1. GENERAL BACKGROUND

The setting of correct prices for the use of transport infrastructure is a basic requirement for any transportation policy. Of no less importance is, however, the awareness on how revenues from transport pricing can be used efficiently. Therefore, the analysis of the efficiency and equity impacts of different options to use revenues from infrastructure charges as well as the acceptability and feasibility of these options were the issues addressed by the EU funded REVENUE project.

The REVENUE project had three ambitions:
- to know what are current institutions and practices of transport revenue use of infrastructure pricing;
- on the basis of sound economic theory to develop guidelines for good use of revenues from social marginal cost pricing;
- to test guidelines on a large set of interurban and urban case studies covering different modes, regulation regimes and countries.

The interurban case study ‘Rotterdam Port’ was among those to be tested. It included the application of a common methodology as well as of a common assessment tool, the MOLINO model, as developed within the REVENUE project.

This paper primarily focuses on one specific part of the REVENUE project: the inter-urban case study ‘Rotterdam Port’. However, before zooming-in on this case study, below a concise overview of the MOLINO model.

1.2 Theoretical Background – MOLINO model

MOLINO is an abstract model to test alternative regulation schemes. By regulation scheme a complete package must be understood of the pricing, revenue use and investment rules that are used for a given infrastructure.

Furthermore, MOLINO is a partial equilibrium model which studies transport problems that can be described in terms of two alternative transport links. For each link a regulation scheme is defined providing input data for the basis scenario. This status quo scenario is then compared with the alternative regulation schemes.

The MOLINO tool includes:
- **Demand model:** Given the level of generalized cost, the model computes, using some behavioural assumptions, the number of users selecting the...
different links, for different time periods. The demand model can deal with passenger as well as freight demand for any combination of modes.

- **Supply model**: Given the number of users selecting the different links, the model computes, using congestion function (such as volume delay functions), the level of congestion on the different links, for different time periods.

- **Equilibrium model**: Given the demand and supply functions, the model computes the corresponding fixed point solution in terms of prices and congestion levels (using for example an iterative model or a variable inequality approach).

- **Evaluation criteria**: The direct outputs of the model are flows, travel times, tolls levied. Indirect output is computed using the direct output: a social welfare function, toll revenues, etc.

- **Control**: There are a variety of control variables: pricing, access control, maintenance policies and investment policies. There are different potential objectives: first or second best welfare maximization, revenue maximization, cost minimization, etc. These objectives are computed for the whole system or for a part of the system. The system is managed by one or several competing (or cooperating) agents. The objectives of the agents can be: social welfare maximization, cost minimization, constraint optimization (financial or equity constraints).

- **Accounting model**: For each setting, the model computes the accounts for some of the agents.

The complete description of MOLINO model can be consulted in Proost et al. (2005).

The next table presents a few possible regulation schemes for one mode/link. Herewith a combination receives a name M1, where the first figure stands for a specific mode/link 1, the second figure stands for the particular set of rules.

### Table 1. Examples of regulation schemes that can be studied with MOLINO

<table>
<thead>
<tr>
<th>Type</th>
<th>Investments</th>
<th>Operation</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residual</td>
<td>Who decides</td>
<td>Type of</td>
</tr>
<tr>
<td></td>
<td>finance</td>
<td>investment</td>
<td>pricing</td>
</tr>
<tr>
<td>M11</td>
<td>Labour</td>
<td>CG</td>
<td>Public Company (no tender)</td>
</tr>
<tr>
<td>M12</td>
<td>Labour</td>
<td>CG</td>
<td>Tender</td>
</tr>
<tr>
<td>M13</td>
<td>Head tax</td>
<td>LG</td>
<td>Public Company (no tender)</td>
</tr>
<tr>
<td>M14</td>
<td>Head tax</td>
<td>LG</td>
<td>Tender</td>
</tr>
<tr>
<td>M15</td>
<td>PS</td>
<td>Tender</td>
<td>Profit max</td>
</tr>
</tbody>
</table>

Legend: CG= central government, LG= local government, PS= private supplier, MSC=marginal social cost pricing

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For instance, M11 combines many sources of inefficiency, as both infrastructure and operation are organised within the government, residual funding via labour taxes and pricing is kept very simple and is not optimized. M12 is another polar case where all elements are optimized. M13 and M14 are run by the local government, which has fewer sources of funding and optimizes only the welfare of its own citizens. M15 is a standard private case. One could imagine other cases (infrastructure public and operation private etc.).

