**Table A 1 Port efficiency studies using non-parametric methods**

|  | DEA |  |  |  |  |  |  |  |  |  |  |  |  |  | FDH |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Authors | CRS |  | VRS |  | RUS | ADD | SE | AE | SUP | BAD | BOO | CRO | FUZ | NET | FDH |  | M | α |
|  | (I) | (O) | (I) | (O) |  |  |  |  |  |  |  |  |  |  | (I) | (O) |  |  |
| Tongzon (2001) |  | ● |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| Wang et al. (2002) | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |
| Estache et al. (2004) | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Park and De (2004) |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barros and Athanassiou (2004) | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cullinane et al. (2005) |  | ● |  | ● |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| Cullinane et al. (2005) | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |
| Cullinane et al. (2006) |  | ● |  | ● |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| Rios and Maçada (2006) |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Lin and Tseng (2007) | ● |  | ● |  |  |  | ● |  | ● |  |  | ● |  |  |  |  |  |  |
| Rodríguez-Álvarez et al. (2007) |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |
| Wu and Goh (2010) |  | ● |  | ● |  |  |  |  | ● |  |  | ● |  |  |  |  |  |  |
| Cheon et al. (2010) |  | ● |  | ● |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| Bichou (2011) |  |  |  |  | ● |  |  |  |  |  |  |  |  | ● |  |  |  |  |
| Wanke et al. (2011) | ● |  | ● |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |
| Yip et al. (2011) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Barros et al. (2012) | ● |  | ● |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| Susila and Wang (2013) |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |
| Chang (2013) |  |  |  |  |  | ● |  |  |  | ● |  |  |  |  |  |  |  |  |
| Schøyen and Odeck (2013) | ● |  | ● |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| Yuen et al. (2013) |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Wanke (2013) |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |
| Wilmsmeier et al. (2013) | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Suárez-Alemán et al. (2014) |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Wan et al. (2014) |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Zheng and Yin (2015) |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |
| De Oliveira and Cariou (2015) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  | ● |
| Wanke and Barros (2015) |  | ● |  | ● |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |
| Nguyen et al. (2015) |  | ● |  | ● |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |
| Wanke et al. (2016) |  | ● |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |
| Nguyen et al. (2018) |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Wanke et al. (2017) |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |

Notes: Tongzon (1993) employed partial indicators.

Roll and Hayuth and Turner, Windle, and Dresner (339-356) declined to specify the exact DEA model that was employed in their studies.

Bichou (6-26) did not specify whether the model used was based on Russell’s model. However, based on its construction, the model can be viewed as a variation of Russell’s model.

Slack-based models (SBM) are not specifically listed in the table because they can be viewed as a variation of additive models focusing on slack values.

Abbreviations: DEA: data envelopment analysis, FDH: free disposal hull, CRS: constant returns to scale; VRS: variable returns to scale, RUS: Russell model, ADD: additive model, SE: scale efficiency, AE: allocative efficiency, SUP: super efficiency, BAD: bad output models, BOO: bootstrapping, CRO: cross efficiency, FUZ: fuzzy DEA, NET: network DEA, M: order-m frontier, α: order-α frontier.

“Order m” and “order α” belong to the category of partial frontiers, as they are closely related to the statistical properties of various production frontiers. They will be detailed in Section 4.

**Table A 2 Port efficiency studies using parametric methods**

|  | DFA | SFA |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | CF | PF | DF |  | FE | TVF | OUT |
|  |  |  |  | (I) | (O) |  |  |  |
| Kim and Sachish (1986) | ● | ● |  |  |  |  |  |  |
| Liu (1995) |  |  | ● |  |  |  |  |  |
| Baños-Pino et al. (1999) |  | ● |  | ● |  |  |  |  |
| Notteboom et al. (2000) |  |  | ● |  |  |  |  |  |
| Coto-Millan et al. (2000) |  | ● |  |  |  |  |  |  |
| Jara-Díaz et al. (2002) | ● | ● |  |  |  |  |  |  |
| Estache (2002) |  |  | ● |  |  |  |  |  |
| Cullinane et al. (2002) |  |  | ● |  |  |  |  |  |
| Cullinane and Song (2003) |  |  | ● |  |  |  |  |  |
| Estache et al. (2004) |  |  |  |  |  |  | ● |  |
| Cullinane et al. (2005) |  |  |  |  |  |  | ● |  |
| Tongzon and Heng (2005) |  |  | ● |  |  |  |  |  |
| Cullinane and Song (2006) |  |  | ● |  |  |  |  |  |
| Cullinane et al. (2006) |  |  | ● |  |  |  |  |  |
| Rodríguez-Álvarez et al. (2007) |  |  |  | ● |  |  |  |  |
| González and Trujillo (2008) |  |  |  |  | ● |  |  |  |
| Cheon et al. (2010) |  |  |  |  |  |  | ● |  |
| Wanke et al. (2011) |  |  | ● |  |  |  |  |  |
| Yip et al. (2011) |  |  | ● |  |  |  | ● |  |
| Barros et al. (2012) |  |  |  |  |  |  | ● |  |
| Susila and Wang (2013) |  |  |  |  |  |  |  | ● |
| Yuen et al. (2013) |  |  |  |  |  |  | ● |  |
| Pagano et al. (2013) |  |  | ● |  |  |  |  |  |
| Wilmsmeier et al. (2013) |  |  |  |  |  |  | ● |  |
| Chang and Tovar (2014a) |  |  |  |  | ● |  |  |  |
| Chang and Tovar (2014b) |  |  |  |  | ● |  | ● |  |
| Zheng and Yin (2015) |  | ● |  |  |  |  |  |  |
| Nguyen et al. (2015) |  |  | ● |  |  |  |  |  |
| Coto-Millán et al. (2016) |  |  |  | ● |  |  |  |  |
| Suárez-Alemán et al. (2016) |  |  | ● |  |  |  | ● |  |
| Serebrisky et al. (2016) |  |  | ● |  |  |  |  |  |
| Wanke and Barros (2016) |  |  |  |  |  | ● |  |  |
| Nguyen et al. (2018) | ● |  | ● |  |  |  | ● |  |
| Wanke et al. (2017) |  |  |  |  |  |  |  |  |

