return for every EUR that is invested. The Deurganckdock results in high cost-benefit ratio's for both work strategies, though the investment cost of the project is significantly higher than the investment costs of analogous projects (with average cost-benefit ratio's between 2,8 and 5). This can be explained by the importance of the time savings that are realized, which attract new port users to the port of Antwerp. Moreover, the creation of capacity results in reduced congestion. According to Teurelincx, Verbeke and Declercq (1997), these positive results would lead to a rise in market share of 2%. (Kloek 2009; Teurelincx et al. 1997)

EX-POST ANALYSIS OF THE 'DEURGANCKDOCK'

The purpose of ex-ante analyses is to estimate the potential benefits of a project based on traffic forecasts. The major concern is the quality of these forecasts, because they determine to a large extent the overall quality of a cost-benefit analysis. (Kloek 2009)

Opposite to an ex-ante analysis, ex-post analyses compare the *actual* costs and benefits with the *estimated* costs and benefits of the ex-ante analysis and stipulate the *actual* cost-

benefit ratio. As a consequence, the ex-post analysis verifies the similarity between the actually realized traffic of containers and the forecasts of demand. (Kloek 2009)

In the case of the Deurganckdock, the different costs and benefits will be discussed in the next section.

Costs of the Deurganckdock

Investment expenses of the government

Table 5 gives an overview of the original planning of different construction phases of the project versus the actual planning of the project in 2004.

Table 5 - Original planning versus actual planning in 2004 (Rekenhof, 2005)

Original planning		**Actual planning of realization in 2004**	
Preparation	1995-1997	Preparation	1995-1997
		Additional studies	1999-2000
Construction phase 1	1997-2000	Construction phase 1+2	1998-2005
Construction phase 2	2000-2006	Suspension of works	2001-2002
Construction phase 3	2006-2010	Construction phase 3	2003-2006

In order to anticipate on the expected growth in container traffic, the Flemish government decided on December, 13th 2002 to execute phase 1 and 2 of the quay walls simultaneously. Next, phase 3 of the quay walls was carried out more rapidly as well. However, these accelerations of the project might lead to an excess in capacity between 2006-2015. (Rekenhof 2005)

Eventually, the Deurganckdock was officially opened on July 6th, 2005. (Rekenhof 2005)

Table 6 gives an overview of the evolution of all costs involved in the project, as well as the share of each cost factor in the total cost.

73,4% of all costs are related to quay walls and dredging works with regard to 4,88% and 7,25% respectively for road works and the social supervision plan of Doel.

All investments of table 6[4] were discounted to 1995 – according to the year when the expenses occurred – and aggregated. The total construction costs for the government (Flemish Region and Port authority of Antwerp) result then in 478.161.120,44 EUR. This means that the investment costs of the government are doubled compared to the estimated construction costs in the ex-ante analysis (215.392.124 EUR).

[4] With exception of nature compensations which will be included in part 1.4.1.3

Table 6 - Estimated versus actual costs Deurganckdock (EUR) (Rekenhof, 2008)

	Estimate 1995 (Start Note)	**Estimate Basic Resolution 1998**	**Actual total costs**	**Share (%)**	**Increase (%)**
Preliminary studies	1.561.729,19	1.561.729,19	2.500.181,62	0,37%	60,09%
Additional studies			1.535.807,09	0,23%	
Quay walls	197.893.399,84	197.893.399,84	259.326.485,47	38,53%	31,04%
Insurance claims			27.218.121,58	4,04%	
Dredging operations	113.950.456,00	137.880.051,76	235.062.785,39	34,92%	70,48%
Other construction works	3.718.402,87	12.394.676,24	11.949.602,07	1,78%	-3,59%
Road works	12.394.676,24	14.997.558,25	32.827.521,49	4,88%	118,89%
Expropriations MIDA	14.687.691,34	14.687.691,34	12.845.868,39	1,91%	-12,54%
Social supervision plan Doel		51.357.622,97	48.794.462,20	7,25%	-4,99%
Nature compensations			41.004.102,30	6,09%	
Total	**344.206.355,48**	**430.772.729,59**	**673.064.937,60**	**100,00%**	**56,25%**

The last column of table 6 refers to the increase in costs compared to the last estimations in 1998. The total increase of 56.25% can be attributed to several reasons.