By default Molino model calculates the effects for the reference regime, fixed toll regime, social marginal cost pricing regime, Nash regime and Mixed regime.

The theoretical prescriptions on optimal pricing, investment and revenue use are not straightforward to implement and depend on the problem characteristics. Often, the best solution is not obvious and one will need to compute numerically effects of the different options and consider their advantages. Moreover, the optimal solution may depend on the normative preference of the policy maker (he may favour a particular equity/efficiency trade-off) and may be path dependent because some institutions have built up a better reputation by their past performance.

MOLINO works with a rather simple model structure that can give different interpretations depending on the case study at hand. Table 2 gives the dimensions that are included in the transport module for every year of the time horizon.

Table 2: Components of the transport module in MOLINO

<table>
<thead>
<tr>
<th>Component</th>
<th>Passenger</th>
<th>Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 User categories</td>
<td>2 types of users (poor vs. rich, or other distinction)</td>
<td>transit and local freight demand</td>
</tr>
<tr>
<td>2 Modes</td>
<td>• free highway vs. toll highway</td>
<td>• free highway vs. toll highway</td>
</tr>
<tr>
<td></td>
<td>• road vs. rail</td>
<td>• road vs. rail</td>
</tr>
<tr>
<td></td>
<td>• rail vs. air</td>
<td>• ….</td>
</tr>
<tr>
<td></td>
<td>• etc</td>
<td></td>
</tr>
<tr>
<td>Sub-periods</td>
<td>Peak and off-peak</td>
<td>Peak and off-peak</td>
</tr>
<tr>
<td>Elasticity of total trip demand</td>
<td>Elastic</td>
<td>Elastic</td>
</tr>
<tr>
<td>Service quality</td>
<td>Dimensions of quality can include:</td>
<td>Dimensions of quality can include:</td>
</tr>
<tr>
<td></td>
<td>• congestion delay</td>
<td>• congestion delay</td>
</tr>
<tr>
<td></td>
<td>• smoothness of road surface</td>
<td>• smoothness of road surface</td>
</tr>
<tr>
<td></td>
<td>• reliability</td>
<td>• reliability</td>
</tr>
<tr>
<td></td>
<td>• ease of toll payment</td>
<td>• ease of toll payment</td>
</tr>
</tbody>
</table>

The MOLINO model is programmed in Mathematica with an interface to MS Excel.

As mentioned previously, the model was applied for the case study of the Port of Rotterdam, which is given the conceptual ground of MOLINO obviously a non-standard application environment.
1.2. Case Study ‘Port of Rotterdam’ - Background

The ‘Port of Rotterdam’ case study examined the existing practice as well as the future arrangements on pricing, investment, revenue use and their respective effects at the competing ports of Rotterdam and Antwerp. Both ports target the same large-scale hinterland and market niches. The ports and the national and municipal authorities of the Netherlands and Belgium (Flemish Government) promote a sustainability policy to provide an optimal balance between the needs of the port, interacting transport modes, the economy and the society in general. The promotion of sea-rail, sea-inland waterways and see-pipeline transport chains and curbing of the sea-road share is a priority in the national transport policies of the Netherlands and Belgium.

Both ports have enjoyed a significant growth of container traffic over the last decade. They are presently experiencing capacity problems in handling the present volume of containers. Both ports are in a period of expansion. For Rotterdam this means the reclamation of sea land (project Maasvlakte 2) and the construction of additional container terminals. For Antwerp the capacity expansion assumes building a new tidal container dock (the Deurganck doc) on the left bank of the Scheldt River.