Notes: Tongzon (1993) employed partial indicators.

Roll and Hayuth and Turner, Windle, and Dresner (339-356) declined to specify the exact DEA model that was employed in their studies.

Bichou, 6-26 did not specify whether the model used was based on Russell’s models. However, based on its construction, the model can be viewed as a variation of Russell’s model.

Abbreviations: DFA: deterministic frontier analysis, SFA: stochastic frontier analysis, CF: cost function, PF: production function, DF: distance function, FE: factor extraction, TVF: time varying frontier, OUT: outliers.

The stochastic specifications of production functions are assumed to be output-oriented.

**Table A 3 Details of the selected sample of studies**

| Authors | Data |  |  |  |  |  | Input and Output |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | No. of ports | Location | Time span | Container port (Y/N) | Terminal level (Y/N) | Data source |  |
| Chang (1978) | 1 | America | 1953-1973 | N | N | Port of Mobile | (I) Number of employees (persons)  Net assets (monetary terms)  (O) Gross earnings for a port |
| Kim and Sachish (1986) | 1 | Israel | 1966-1983 | N | N | Port of Ashdod | (I) Effective number of employees  Equipment (cranes; buildings)  (O)  Total cargo (tons) loaded and unloaded |
| Roll and Hayuth (1993) | 20 | NA | NA | NA | NA | Hypothetical | (I) Number of employees (persons)  Capital (monetary terms)  Cargo uniformity index  (O) Cargo throughput (tons)  Level of service (handling time/total time in port)  Users’ level of satisfaction  Ship calls (number) |
| Tongzon (1993) | 1 | Australia | 1987-1991 | N | Y | NA | (I) Berth hour  (O) Revenue tones |
| Liu (1995) | 28 | Britain | 1983-1990 | N | N | Annual reports and financial accounts by the port authority, | (I) Labor  capital  (O) Port turnover volume |
| Baños-Pino et al. (1999) | 27 | Spain | 1985-1997 | N | N | The port authority’s annual report  The port authority’s annual report | (I) Labor (number of workers)  Energy consumption  Capital (net assets)  (O) Cargo handled |
| Notteboom et al. (2000) | 36;40 | EU, Asia | 1994 | Y | Y | CIY | (I) Quay length (m)  Terminal surface (ha)  Gantry cranes (number)  No. of workers (persons)  Centrality index  Diversion distance  (O) Containers handled (TEUs) |
| Coto-Millan et al. (2000) | 27 | Spain | 1985-1989 | N | N | NA | (I) Labor (number of workers)  Intermediate consumption  Capital (net assets)  (O) Cargo handled |
| Tongzon, Jose (2001) | 16 | World | 1996 | Y | N | NA | (I) No. of cranes (number)  No. of berths (number)  No. of tugs (number)  Terminal area (m2)  Delay time (hours)  No. of employees (persons)  (O) Container throughput (TEUs)  Ship rate (TEUs/hour) |
| Jara-Díaz et al. (2002) | 26 | Spain | 1985-1995 | N | N | Spanish port reports | (I) Labor  Amortization  Other expenses  (O) Containerized general cargo  Non-containerized general cargo  Dry bulk  Liquid bulk  Total rent received |
| Estache et al. (2002) | 13 | Mexico | 1996-1999 | N | N | NA | (I) No. of workers  Length of dock  (O) Cargo handled |
| Cullinane et al. (2002) | 15 | East Asia, Southeast Asia | 1989-1998 | Y | Y | CIY,  First-hand data sources | (I) Terminal quay length (m)  Terminal area (ha)  Cargo-handling equipment (number)  (O) Container throughput (TEUs) |
| Wang et al. (2002) |  |  |  |  |  |  |  |
| Cullinane and Song (2003) | 5 | UK, Korea | 1978-1996 | Y | Y | Annual reports and  financial accounts published by terminals | (I) Total remuneration of  directors or executives  Total wages and salaries paid to employees  Net book value of fixed equipment  Net book value of mobile equipment  (O) Turnover derived from the container terminal services |
| Turner et al. (2004) | 26 | US, Canada | 1984-1997 | Y | N | American Association of Port Authorities, CIY,  Other first-hand data sources | (I) Quay length (m)  Terminal land (ha)  Container cranes (number)  (O) Container throughput (TEUs) |
| Park and De (2004) | 11 | Korea | 1999 | N | N | Statistical Yearbook of Maritime Affairs and Fisheries,  Ministry of Maritime Affairs and  Fisheries | (I) Berthing capacity (Number)  Cargo-handling capacity (MTs)  (O) Cargo throughputs (tons)  No. of ship calls (number)  Revenue (billions of won)  Customer satisfaction (score) |
| Barros and Athanassiou (2004) | 6 | Greece, Portugal | 1998-2000 | N | N | Annual financial reports by ports,  National Statistical Service | (I) Number of employees (persons)  Fixed capital (euros)  (O) No. of ships (number)  Movement of freight (tons)  Cargo handled (tons)  Containers handled (tons) |