- A number of preliminary and additional studies were not foreseen in the Basic Resolution
- The feeder quay of the 'Doeldock' was not executed and costs related to a close down increased quickly.
- The insurance claims were not taken into account either
- The increased costs related to dredging operations are due to the construction of a dam in the Doeldock, not estimated VAT and price adjustments
- A number of additional road links were not foreseen (among which the construction of a ringroad
- Nature compensations were not taken into account

Maintenance expenses of the government

According to the port authority of Antwerp, the maintenance costs involve an annual amount of 25 million EUR. The maintenance costs for the commercial berths in the port are not included. Discounted at a rate of 4% to 1995, this results in an amount of 16.889.104 EUR. (Kloek 2009)

Because it concerns a periodic amount that will be received indefinitely, the formula of perpetuity can now be applied:

$$\text{Present Value (PV)} = \frac{\text{Periodic payment (C)}}{\text{Periodic rate of interest (i)}}$$

$$\text{PV} = \frac{16.889.104\ \text{EUR}}{0.04}$$

$$\text{PV} = 422.227.600\ \text{EUR}$$

The present value of the actual maintenance costs is thus tripled compared to the estimated maintenance costs (132.193.684,76 EUR) in the cost-benefit analysis of Teurelincx, Verbeke and Declercq (1997).

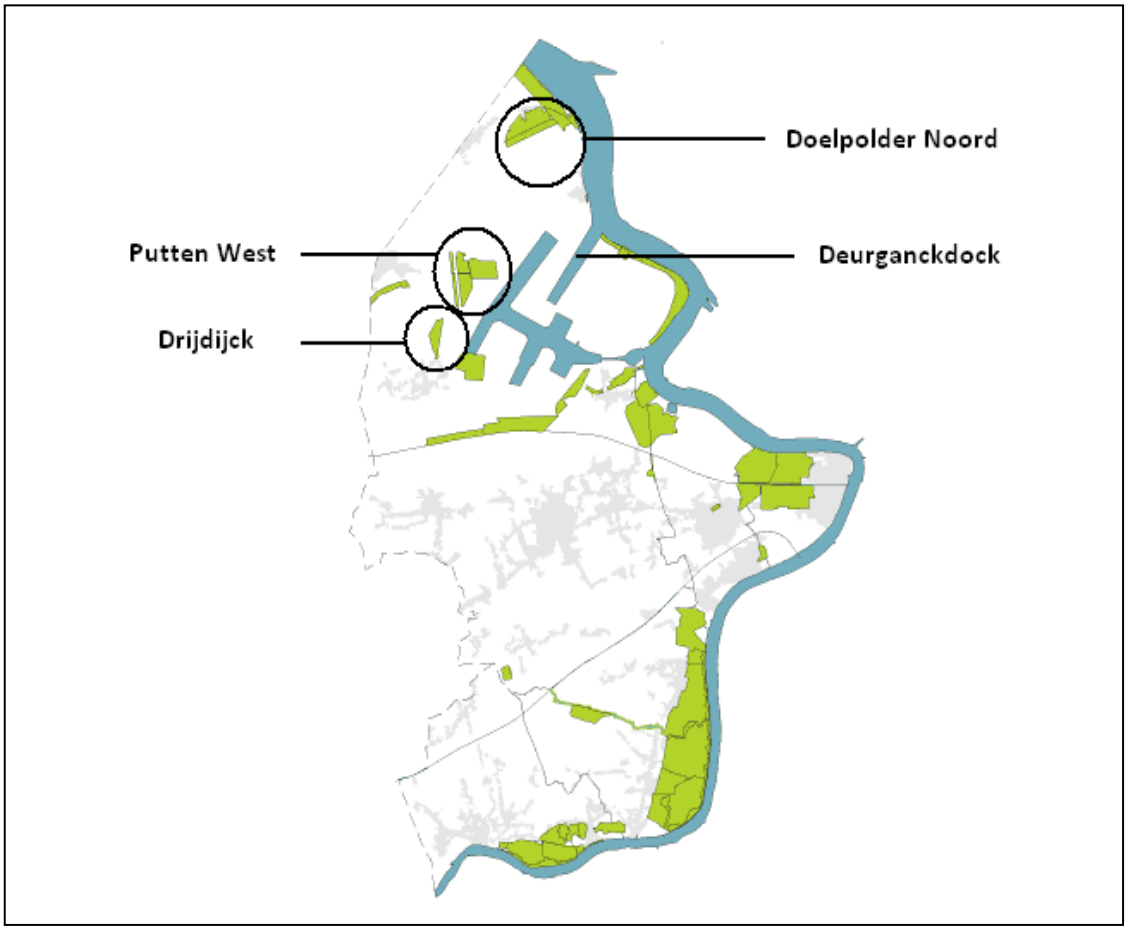
Environmental costs

All costs related to environmental consequences of the Deurganckdock, were not taken into consideration by Teurelincx, Verbeke and Declercq (1997). They refer to the environmental impact assessment of the project to support their opinion about this matter. (Kloek 2009)