In addition, for accommodation of larger container vessels and improvement of the access to the port of Antwerp, the deepening of the Westerschelde sea waterway connection is considered necessary. This raises a number of cross-border issues and is rather politically controversial as the sea-access route to Antwerp lies on Dutch territory. This controversy is intensified as Antwerp and Rotterdam are to a large extent competing ports and therefore the societal impact on the Netherlands (despite having limited positive impacts on some smaller Dutch ports in the Sealand province) is expected to be very negative.

2. RESEARCH SCOPE

The case study analysed two competing transport options, which were

- Container transport via the port of Rotterdam,
- Container transport via the port of Antwerp.

The analysis considered the direct investment in the port infrastructure expansion (namely, sea land reclamation and additional container terminal building) and the investment sources both for Rotterdam and Antwerp. In figure 1 the expansion plans are marked.

Figure 1: Coastal map and planned new infrastructures (in red)
The research issues were shaped on the basis of the strategic long-term targets of the national Dutch policy with regard to Rotterdam port and can be summarised, as follows:

1) Analysing the existing and testing the theoretical options, which comprise different combinations of (port) revenues, pricing/taxation and investment schemes to facilitate the targeted welfare for the port of Rotterdam.

2) The financial combinations mentioned in the first research issue to be considered also from the point of legal and environmental obligations. By meeting the legal obligations of the Netherlands towards Belgium, i.e. to ensure a proper access to the port of Antwerp for the navigation on the Dutch part of the Westerschelde, the Netherlands facilitates the development of the port of Antwerp - an important competitor for the Rotterdam port. On the other hand, the environmental obligations require conservation of the nature in the Westerschelde estuary and protection against flood. Both targets are endangered by the requirement to deepen Westerschelde.

3) In practice the use of inland and sea access waterway network in the Netherlands is free of charge. Therefore, an insight on the “user pays” possibility in relation to navigation on Westerschelde is opted for the analysis of an optimal revenue-pricing-investment regimes combination. This theoretical option is also explored with marginal cost pricing on Westerschelde route in order to (partly) compensate the negative environmental implications and the effects of the indulged additional competition for the port of Rotterdam.

The above schemes were assessed from the efficiency, feasibility as well as acceptability point of view. A set of option-specific research questions within
this particular study case were analysed and assessed primarily from the Dutch point of view. They included:

**Port of Rotterdam (Maasvlakte 2):**

(1) What are the social costs and benefits of the expansion of the port infrastructure (restricted to the container handling facilities)?

(2) What are the impacts of the possible cost recovery mechanisms for the Maasvlakte 2 investments for the Netherlands (e.g. ‘user pays’ and other pricing mechanisms, port dues adjustment, creation of a Scheldt fund, port rent adjustment, financial transfers between authorities, etcetera) in terms of efficiency, equity, feasibility and acceptability?

(3) Can the proposed cost recovery mechanism from the Maasvlakte 2, as approved between stakeholders (Port Authority Rotterdam, Gemeente Rotterdam and the Dutch Government) be justified on the basis of the findings of the study?

**Port of Rotterdam (Maasvlakte 2 in combination with deepening of Westerschelde):**

(4) What are the social costs and benefits of the deepening of the Westerschelde for Dutch society?

(5) What are the impacts of the possible cost recovery mechanisms for the Westerschelde investments for the Netherlands (e.g. ‘User pays” and other pricing mechanisms, port dues adjustment, creation of Scheldt Fund, port rent adjustment, financial transfers between authorities etc) in terms of efficiency, equity, feasibility and acceptability?

(6) What are the possible cost recovery mechanisms for the Westerschelde investments for the Netherlands (e.g. ‘User pays” and other pricing mechanisms, port dues adjustment, creation of Scheldt Fund, port rent adjustment, financial transfers between various authorities etc) in terms of efficiency, equity, feasibility and acceptability considerations?