| Cullinane et al. (2005) | 30 | World | 1992-1999 | Y | N | CIY,  Lloyd’s Ports  of the World,  China’s Shipping Development Annual  Report | (I) Terminal length (m)  Terminal area (ha)  Quayside gantry (number)  Yard gantry (number)  Straddle carrier (number)  (O) Container throughput (TEUs) |
| Cullinane et al. (2005) | 57 | World | 2001 | Y | Y | CIY,  Lloyd’s Ports  of the World | (I) Terminal length (m)  Terminal area (ha)  Quayside gantry (number)  Yard gantry (number)  Straddle carrier (number)  (O) Container throughput (TEUs) |
| Tongzon and Heng (2005) | 25 | World | 1999 | Y | Y | First-hand data from questionnaires sent to terminals | (I) Terminal quay length (m)  Terminal area (ha)  Quay cranes (number)  (O) Container throughput (TEUs) |
| Cullinane and Song (2006) | 74 | World | 2002 | Y | Y | CIY,  Lloyd’s Ports  of the World | (I) Terminal quay length (m)  Terminal area (ha)  Cargo-handling equipment (number)  (O) Container throughput (TEUs) |
| Cullinane et al. (2006) | 57 | World | 2001 | Y | Y | CIY,  Lloyd’s Ports  of the World | (I) Terminal length (m)  Terminal area (ha)  Quayside gantry (number)  Yard gantry (number)  Straddle carrier (number)  (O) Container throughput (TEUs) |
| Rios and Maçada (2006) | 23 | Brazil,  Argentina,  Uruguay | 2002-2004 | Y | Y | Contact with terminals by email or telephone | (I) Number of cranes  Number of berths  Number of employees  Terminal area  Yard equipment  (O) Container throughput  Containers/hour |
| Lin and Tseng (2007) | 10 | Asia-Pacific Region | 1998-2011 | Y | N | CIY | (I) Number of deep-water piers (units)  Length of container terminals (m)  Number of gantry cranes (units)  Area of container base (units)  (O) Vessel arrivals (number)  Container throughput (TEUs) |
| Rodríguez-Álvarez et al. (2007) | 3 | Spain | 1992-1997 | N | Y | NA | (I) Ordinary workers (persons)  Special workers (persons)  Capital  Intermediate consumption  Total area (m2)  (O) Containers (KTs)  Ro-Ro cargo (KTs)  General break-bulk cargo (KTs) |
| González and Trujillo (2008) | 9 | Spain | 1990-2002 | Y | N | Spanish port authorities’ annual reports,  Statistical yearbooks released by state-run ports | (I) Berths (number)  Surface (m2)  Labor (persons)  (O) Container throughput (TEUs)  Liquid bulk (tons)  Other cargo (tons)  Passengers (persons) |
| Wu and Liang (2009) | 77 | World | 2007 | Y | N | NA | (I) Capacity of cargo-handling machines  Number of berths  Terminal area  Storage capacity  (O) Container throughput |
| Wu and Goh (2010) | 21 | World | 2006 | Y | N | CIY | (I) Terminal area (ha)  Total quay length (m)  Handling equipment (units)  (O) Containers handled (TEUs) |
| Cheon et al. (2010) | 98 | World | 1991, 2004 | Y | N | CIY | (I) Berth length (m)  Terminal area (m2)  Container cranes’ capacity  (O) Containers handled (TEUs) |
| Bichou (2011) | 10 | World | 2002-2008 | Y | Y | Information reported on websites | (I) Gate lanes (number)  Cut-off time (hours)  Gate outbound TEUs (TEUs)  Yard-staking index  Free yard storage (TEUs)  STS crane index (TEUs/hour)  LOA max draft (m)  (O) Gate outbound TEUs (TEUs)  Export TEUs (TEUs)  Yard-dwelling time (hours)  STS crane moves/hour |
| Wanke et al. (2011) | 25 | Brazil | 2008 | N | Y | NA | (I) Number of berths (units)  Terminal area (m2)  Parking lot (units)  (O) Aggregate throughput (tons)  Loaded shipments (units) |
| Yip et al. (2011) | 141 | World | 1997-2004 | Y | Y | CIY,  Containerization intelligence website maintained by port authorities | (I) No. of workers  Length of dock  (O) Cargo handled |
| Barros et al. (2012) | 23 | Brazil | 2004-2010 |  | N | http://www.antaq.gov.br,  Ports’ publications,  Portos e Terminais Marı´timos do Brasil | (I) Quay length (m)  Cranes (units)  Labor (persons)  (O) Container throughput (TEUs)  Dry bulk (tons)  Liquid bulk (tons) |
| Susila and Wang (2013) | 69 | Asia | 2006 | Y | N | CIY | (I) Quayside crane  Yard equipment  Total reefer points  Terminal area  Berth length  (O) Container throughput |
| Chang (2013) | 23 | Korea | 2010 | N | N | Statistical Yearbook of the Korean Ministry of Land, Transport, and  Maritime Affairs (MLTM)  (www.spidc.go.kr);  KMI | (I) Labor (persons)  Quay length (m)  Terminal area (m2)  Energy consumption (TOE)  (O) Vessel (KT)  Cargo handled (KT)  CO2 emission (tons) |
| Schøyen and Odeck (2013) | 24 | Norway, Nordic Countries,  UK | 2002-2008 | Y | N | CIY | (I) Berth length (m)  Terminal area (m2)  Yard gantry cranes (units)  Straddle carriers (units)  Container-handling trucks (units)  (O) Container throughput (TEUs) |
| Yuen et al. (2013) | 21 | Asia-Pacific Region | 2003-2007 | Y | Y | CIY,  Companies’ websites and news reports | (I) No. of berths (units)  Berth length (m)  Land size (m2)  No. of quay cranes (units)  Yard cranes (units)  (O) Container throughput (TEUs) |