However, the environmental impact of an infrastructure project is of primordial interest at present. The importance of aspects concerning the environment increased gradually the last decades. The European Commission judged that the nature compensations for the Deurganckdock were not sufficient and the original environmental impact assessment was poor. This statement led to one of the suspensions of the construction of the project by the Council of State, which led to a lot of claims. A special decree was necessary to resume the work. (Kloek 2009)

If a generally recognized and valuable nature area is threatened by the destruction or vanishing of this area, noise pollution, changes in water balance or influencing the landscape, the entire environmental damage must be compensated by investments in environmental projects. In case of the Deurganckdock, new bird areas (“Doelpolder Noord” and “Putten West”) and marshland (“Drijdijck”) were laid out as represented in figure 2. (Cant 2009)

Figure 2 - Nature compensations for the Deurganckdock (Natuurpunt – WAL, 2010)



In prices of 2008, the total costs related to compensations for nature add up to 41.004.102 EUR. It concerns ground acquisitions, studies, licences and so on. In a next step, all costs for

nature compensations were discounted to 1995 – according to the year when the expenses occurred – and aggregated. This results in a total amount of 26.982.163,70 EUR.

Inefficient use of capacity in other ports caused by the project

Teurelincx, Verbeke and Declercq (1997) appeal to the concept of reciprocity in order to justify why they left out the costs related to inefficient use of capacity that is caused in other ports due to the infrastructure project.

From the international point of view, a shift of traffic – that results in inefficient use of capacity in other ports – does harm the international community. However, these costs are not part of the cost-benefit analysis, because of a reciprocal principle. The costs of investments of other (international) ports, that cause inefficient use in Belgian ports, are disregarded in their analyses as well. As a consequence, it would be inconsistent to include these costs in our analysis. Moreover, this reasoning is in accordance with previous Belgian cost-benefit analyses. (Teurelincx et al. 1997)

However, from the Belgian point of view, these costs should be taken into account. A loss of traffic in one Belgian port coupled to an increase in traffic in another Belgian port leads up to a zero net-benefit. As a result, the effect of inefficient use of capacity in another port should be taken into consideration in the cost-benefit analysis. In the case of the Deurganckdock, it concerns port and berth charges that are lost in the port of Zeebrugge due to the shift of traffic in the direction of the port of Antwerp. These costs amount to 16.857.202,55 EUR and 16.772.431,09 EUR in respectively the first and second work strategy (prices of 1995). (Teurelincx et al. 1997)

Comparison of ex-ante costs versus ex-post costs

Table 7 represents a comparison of the costs involved in the project of the Deurganckdock. It should be noticed that the amounts in the table are the same for both work strategies.

Table 7 - Comparison of costs Deurganckdock between ex-ante analysis and ex-post analysis (prices, 1995) (Kloek, 2009; Teurelincx et al, 1997)

	Estimated (EUR)	**Actual (EUR)**
Costs		
Investment expenses of the government	215.392.124	478.161.120
Maintenance expenses of the government	132.193.685	422.227.600
Environmental costs	0	26.982.164
Inefficient use of capacity in other ports caused by the project	0	0
Total costs	**359.199.333**	**927.370.884**

Comparing the costs of the ex-post analysis with the costs of the ex-ante analysis leads to a number of important results.

The actual investments are doubled compared to the estimated investments and the actual maintenance costs are even tripled. Moreover, the environmental costs were left out of the

cost-benefit analysis, whereas the total amount adds up to 26.982.164 EUR in the ex-post analysis.

In conclusion, the overall costs were heavily underestimated. The actual costs are 2,58 times higher than the estimated costs (in prices of 1995).

Benefits of the Deurganckdock

Past trends in traffic and traffic forecasts

In order to determine the potential benefits of a large infrastructure project, forecasting the growth in container traffic is essential. However, these forecasts are always subject to uncertainty and should be considered with care. Investments in large infrastructure projects require a long preliminary investigation period. Besides, large infrastructure projects are characterized by a life expectancy of at least 25 years. Therefore, the cost-benefit analysis of these projects focus on a long term perspective concerning the traffic forecasts as well. (Teurelincx et al. 1997)

In this section, past trends in container traffic will be reviewed. Moreover, the initial traffic forecasts of the cost-benefit analysis will be compared to the actual container traffic until 2009 and new forecasts will be produced for the period between 2010 and 2015.

Table 8 gives an overview of the container traffic in the port of Antwerp in the Hamburg-Le Havre range between 1980 and 1995.

