**Appendix 1. The expression of shipper surplus**

|  |  |  |
| --- | --- | --- |
|  |  | (A1) |

**Appendix 2. Numerical simulation on PA expected profit and expected regional welfare .**

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Figure A1. PA’s expected profit with changes in the number of TOCs in its own port (i.e., ) and the other port (i.e., )



Figure A2. The expected regional welfare with changes in the number of TOCs at two ports (i.e., and )

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(*, , , ,, , , x=0.01*)

Figure A3. PA expected profit with changes in the number of TOC JV pairs across two ports (i.e., )

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(*, , , ,, , , x=0.01*)

Figure A4. The expected regional welfare with changes in the number of TOC JV pairs across two ports (i.e., )

**Appendix 3. TOC throughputs for JV and non-JV participants**

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(*, , , ,, , , x=0.01*)

Figure A5. Difference in throughput between JV and non-JV TOCs (i.e., ) with the number of JV pairs cross two ports (i.e., )

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(*, , , ,, , , x=0.01*)

Figure A6. Total port throughput between (i.e., ) with the number of JV pairs cross two ports (i.e., )