| Pagano et al. (2013) | 10 | US and Panama | 1997-2006 | N | N | American Association of Port Authorities (AAPA) Surveys,  CIY | (I) Net investment  Average revenue per ton (operating income/tons of cargo)  (O)  Profit (operating income/tons of cargo)  Container traffic (TEUs) |
| Wanke (2013) | 27 | Brazil | 2011 | N | N | http://www.antaq.gov.br | (I) Number of berths (units)  Warehousing area (m2)  Yard area (m2)  (O) Solid bulk frequency  Container frequency  Solid bulk throughput (tons)  Container throughput (TEUs) |
| Wilmsmeier et al. (2013) | 20 | LAC | 2005-2011 | Y | Y | Secondary and primary sources | (I) Ship-to-shore crane capacity equivalent  Terminal area  Labor  (O) Container throughput (TEUs) |
| Suárez-Alemán et al. (2014) | 16 | Africa | 2011 | N | N | http://www.infrastructureafrica.org/aicd/,  CIY | (I) Number of available cranes (units)  Terminal area (m2)  Total Number of Berth length (m)  (O) Cargo movement (tons)  Cargo movement per hour (tons/hour) |
| Wan et al. (2014) | 12 | US | 2000-2009 | Y | N | American Association of Port Authorities,  CIY | (I) Total number of cranes (units)  Total berth length (m)  Terminal size  (O) Container throughput (TEUs) |
| Chang and Tovar (2014a) | 14 | Peru, Chile | 2004-2010 | N | Y | Annual reports by governments and companies | (I) Number of employees (persons)  Net stock of fixed assets (M$)  (O) Containerized cargo (KTs)  General and rolling freight (KTs)  Bulk cargo (KTs) |
| Chang and Tovar (2014b) | 14 | Peru, Chile | 2004-2010 | N | Y | Annual reports by governments and companies | (I) Number of employees  Number of berths  Port area  Quay length  (O) Containerized cargo (TEUs, units, and MTs)  General and rolling freight (MTs)  Bulk cargo (MTs) |
| Zheng and Yin (2015) | 16 | China | 1998-2011 | N | N | China  Port Yearbook | (I) Labor (persons)  Port physical facilities (units)  Expenses related to repairs, power, R&D, and management  (O) Container throughput  Dry bulk throughput  Liquid bulk throughput |
| De Oliveira and Cariou (2015) | 200 | World | 2007, 2010 | Y | N | CIY,  Guide to port entry  CI online | (I) Total length of berths (m)  Gantry crane (unit)  Yard cranes (unit)  Port area (m2)  Storage area (m2)  (O) Annual traffic (TEUs) |
| Wanke and Barros (2015) | 27 | Brazil | 2012 | N | N | http://www.antaq.gov.br | (I) Number of berths  Channel width  Channel depth  Yard area  Warehousing area  Quay length  Max. quay depth  (O) Solid bulk-loading hours  Container-loading hours  Solid bulk throughput  Container throughput  Solid bulk vessel frequency  Container vessel frequency |
| Nguyen et al. (2015) | 43 | Vietnam | 2014 | N | N | Data from the Vietnam Seaports Association | (I) Berth length (m)  Terminal areas (m2)  Warehouse capacity (tons)  Cargo handling equipment (units)  Information technology (no)  (O) Total cargo throughput (tons) |
| Coto-Millán et al. (2016) | 26 | Spain | 1986-2012 | N | N | Financial statements published annually by the ENP,  Annual traffic reports | (I) Stock of net fixed assets (euros)  No. of employees (persons)  Berths necessary for docking (m)  (O) Solid bulk (tons)  Liquid bulk (tons)  Containerized general cargo (tons)  Non-containerized general cargo (tons)  Passengers (persons) |
| Pérez et al. (2016) | 40 | LAC | 2000-2010 | Y | N | CIY | (I) Number of available cranes (units)  Storage capacity (TEUs)  Quay length (m)  (O) Containers handled (TEUs) |
| Suárez-Alemán et al. (2016) | 203 | World (developing countries) | 2000-2010 | Y | N | CIY | (I) Terminal area (m2)  Berth length (m)  Mobile crane (units)  Ship-to-shore gantry cranes (units)  (O) Annual throughput (TEUs) |
| Serebrisky et al. (2016) | 63 | LAC | 1999-2009 | Y | N | CIY | (I) Number of available cranes (units)  Terminal area  Berth length  (O) Container throughput |
| Wanke and Barros (2016) | 27 | Brazil | 2007-2011 | N | N | http://www.antaq.gov.br | (I) Number of berths  Channel width  Channel depth  Yard area  Warehousing area  Quay length  Max quay depth  (O) Solid bulk-loading hours  Container-loading hours  Solid bulk throughput  Container throughput  Solid bulk vessel frequency  Container vessel frequency |
| Nguyen et al. (2018) | 47 | Vietnam | 2014 | N | N | Data from the Vietnam Seaports Association | (I) Infrastructure (m)  Land (m2)  Cargo storage facility (m2)  Cargo handling facility (tons)  Information technology (no)  (O) Total cargo throughput (tons) |
| Wanke et al. (2017) | 6 | Nigeria | 2007-2013 | N | N | Data from the Nigerian Port Authority | (I) Number of employees  Number of berths  Port area  Quay length  (O) Ship traffic  Gross tonnage  General cargo  Dry bulk cargo  Liquid bulk cargo |