Table 8 - Container traffic of Antwerp in the Hamburg-Le Havre range (million ton) (Teurelincx et al, 1997)

Million ton	Antwerp	Other ports	Total	Market share Antwerp
1980	6,1	41	47,1	13,00%
1985	10,9	56,4	67,3	16,20%
1990	16,6	85,8	102,3	16,20%
1995	25,8	114,4	140,2	18,40%

In this period, the port of Antwerp experienced a bigger growth than the other ports in the range. Moreover, the overall market share was even higher than the average market share. The port of Antwerp reached a positive growth between 1980 and 1995, while on average a decrease in traffic occurred for the Hamburg-Le Havre range. (Teurelincx et al. 1997)

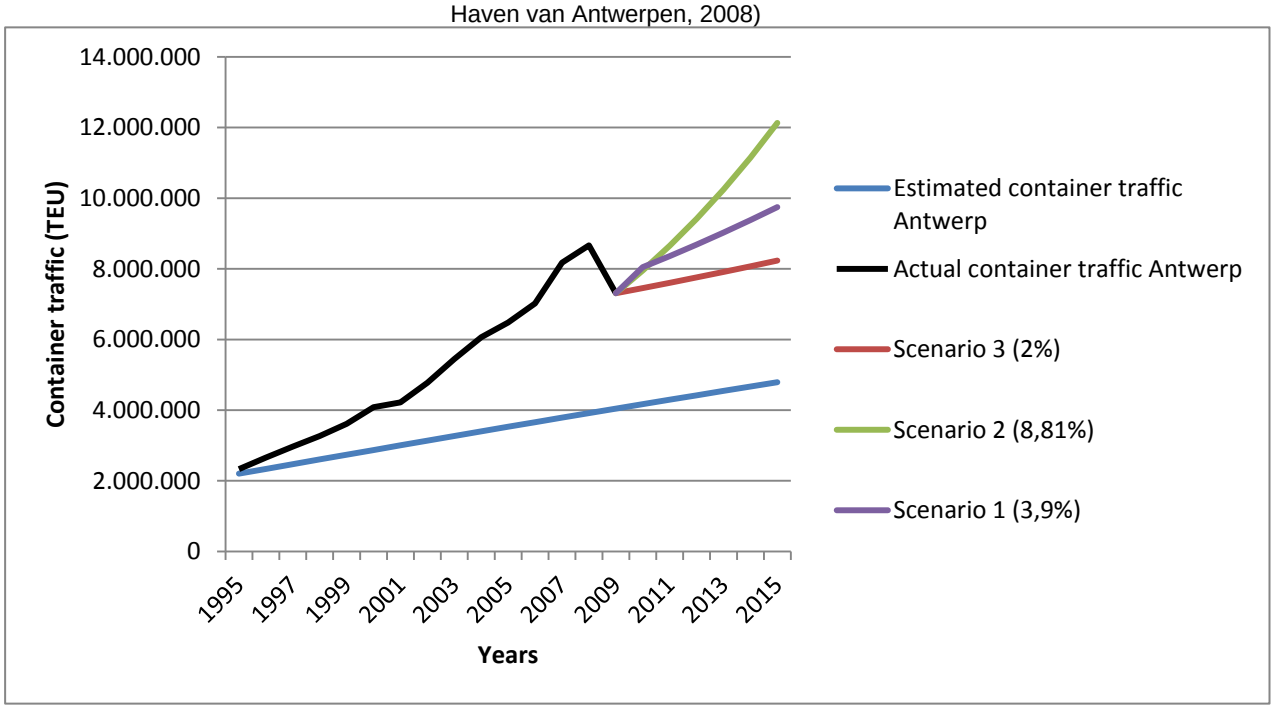
As table 9 reflects, the total traffic followed an analogous trend in growth and market share as the container traffic in table 8. As a consequence, the container traffic between 1980 and 1995 contributed considerably to the overall traffic in the port of Antwerp. (Teurelincx et al. 1997)

Table 9 - Total traffic of Antwerp in the Hamburg-Le Havre range (million ton) (Teurelincx et al, 1997)

Million ton	Antwerp	Other ports	Total	Market share Antwerp
1980	81,9	540,7	622,7	13,20%
1985	86,2	489,6	575,9	15,00%
1990	102	556,1	658,1	15,50%
1995	108,1	572,9	681	15,90%

Based on the market share of the port of Antwerp in the Hamburg-Le Havre range and the total container traffic in the range, Teurelincx et al (1997) made up the traffic forecasts in their cost-benefit analysis for 1996-2015. In order to express all data in TEU (Twenty Foot Equivalent Unit), the forecasts in million tons were divided by the average load in tons of a TEU in the port of Antwerp which was 11 ton/TEU in 1994. Under the assumption that this would be the average load for the next 10 years, the traffic forecasts according to Teurelincx et al (1997) are reflected in figure 3.