### 3 REGULATION SCHEMES ANALYSED

Three principal regulation schemes (see table 3 for a more detailed description and for an outline of the scenario variants) were defined for both competing transport options:

**Status Quo situation (2004-2006):**
- Ownership status (port authority-local authority-government)
- Current pricing, revenue use and investment schemes in the ports of Rotterdam and Antwerp (harbour dues for container vessels 2004)
- Ongoing infrastructure investment financing (new infrastructure at ports, hinterland access)
- Applicable regulatory framework/welfare perceptions
Adopted policy (2004-2012):
- Launching new infrastructure (sea land reclamation Maasvlakte 2, Deurganck container terminal)
- Sea-wall for Rotterdam
- Obligation to maintain necessary depth on the Westerschelde access route (but no deepening)
- Status quo regulatory framework/welfare perceptions

Trade-off policy (2004-2012):
- Launching new infrastructure (Maasvlakte 2, Deurganck)
- Sea-wall for Rotterdam
- Obligation to maintain necessary depth on the Westerschelde access route
- Negotiated further deepening of the Westerschelde access route
- Nature/flood protection on the Westerschelde access route
- Status quo regulatory framework/welfare perceptions

The Adopted policy scheme and the Trade-off policy scheme were each further subdivided into two sub-scenarios A and B with the B-variant considering a cross-country funds transfer between Belgium and the Netherlands for financing the cost of Westerschelde deepening.

Table 3 Regulation schemes for the Port of Rotterdam case study

<table>
<thead>
<tr>
<th>Regulation Scheme</th>
<th>Scenario</th>
<th>Pricing</th>
<th>Revenue Use</th>
<th>Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status Quo</td>
<td>(0)</td>
<td>Reference</td>
<td>Revenues shared between the Port Authority and the Municipality of Rotterdam</td>
<td>Option 1: investment to build Maasvlakte 2 (Port Authority), hinterland access (State, local authorities);</td>
</tr>
<tr>
<td></td>
<td>status quo 2004</td>
<td>Fixed toll</td>
<td></td>
<td>Option 2: Investment to build Deurganck dock (Port Authority, Local and Central Authority); hinterland access (State, local authorities);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSC tolling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adopted Policy</td>
<td>(1-A)</td>
<td>Reference</td>
<td>Maasvlakte profit to be shared 50:50 between the Municipality of Rotterdam and the State</td>
<td>Option 1: Maasvlakte 2 in operation; State investment into sea-wall, nature protection in Rotterdam area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fixed toll</td>
<td></td>
<td>Option 2: Deurganck dock in operation;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSC tolling</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(no financial contribution by Belgium to Westerschelde costs coverage)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table: Trade-off Policy

<table>
<thead>
<tr>
<th>Regulation Scheme</th>
<th>Scenario</th>
<th>Pricing</th>
<th>Revenue Use</th>
<th>Investment</th>
</tr>
</thead>
</table>
| (1-B)            | Horizon 2012 | Reference | Revenues to be shared between the Port Authority, Municipality and the State. Revenues from Westerschelde charges to be used for maintenance of Westerschelde | Option 1: Maasvlakte 2 in operation; State investment into sea-wall, nature protection in Rotterdam area  
Option 2: Deurganck dock in operation; Belgium co-invests in the maintenance of port access on Westerschelde |
|                  | New container terminals | Fixed toll | (Belgium contributes to Westerschelde costs coverage) |          |
|                  | Westerschelde maintenance | MSC tolling |          |          |
|                  | Protection of nature |          |          |          |
|                  | Belgium contribution |          |          |          |
| (2-A)            | Horizon 2012 | Reference | Revenues and costs from Maasvlakte to be shared between the Port Authority, Municipality and the State. Revenues from Westerschelde charges to be used for maintenance and deepening of Westerschelde | Option 1: Maasvlakte 2 in operation (port Authority); Deepened Westerschelde (State & local authorities); State investment into sea-wall, nature protection in Rotterdam area;  
Option 2: Deurganck dock in operation; sea and hinterland access improved |
|                  | New container terminals | Fixed toll | (no financial contribution by Belgium to Westerschelde costs coverage) |          |
|                  | Westerschelde maintenance | MSC tolling |          |          |
|                  | Deepening |          |          |          |
|                  | Protection of nature |          |          |          |
|                  | No Belgium contribution |          |          |          |
| (2-B)            | Horizon 2012 | Reference | Revenues and costs from Maasvlakte to be shared between the Port Authority, Municipality and the State. Revenues from Westerschelde charges to be used for maintenance and deepening of Westerschelde | Option 1: Maasvlakte 2 in operation (Port Authority); Deepened Westerschelde (State & local authorities of the Netherlands, Belgium contribution); State investment into sea-wall, nature protection in Rotterdam area;  
Option 2: Deurganck dock in operation; sea and hinterland access improved, Belgium co-invests in the deepening of port access on Westerschelde |
|                  | New container terminals | Fixed toll | (Belgium contributes to Westerschelde costs coverage) |          |
|                  | Westerschelde maintenance | MSC tolling |          |          |
|                  | Deepening |          |          |          |
|                  | Protection of nature |          |          |          |
|                  | Belgium contribution |          |          |          |