Notes:

Y corresponds to studies focused on solely container ports; N pertains to studies focused on entire seaports.

Y corresponds to studies conducted at the terminal level; N pertains to studies conducted at the port level (contemporary container ports allow several container terminals to operate in parallel within a container port, and each terminal is operated by different operator).

The top 30 ports in the world are included in the sample. Each port contains several terminals, and this is a terminal-level study.

Pérez et al. (2016) stated that they examined the 40 main container terminals in LAC through an aggregation of the individual container terminals located in each port, but we do not consider this a terminal-level study.

**Table A4 Study profile**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Authors | No. of Ports | Location | Time span | Container port (Y/N) |
| Chang (1978) | 1 | U.S. | 1953-1973 | N |
| Kim and Sachish (1986) | 1 | Israel | 1966-1983 | N |
| Roll and Hayuth (1993) | 20 | - | - | - |
| Tongzon (1993) | 1 | Australia | 1987-1991 | N |
| Liu (1995) | 28 | Britain | 1983-1990 | N |
| Tongzon (1995a) | 23 | World | 1991 | N |
| Tongzon (1995b) | 23 | World | 1991 | N |
| Baños-Pino et al. (1999) | 27 | Spain | 1985-1997 | N |
| Martínez-Budría et al. (1999) | 26 | Spain | 1993-1997 | N |
| Coto-Millán et al. (2000) | 27 | Spain | 1985-1989 | N |
| Notteboom et al. (2000) | 36;40 | EU, Asia | 1994 | Y |
| Tongzon (2001) | 16 | World | 1996 | Y |
| Valentine and Gray (2001) | 31 | World | 1998 | Y |
| Cullinane et al. (2002) | 15 | East Asia, Southeast Asia | 1989-1998 | Y |
| Estache et al. (2002) | 13 | Mexico | 1996-1999 | N |
| Itoh (2002) | 8 | Japan | 1990-1999 | Y |
| Jara-Díaz et al. (2002) | 26 | Spain | 1985-1995 | N |
| Wang et al. (2002) | - | - | - | - |
| Barros (2003a) | - | Portugal | - | N |
| Barros (2003b) | - | Portugal | - | N |
| Cullinane and Song (2003) | 5 | UK, Korea | 1978-1996 | Y |
| Wang et al. (2003) | 30 | World | 2001 | Y |
| Barros and Athanassiou (2004) | 6 | Greece, Portugal | 1998-2000 | N |
| Cullinane et al. (2004) | 30 | World | 1992-1999 | Y |
| Estache et al. (2004) | 11 | Mexico | 1996-1999 | N |
| Park and De (2004) | 11 | Korea | 1999 | N |
| Turner et al. (2004) | 26 | US, Canada | 1984-1997 | Y |
| Cullinane, Ji et al. (2005) | 30 | World | 1992-1999 | Y |
| Cullinane, Song et al. (2005) | 57 | World | 2001 | Y |
| Lee et al. (2005) | 16 | Asia-Pacific Region | 1996 | Y |
| Lin and Tseng (2005) | 27 | World | 1999-2002 | Y |
| Tongzon and Heng (2005) | 25 | World | 1999 | Y |
| Cullinane and Song (2006) | 74 | World | 2002 | Y |
| Cullinane et al. (2006) | 57 | World | 2001 | Y |
| Kaisar et al. (2006) | 25 | US | 1998-2003 | Y |