Figure 3: Container traffic forecasts in the port of Antwerp between 1995-2015 (in TEU) (Teurelincx et al, 1997; Haven van Antwerpen, 2008)



In order to compare the forecasts in the cost-benefit analysis with the actual data, the above figure also contains the actually realized container traffic for 1995-2009. Teurelincx et al (1997) assumed an average growth of the container traffic in TEU of 3,96% for the port of Antwerp until 2015. However, the actual average growth between 1995 and 2009 amount up to 8,81%, which is remarkably higher than originally forecasted in the cost-benefit analysis.

As a next step, new forecasts can be calculated for the period between 2010-2015. According to a study concerning the future economic development of the port of Antwerp (2008b), an annual growth of the container traffic expressed in million tons of 3,9% until 2015 and 2% between 2015 and 2030 would be a realistic assumption. Given the average load of containers over the last 15 years (since 1995) of 11,26 ton/container, this results in acceptable forecasts of the container traffic in TEU between 2010 and 2015. Figure 3 refers to this situation as ‘scenario 1’.

Besides this scenario, two other cases can be developed. Because of the economic crisis, the container traffic dropped 15,62% in 2009. In an even more optimistic scenario than scenario 1, the container traffic recovers well from the crisis after 2009 and growth figures resume to 8.81%, as they were on average before the crisis. This case is referred to as 'scenario 2' in figure 3. However, container traffic would reach unlikely high volumes by 2015 at this growth rate. Therefore, this scenario turns out to be the least plausible.

In a less favorable scenario 3, the economic crisis is harder to recover than expected and the regression gets structural. The container traffic increases slowly at an annual growth rate of 2%. This scenario is not very plausible either. By 2015, the container volumes would still not reach the amounts as they were before the crisis. As a consequence, this scenario should be avoided and higher volumes should be aimed at. Nevertheless, this would be at the expense of the yield, because more acceptable volumes – as in scenario 1 – can only be reached by a decrease in price.

As a conclusion, scenario 1 is the most realistic forecast. The volumes of scenario 2 are unlikely to be reached. Part of the container traffic will be captured by the port of Rotterdam for instance. By 2013, 'Maasvlakte 2[5]' will be in a final stage, which will triple the existing capacity for transhipment of containers in Rotterdam. As a consequence, this has its effect on the container traffic in other ports as the port of Antwerp.

Cost savings for the port users

The cost savings for port users (among which shippers and shipping companies) are composed of time savings for vessels as well as for goods on the one hand and savings in congestion on the other hand.

The construction of the Deurganckdock makes the use of any locks redundant, which leads to substantial time reductions for vessels over the distance between the Delwaidedock and the Deurganckdock. According to Teurelincx, Verbeke and Declercq (1997), the avoidance of locks leads to maximum time savings of 3,2 hours. However, terminal operator PSA estimates the total gain in time at 4 hours. This means an actual increase of 25% in time savings. (Kloek 2009)

Under the assumption that the actual time savings are 25% higher than the estimated time savings, the benefits add up to 890.114.115 EUR (first work strategy) and 979.994.193 EUR (second work strategy).

The saving in congestion is the second important factor that determines the total cost savings for the port users. Congestion leads to increased waiting times for the handling of vessels, which reflects in higher costs. The construction of the Deurganckdock increases the capacity for containers in the port of Antwerp and suppresses or avoids imminent congestion. (Teurelincx et al. 1997)

As mentioned in the section about 'cost-benefit analysis of the Deurganckdock' of this paper, the concept of congestion is different for the two work strategies that are used in the ex-ante analysis. The first work strategy adopts the conventional method if congestion arises and capacity growth will be halved. The second work strategy on the other hand recognizes the occurrence of improvements in productivity during handling procedures. The capacity of a

[5] A second industrial area (after 'Maasvlakte 1') in the North sea that increases the total area of the port from 2.000 ha to 6.000 ha.

container terminal will not just be halved within this strategy, but will be calculated with respect to waiting times. If waiting times would be too high, shipping companies can still opt for handling behind the locks. This method allows thus not only to determine the level of congestion more precisely, but gives information about the division of traffic over different port facilities as well. According to this second work strategy and in case of congestion, growth on the new terminal of the Deurganckdock would only be possible if the handling productivity of containers increases. (Teurelincx et al. 1997)

Besides the difference between the first and second work strategy concerning congestion, another distinction should be considered. On the one hand, the savings in congestion include the traffic that would be lost due to increased congestion costs in the port of Antwerp, if the Deurganckdock would not be constructed. On the other hand, the existing traffic in the port of Antwerp – which is fully subjected to congestion if that would be the case – also contributes to the cost savings in congestion. (Teurelincx et al. 1997)