### 4. Modeling Considerations

In order to answer the research questions, the MOLINO model was applied. Although the original concept of MOLINO is based on description of the costs–revenues–investment regimes for competing transportation options for road and/or rail, rather than ports, efforts were made to abstract the driving forces characteristic to competing ports and translate them into the MOLINO concept.

In this respect, a number of simplifications and/or restrictions were introduced:
- Abstraction towards two port competition only (third option is ignored)
- Artificial inclusion of passenger transport (technically required to make model running)
- Simplification of port ownership relations (to better trace revenue flow)
- Operator’s concept is replaced with Resultant Operator concept (resultant shipper)

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• Eliminating the dual government problem (MOLINO assumes one central government)
• Costs related to tide-waiting of ships are assumed as infrastructure capacity restriction costs

Having in mind the complexity of the port system and the restrictions of the model, the outcome should therefore be considered as tentative.

5. MAIN FINDINGS

Figure 2 shows the toll per TEU per regime (reference, fixed, MSC) for each policy scenario. The reference toll is adequate to the port dues for container ships applied in 2004. The fixed toll in each scenario is estimated on the basis of the size of the investments foreseen in that particular scenario having the purpose to pay them back. The MSC toll, as far as the congestion part concerned, is computed internally by MOLINO. The remaining components are based on estimates by the case study team.

One can notice, that in order to pay back the investments foreseen in the trade-off policy scenario both for Rotterdam and for Antwerp routes, the toll has to be increased up to euro 8.62 and 8.27 respectively. Similarly, the route-bound marginal social cost pricing would almost equal each other exceeding 4 euro/TEU value. The price difference per transportation option would become minimal. At the moment, the so called reference situation, the toll on the Rotterdam route is noticeably higher than the one applied at the port of Antwerp.

Figure 2: Tolls per regime for different investment policies
5.1 Effect on Demand and Revenues

As shown in Figure 3, charging the Antwerp option in proportion to the investments planned for the deepening of Westerschelde would have the biggest effect on the container volumes at Antwerp port.

The introduction of the fixed toll high enough to pay-back the investments would have caused the reduction of the total demand (for Rotterdam and Antwerp together) in every policy respectively by 11.5%, 15.3% and 17.2%. This most likely would mean a recapture of this “lost” share by other seaports in the Le Havre-Hamburg region because the general trend of container traffic shipping is increasing both in Europe and in the rest of the world.

Figure 3: Effect of the tolling policies on demand
Obviously, the introduction of a fixed toll would cause higher toll revenues but lower tax revenues. The reduction of demand would subsequently cause reduction of the port related businesses and this affects the tax revenues of the authorities. At the end of the day the obtained benefits would be less than expected, although the investment costs for infrastructure expansion can be paid-off. This is therefore in general not an economically feasible situation, endangering the long-term sustainability of port activities.