| Le-Griffin and Murphy (2006) | 10 | World | 2004 | Y |
| Rios and Maçada (2006) | 23 | Brazil, Argentina, Uruguay | 2002-2004 | Y |
| Lin and Tseng (2007) | 10 | Asia-Pacific Region | 1998-2011 | Y |
| Rodríguez-Álvarez et al. (2007) | 3 | Spain | 1992-1997 | N |
| Al-Eraqi et al. (2008) | 22 | Middle East,  East Africa | 2000-2005 | N |
| Cheon (2008) | 140 | World | 1991, 2004 | Y |
| Díaz-Hernández et al. (2008a) | 19 | Spain | 1990-1998 | N |
| Díaz-Hernández et al. (2008b) | 21 | Spain | 1994-1998 | N |
| González and Trujillo (2008) | 9 | Spain | 1990-2002 | Y |
| Liu (2008) | 10 | Asia-Pacific Region | 1998-2001 | N |
| Min and Park (2008) | 11 | South Korea | 2001 | Y |
| Cheon (2009) | 110 | World | 2004 | Y |
| De Koster et al. (2009) | 38 | World | 2006 | Y |
| Jiang and Li (2009) | 12 | Northeast Asia | 2007 | Y |
| Quaresma Dias et al. (2009) | 10 | Iberian Peninsula | 2007 | Y |
| Sharma and Yu (2009) | 70 | World | - | Y |
| Sohn and Jung (2009) | 16 | Asia | 1995-2005 | Y |
| Wu and Liang (2009) | 77 | World | 2007 | Y |
| Wu et al. (2009) | 28 | Asia | 2003 | Y |
| Wu and Goh (2010) | 21 | World | 2006 | Y |
| Ablanedo‐Rosas et al. (2010) | 11 | China | 2007 | N |
| Al-Eraqi et al. (2010) | 22 | Middle East,  East Africa | 2000-2005 | N |
| Cheon et al. (2010) | 98 | World | 1991, 2004 | Y |
| Hung et al. (2010) | 31 | Asia | 2003 | Y |
| Low (2010) | 23 | Asia | 2009 | N |
| Wu et al. (2010) | 77 | World | 2007 | Y |
| Bichou (2011a) | 113 | World | 2002-2008 | Y |
| Bichou (2011b) | 10 | World | 2002-2008 | Y |
| De Oliveira and Cariou (2011) | 122 | World | 2005 | N |
| Munisamy and Singh (2011) | 69 | Asia | 2007 | Y |
| Wanke et al. (2011) | 25 | Brazil | 2008 | N |
| Yip et al. (2011) | 141 | World | 1997-2004 | Y |
| Barros and Peypoch (2012) | 23 | Africa | 2002-2008 | N |
| Barros et al. (2012) | 23 | Brazil | 2004-2010 | Y |
| Demirel et al. (2012) | 7 | Turkey | 2006-2008 | Y |
| Haralambides and Gujar (2012) | 16 | India | 2006-2009 | N |
| Jiang et al. (2012) | 24 | Asia | 2008 | Y |
| Niavis and Tsekeris (2012) | 30 | Southeast Europe | 2008 | Y |
| Pjevčević et al. (2012) | 5 | Serbia | 2001-2008 | N |
| Rodríguez-Álvarez and Tovar (2012) | 3 | Spain | 1992-1997 | N |
| Seo et al. (2012) | 32 | ASEAN countries | 2010 | Y |
| Bichou (2013) | 60 | World | 2004-2010 | Y |
| Chang (2013) | 23 | Korea | 2010 | N |
| Kasypi et al. (2013) | - | - | - | Y |
| Munisamy and Wang (2013) | 69 | Asia | 2006 | Y |
| Pagano et al. (2013) | 10 | US, Panama | 1997-2006 | N |
| Schøyen and Odeck (2013) | 24 | Nordic Countries, UK | 2002-2008 | Y |
| Wanke (2013) | 27 | Brazil | 2011 | N |
| Wilmsmeier et al. (2013) | 20 | LAC | 2005-2011 | Y |
| Wang et al. (2013) | 46 | US | 1997-2006 | N |