Under the assumption that the savings in congestion are the same as calculated in the ex-ante analysis, the total time savings amount to:

$$\begin{aligned}\text{Total cost savings}_{\text{work strat.1}} &= 890.114.115\ \text{EUR} + 572.962.893\ \text{EUR} \\ &= 1.463.077.008\ \text{EUR}\end{aligned}$$

$$\begin{aligned}\text{Total cost savings}_{\text{work strat.2}} &= 979.994.193\ \text{EUR} + 839.582.341\ \text{EUR} \\ &= 1.819.576.534\ \text{EUR}\end{aligned}$$

Employment during construction and maintenance

According to the cost-benefit analysis, every BEF of project costs creates direct and indirect personnel costs of 0,646 BEF. In other words: 64,6% of the project costs are personnel costs. This means that the benefits of employment related to construction and maintenance are directly linked to the size of the construction and maintenance costs themselves. (Kloek 2009)

Teurelincx et al (1997) left out the costs related to insurance claims, expropriations and the social supervision plan Doel in order to calculate the project costs. Since the employment effects of these particular costs are not linked to construction and maintenance activities, they are not taken into consideration. In prices of 1995, the total project cost amount up to 831.771.497 EUR. Hence, the personnel cost that is being created is 537.324.387 EUR.

$$\begin{aligned}\text{Personnel cost} &= 0{,}646 \text{ x Project Cost} \\ &= 0{,}646 \text{ x } 831.771.497\ \text{EUR} \\ &= 537.324.387\ \text{EUR}\end{aligned}$$

In order to calculate the employment benefits, Teurelincx et al (1997) used the following formula:

$$\begin{aligned}\text{Employment benefit}^{6} &= 0{,}97 \text{ x } (\text{L} + 0{,}83\text{L}) \text{ x } 0{,}5 \\ &= 0{,}8924 \text{ x L} \\ &= 0{,}8924 \text{ x } 537.324.387\ \text{EUR} \\ &= 479.508.283\ \text{EUR}\end{aligned}$$

[6] With L = personnel costs

The employment benefit turns out to be three times higher than forecasted in the original cost-benefit analysis (154.724.864 EUR), because the project cost also multiplied with factor three. This reasoning is quite consistent, since the employment benefits that arise from construction and maintenance are directly linked to the size of the construction and maintenance costs themselves.

Additional port revenues

Concessions on the one hand and port charges on the other hand are part of the additional port revenues. Based on the data below, the concessions were estimated in the cost-benefit analysis at 154.258.026 EUR (for both work strategies). Hereby, a total surface of 202 hectare was considered. According to the analysis, 48 ha of the total surface would already be available in the first phase (2001-2005), 111 ha would be available in 2006 and 202 ha in 2010. (Teurelincx et al. 1997)

Concessions: 4,56 EUR/m²
Port charges: 0,64 EUR/ton or 7 EUR/TEU

However, based on actual data, 228 ha was rented out to the terminal operators DP World and PS HNN between 2001 and 2010. From 2011 onwards, the port authority will rent out 428 ha for which they will receive perpetual an amount of 10,4 million euro. (Kloek 2009)

Assuming the same tariffs as mentioned above, the actual concessions amount up to 340.235.600 EUR. All previous amounts are discounted and expressed in prices of 1995. (Kloek 2009)

The difference between the estimated concessions in the cost benefit analysis and the actual received concessions is due to the fact that only 202 ha are considered in the cost-benefit analysis, while in reality 428 ha will be rented out by the final stage of the project. (Kloek 2009)

Besides the concessions, the port charges are also part of the additional port revenues as represented in table 10. In 2006 and 2007, the actual port charges are respectively 810.000 EUR and 1,6 million EUR. Future port charges can be forecasted based on traffic estimations of the Deurganckdock. As in the cost-benefit analysis, there are two work strategies. Work strategy 1 has an average traffic growth of 13,2%, whereas scenario 2 has an average traffic growth of 13,6%. (Kloek 2009)

Table 10 - Additional Port charges (EUR, prices 1995) (Kloek, 2009)

	1st work strategy		2nd work strategy	
year	**Estimated**	**Actual**	**Estimated**	**Actual**
2001	923.193		1.478.188	
2002	1.611.593		2.049.311	
2003	1.932.901		2.683.913	
2004	1.948.131		2.607.983	
2005	1.956.831		2.537.057	
2006	2.801.362	3.683.124	3.444.062	3.683.124
2007	3.341.662	6.995.487	4.576.677	6.995.487
2008	3.568.809	7.614.712	5.271.476	7.642.870
2009	3.561.132	8.288.750	5.098.335	8.350.165
2010	4.180.729	9.022.451	6.442.107	9.122.914
2011	4.518.947	9.821.099	7.438.528	9.967.176
2012	4.645.420	10.690.441	7.486.797	10.889.568
2013	4.611.545	11.636.735	7.566.425	11.897.321
2014	4.572.674	12.666.794	7.366.610	12.998.335
2015	4.529.409	13.788.030	7.208.467	14.201.240
perpetuity	**113.235.214**	**344.700.757**	**180.211.670**	**355.031.005**
sum	**161.939.552**	**438.908.380**	**253.467.607**	**450.779.205**