Trying to recover the real investment costs only by increasing harbour dues is obviously not the optimal regime for the port authorities. The combination of charging, land/infrastructure renting or even land selling seems to be a more promising way to follow.

Table 4. Policy-bound toll revenues versus investments at the end of respective period (mln euro)

<table>
<thead>
<tr>
<th>Regimes vs</th>
<th>Status Quo</th>
<th>Adopted Policy</th>
<th>Trade-Off Policy Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>End 2006</td>
<td>End 2012</td>
<td>End 2012</td>
</tr>
</tbody>
</table>

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5.2 Changes in Welfare
For all regulation schemes with exogenously fixed tolls welfare decreases compared to the reference situation while for all scenarios with a MSCP regime welfare would increase. One can conclude that marginal social cost pricing leads in all cases to an improvement in freight volumes and welfare levels but to a relatively low level of charging revenues. This would be attractive for the port users (container operators, transhipment companies) but the revenues would not be sufficient to fund the infrastructure investments made to realise container transport and transhipment capacity extensions.

5.3 Acceptability issues
The major acceptability problem is that under the current legal arrangements the costs of maintaining and deepening the Westerschelde are being paid by the Dutch government and the regional authorities of Zeeland, e.g. to 100% by Dutch taxpayers. The users of Antwerp port and the Antwerp port authority enjoy the benefits of this arrangement. Therefore, all sub-scenarios, which foresee a compensation payment for this burden (scenario-variants B), would increase acceptability.

With regard to political feasibility/acceptability one needs to mention that subject to the latest (2005) developments in the negotiations between the Dutch government and the Flemish government in relation to deepening of Westerschelde, it was agreed to start the deepening in 2007. It was also agreed that the Dutch government and Zeeland authorities would pay the investment costs fully. Instead of agreeing on a direct financial contribution of Belgium to the Westerschelde deepening project, the Belgians will now ensure the necessary technical/financial arrangements for accommodating Dutch requirements with regard to services on the high-speed ‘North-South’ railway line from Amsterdam-Paris (thus creating a possibility for the citizens of The Hague to reach Paris by rail in 3 hours).

It is very difficult in such a political “trade-off” between large-scale infrastructure projects to estimate welfare impacts, since it implies that one
should also model other infrastructure projects. From a more general point of view such cross-border political “deals” are not the ones to be recommended for making infrastructure financing more transparent. For instance, applying the “user-pays” principle may now become more difficult. Having in mind the above-mentioned agreement between the two governments, the trade-off scenario should therefore be considered as purely theoretical.

6. CASE STUDY CONCLUSIONS

- Fixing the level of charges sufficiently high to recover, in a reasonable time, the investment costs allocated to container transport, significantly reduces the volume of container transport and has a negative impact on the welfare levels. Only charging at marginal cost levels performs better on these indicators, but it does not produce a sufficiently high level of revenues to recover the investment costs.

- The case study results appear to suggest that it is not possible to self-finance port investments like those in the Westerschelde project and Maasvlakte 2 project (as far as these costs can be allocated to container traffic) to a significant extent by such charges. Either the flows of goods to the ports decrease too strongly or the revenues are insufficient. One should realise that in practice the elasticity of transport consumption might be even higher because of “third port” competition. It might be even more difficult to earn back the investments. This means that the rationale for such type of port investments may consist in indirect effects and not in shipping transport as such.

- One could think of a modification of current port tariffs in the implementation of charges. However, legally there may be problems in the Netherlands with charging on waterways. Furthermore, charging on marginal social cost levels may be technically difficult because it is not straightforward to determine transparent charge levels.

- The practical solution of the cross-border problem of the Westerschelde-project, as recently agreed between Belgium and the Netherlands, is a purely political trade-off. From the point of view of making seaport related investments more transparent, it could be considered as an example rather not to be followed.

Further details and deliverables of the REVENUE project one can find on-line on the website www.revenue-eu.org

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