| Yuen et al. (2013) | 21 | Asia-Pacific Region | 2003-2007 | Y |
| Chang and Tovar (2014a) | 14 | Peru, Chile | 2004-2010 | N |
| Chang and Tovar (2014b) | 14 | Peru, Chile | 2004-2010 | N |
| Díaz-Hernández et al. (2014) | 27 | Spain | 2000-2007 | N |
| Song and Cui (2014) | 26 | China | 2006-2011 | Y |
| Suárez-Alemán et al. (2014) | 16 | Africa | 2011 | N |
| Wan et al. (2014) | 12 | US | 2000-2009 | Y |
| Almawsheki and Shah (2015) | 19 | Middle East | 2012 | Y |
| De Oliveira and Cariou (2015) | 200 | World | 2007, 2010 | Y |
| Ding et al. (2015) | 21 | China | 2008-2012 | Y |
| Güner (2015) | 13 | Turkey | 1996-2008 | N |
| Gutiérrez et al. (2015) | 85 | Spain | 2008 | - |
| Ju and Liu (2015) | 14 | China | 2001-2011 | Y |
| Nguyen et al. (2015) | 43 | Vietnam | 2014 | N |
| Tovar and Wall (2015) | 26 | Spain | 1993–2012 | N |
| Tovar and Rodríguez-Déniz (2015) | 26 | Spain | 1993–2007 | N |
| Wanke and Barros (2015) | 27 | Brazil | 2012 | N |
| Zheng and Yin (2015) | 16 | China | 1998-2011 | N |
| Akinyemi (2016) | 9 | Nigeria | 2000-2011 | N |
| Coto-Millán, Fernández et al. (2016) | 26 | Spain | 1986-2012 | N |
| Coto-Millán, Casares-Hontañón et al. (2016) | - | Spain | 2002-2011 | N |
| da Cruz and de Matos Ferreira (2016) | 10 | Iberian Peninsula | 2009 | N |
| Nwanosike et al. (2016) | 6 | Nigeria | 2000–2005 | N |
| Pérez et al. (2016) | 40 | LAC | 2000-2010 | Y |
| Suárez-Alemán et al. (2016) | 203 | Developing Countries | 2000-2010 | Y |
| Serebrisky et al. (2016) | 63 | LAC | 1999-2009 | Y |
| Wanke and Barros (2016) | 27 | Brazil | 2007-2011 | N |
| Zheng and Park (2016) | 30 | China | 2014 | Y |
| Chang and Tovar (2017a) | 14 | Peru, Chile | 2004-2014 | N |
| Chang and Tovar (2017b) | 14 | Peru, Chile | 2004-2014 | N |
| Cheon et al. (2017) | 10 | US | 2004 | Y |
| Liu and Lim (2017) | 20 | US | 2005 | Y |
| Na et al. (2017) | 30 | China | 2005-2014 | Y |
| Pinto et al. (2017) | - | - | - | - |
| Schøyen and Odeck (2017) | 14 | Nordic Countries | 2009-2014 | Y |
| Sun et al. (2017) | 17 | China | 2013 | N |
| Tovar and Wall (2017) | 26 | Spain | 1993-2012 | N |
| Wiegmans and Witte (2017) | 44 | Europe | - | Y |
| Wiśnicki et al. (2017) | 9 | Europe | - | Y |
| Zahran et al. (2017) | 18 | World | 2012 | N |
| Beuren et al. (2018) | 15 | Brazil | 2013 | N |
| Cabral and Ramos (2018) | 44 | Brazil | 2016 | Y |
| Chang et al. (2018) | 58 | Europe | 2000-2011 | Y |
| Chen et al. (2018) | 35 | World | 2004-2011 | Y |
| Hlali (2018) | 7 | Tunisia | 1998-2005 | N |
| Luna et al. (2018) | - | Mexico | 2015 | Y |
| Nguyen et al. (2018) | 47 | Vietnam | 2014 | N |
| Schøyen et al. (2018) | 26 | Europe | 2010-2014 | Y |
| Wanke et al. (2018) | 6 | Nigeria | 2007-2013 | N |