The port charges can then be calculated by multiplying the forecasted container traffic with 7 EUR/TEU, which is the same tariff as mentioned in the cost-benefit analysis. All amounts are discounted to 1995. From 2015 onwards, 13,8 million EUR (work strategy 1) and 14,2 million EUR (work strategy 2) will be received perpetually. (Kloek 2009)

The total additional port charges for work strategy 1 result in 438.908.308 EUR compared to the estimated 161.939.552 EUR in the cost-benefit analysis. In the second work strategy, the total additional port charges add up to 450.779.205 EUR compared to the estimated 253.467.607 EUR. (Kloek 2009)

As a result, the total additional port revenues add up to 779.143.980 EUR (first work strategy) and 791.014.805 EUR (second work strategy).

Contribution to other port projects

As mentioned in the section of 'cost-benefit analysis of the Deurganckdock' earlier, the contribution to other port projects refers to the amount of dredgings that becomes available (29.850.000 m^3) to raise industrial areas in the environment of the container dock. These terrains are classified as 'Maritime Industrial Development Area' (MIDA). (Teurelincx et al. 1997)

The delivery of the dredgings implies no actual payment, since the parties that are involved are the same. Nevertheless, this contribution is quantified in the cost-benefit analysis, because the it concerns a benefit that is brought on by the project. (Teurelincx et al. 1997)

However, the cost-benefit analysis does not consider the industrial activity on these areas as a benefit. This is explained by the indifferent attitude of the international community against

the industrial development in a specific country. Under the assumption that there would be no raise of the terrains and no raise in industrial activity in the port of Antwerp as a consequence, the net benefit out of international point of view would be zero since the industrial activity would develop elsewhere in the international community. (Teurelincx et al. 1997)

The total contribution to other port projects was estimated in the cost-benefit analysis at 84.199.611 EUR (in prices of 1995). The same value will be assumed in the ex-post analysis.

Comparison of ex-ante benefits versus ex-post benefits

Table 11 and table 12 represent a comparison of the ex-ante and ex-post benefits involved in the project of the Deurganckdock in respectively the first and second work strategy.

Table 11 - Comparison of benefits Deurganckdock between ex-ante analysis and ex-post analysis (first work strategy, prices 1995) (Kloek 2009; Teurelincx et al. 1997)

Benefits	**1st work strategy (estimated, EUR)**	**1st work strategy (actual, EUR)**
Cost savings for the port users	1.285.054.185	1.463.077.008
Time benefits	*712.091.292*	*890.114.115*
Savings in congestion	*572.962.893*	*572.962.893*
Employment during construction and maintenance	154.724.864	479.508.283
Additional port revenues	316.197.578	779.143.980
Concessions	*154.258.026*	*340.235.600*
Port charges	*161.939.552*	*438.908.380*
Contribution to other port projects	84.199.611	84.199.611
Total benefits	**1.840.176.238**	**2.805.928.883**

Table 12: Comparison of benefits Deurganckdock between ex-ante analysis and ex-post analysis (second work strategy, prices 1995) (Kloek 2009; Teurelincx et al. 1997)

Benefits	**2nd work strategy (estimated, EUR)**	**2nd work strategy (actual, EUR)**
Cost savings for the port users	1.623.577.695	1.819.576.534
Time benefits	*783.995.354*	979.994.192,72
Savings in congestion	*839.582.341*	*839.582.341*
Employment during construction and maintenance	154.724.864	479.508.283
Additional port revenues	407.725.633	791.014.805
Concessions	*154.258.026*	*340.235.600*
Port charges	*253.467.607*	*450.779.205*
Contribution to other port projects	84.199.611	84.199.611
Total benefits	**2.270.227.803**	**3.174.299.233**

Besides the costs of the Deurganckdock, also the benefits are underestimated in both work strategies. An overview of the main reasons will be given in the section 'conclusions' later in this paper.

Actual cost-benefit ratio's

$$\text{Cost benefit ratio} = \frac{(\text{Total of discounted benefits} - \text{Total of discounted costs})}{\text{Non discounted investment expenses}}$$

$$\text{Cost benefit ratio}_{\text{work strat.1}} = \frac{(2.805.928.883\ \text{EUR} - 927.370.884\ \text{EUR})}{632.060.835\ \text{EUR}} = 2{,}97$$

$$\text{Cost benefit ratio}_{\text{work strat.2}} = \frac{(3.174.299.233\ \text{EUR} - 927.370.884\ \text{EUR})}{632.060.835\ \text{EUR}} = 3{,}55$$

In Teurelincx et al (1997), the cost-benefit ratio was respectively 5,19 and 6,69 for the first and second work strategy. The actual cost-benefit ratio's on the other hand are 2,97 and 3,55. This means that the net benefit per invested euro is almost halved in both strategies.

Conclusions

When studying the ex-post costs and benefits, a number of conclusions and recommendations regarding future cost-benefit analyses can be formulated. Lessons can be drawn with respect to the caution that is needed when estimating ex-ante costs and benefits, and with respect to the cost and benefit elements that are of highest importance in port investment analysis.

Particularly in the case of the Deurganckdock, the costs as well as the benefits were heavily underestimated.

The reasons for the cost underestimations are numerous. First, the planning period of the project was assessed wrong. Due to several suspensions of work because of procedural mistakes, the different construction phases were executed more quickly. This led to the opening of the Deurganckdock in 2005, 5 years earlier than originally planned.

Second, the ex-ante analysis neglected the impact of inflation, which resulted in significantly higher ex-post costs. Besides the impact of inflation, many changes and new decisions during the progress of the project led to further cost underestimations. Additional studies and constructions works were carried out, maintenance costs turned out to be three times higher than originally calculated and environmental costs were initially neglected while this cost element has high importance.

Third, the costs resulting from expropriations were left out of the ex-ante analysis, because Teurelincx et al (1997) were of the opinion that the expropriations resulted from a previous decision to build out the left bank of the river Scheldt as part of the port area. However, they should be incorporated in the analysis, because the realization of the Deurganckdock required the expropriation of a number of additional areas in order to get rid of the dredgings on the one hand and to anticipate on nature compensations on the other hand. In this way,

the expropriations do result from the decision to build the Deurganckdock and are thus part of the investment expenses of the government.

Hereby, one can wonder whether there are benefits on the other side resulting from the expropriations. This would be the case if the market value of the houses in the village Doel is higher than 'normal' prices for expropriations, because this situation would then result in benefits for the residents of Doel.

On the other hand, the total benefits of the project are also underestimated, but to a lesser degree compared to the total costs. The main cause is the underestimation of the container traffic until 2015. Teurelincx et al (1997) assumed an average growth rate of 3,9% whereas the container traffic in Antwerp grew on average with 8,81% between 1995 and 2009.

Moreover, the cost savings for the port users turned out to be higher than initially expected, because the time savings resulting from the construction of the Deurganckdock were higher than the estimations.

Furthermore, the employment benefits and the additional port revenues were higher than forecasted in the cost-benefit analysis, because they resulted respectively from higher project costs and more concessions and port charges.

However, based on the ex-post analysis, the project is still cost-effective, but the net-benefits are lower than estimated in the ex-ante analysis. The actual cost-benefit ratio's (2,97 and 3,55) are lower than expected (5,19 and 6,69) and thus, per invested euro, the net benefits are halved.

Although all underestimations of costs and benefits, the costs relating to the project can be entirely recovered and the project ends up well-considered. The decisions of the Flemish government concerning the future of Doel and its environment, the lack of nature compensations and a number of procedural mistakes were risk factors that led to additional charges. An accurate preparation of the project with an underlying risk analysis and a good risk managing system combined with a structured communication system between all actors and a good organizational structure might have limited a part of those additional charges.

Recommendations

In order to improve the preparation and execution of future transport infrastructure projects, a number of recommendations can be formulated: (Rekenhof 2005)

1. In the case of large infrastructure projects, the government needs to include all relevant elements in a cost-benefit analysis in order to be able to make accurate investment decisions. Moreover, it is important to assess the impact of significant adaptations on the profitability of the project.

2. At the start of the project, there was a lack of a coordination between the different administrations that were involved. Only after the issue of the decree that provided the required building licenses and environmental compensations, a number of structures were created in order to improve the communication. As a consequence, it is of high importance to dispose of a structured consultative body to optimize the communication between all involved administrations and agencies.

3. The long-range plan of the project needs to take the expected evolution in price and the value added tax into account in order to assess the required budget better.

4. The authorities must dispose of sufficient control measures on subsidized works, especially when they are bearing a major part of the costs. It is important to verify whether the subsidies were used well.

5. The administration needs to examine instantly the receptivity of insurance claims. Incontestable debts need to be paid forthwith with the purpose to minimize costs of delayed interests.

6. The government neglected the opportunity to renegotiate or end the terms of the thirty year old contract on which the assignment of the dredging works was based. If open competition is not possible, the authorities should provide a reliable system to control prices and which makes recalculation feasible in order to manage abnormal price settings.

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