Notes: “-” indicates that the researcher did not provide details regarding their dataset.

**Table A5 Regression results on *Meta-TE***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Regressors |  | Fixed | Random | Fixed Tobit▲ | Random Tobit |
| *Re-examination* |  |  |  |  |  |
|  | *Year of Publication* | **0.0125\*\*** | **0.0118\*\*** | **0.0128\*\*** | 0.000267 |
|  |  | (2.85) | (2.65) | (2.98) | (0.04) |
|  | *Year of Dataset* | -0.00601 | -0.00562 | -0.00613 | 0.00341 |
|  |  | (-1.77) | (-1.62) | (-1.83) | -0.61 |
|  | *D\_Asia* | **0.159\*\*** | **0.155\*\*** | **0.160\*\*** | 0.0938 |
|  |  | (3.1) | (3.01) | (3.15) | (1.39) |
|  | *D\_Europe* | -0.142 | -0.144 | -0.142 | -0.164 |
|  |  | (-1.51) | (-1.53) | (-1.53) | (-1.68) |
|  | *D\_Africa* | -0.111 | -0.111 | -0.112 | -0.126 |
|  |  | (-0.80) | (-0.80) | (-0.81) | (-0.95) |
|  | *D\_NA* | -0.122 | -0.126 | -0.120 | -0.183 |
|  |  | (-1.17) | (-1.21) | (-1.17) | (-1.81) |
|  | *D\_SA* | -0.0435 | -0.0427 | -0.0449 | -0.0384 |
|  |  | (-0.46) | (-0.45) | (-0.48) | (-0.40) |
| *Regional factors* |  |  |  |  |  |
|  | *Australia* | -0.0804 | -0.0855 | -0.0782 | **-0.180\*** |
|  |  | (-1.10) | (-1.18) | (-1.09) | (-2.33) |
|  | *Mainland China* | **0.190\*\*** | **0.183\*\*** | **0.193\*\*\*** | 0.103 |
|  |  | (3.31) | (3.17) | (3.40) | (1.47) |
|  | *Hong Kong* | **0.357\*\*\*** | **0.352\*\*\*** | **0.375\*\*\*** | **0.307\*\*** |
|  |  | (3.91) | (3.88) | (4.11) | (3.29) |
|  | *Taiwan* | 0.0833 | 0.0777 | 0.0919 | 0.0236 |
|  |  | (1.01) | (0.94) | (1.12) | (0.27) |
|  | *Korea* | -0.0559 | -0.0522 | -0.0558 | -0.0106 |
|  |  | (-1.06) | (-0.97) | (-1.07) | (-0.14) |
|  | *Japan* | **-0.242\*\*\*** | **-0.240\*\*\*** | **-0.241\*\*\*** | **-0.220\*\*** |
|  |  | (-3.70) | (-3.68) | (-3.74) | (-3.02) |
|  | *ASEAN Countries* | **-0.121\*** | **-0.118\*** | **-0.121\*** | -0.108 |
|  |  | (-2.20) | (-2.13) | (-2.23) | (-1.55) |
|  | *Singapore* | **0.338\*\*\*** | **0.330\*\*\*** | **0.349\*\*\*** | **0.265\*\*** |
|  |  | (4.25) | (4.17) | (4.43) | (3.15) |
|  | *South Asia* | 0.0393 | 0.0372 | 0.0465 | 0.0103 |
|  |  | (0.48) | (0.45) | (0.57) | (0.12) |
|  | *Middle East* | -0.00845 | -0.0108 | -0.00867 | -0.0396 |
|  |  | (-0.16) | (-0.21) | (-0.17) | (-0.55) |
|  | *North Europe* | 0.13 | 0.123 | 0.132 | 0.0402 |
|  |  | (1.4) | (1.33) | (1.44) | (0.42) |
|  | *Iberian Peninsula* | **0.230\*** | **0.228\*** | **0.231\*** | **0.247\*** |
|  |  | (2.24) | (2.22) | (2.29) | (2.15) |
|  | *Mediterranean Sea* | **0.214\*** | 0.209 | **0.215\*** | 0.152 |
|  |  | (1.98) | (1.95) | (2.02) | (1.42) |
|  | *U.S.* | 0.131 | 0.126 | 0.131 | 0.0739 |
|  |  | (1.26) | (1.22) | (1.27) | (0.77) |
|  | *Mexico* | -0.0646 | -0.0671 | -0.0647 | -0.0704 |
|  |  | (-0.63) | (-0.66) | (-0.64) | (-0.75) |
|  | *Central America* | 0.0599 | 0.0568 | 0.0629 | 0.0562 |
|  |  | (0.67) | (0.64) | (0.71) | (0.68) |
|  | *Panama* | 0.0866 | 0.0856 | 0.0863 | 0.095 |
|  |  | (0.78) | (0.77) | (0.79) | (0.94) |
|  | *Chile* | -0.12 | -0.122 | -0.120 | -0.116 |
|  |  | (-1.18) | (-1.21) | (-1.20) | (-1.25) |
|  | *Argentina* | -0.178 | -0.182 | -0.179 | -0.182 |
|  |  | (-1.48) | (-1.52) | (-1.50) | (-1.66) |
|  | *Brazil* | -0.115 | -0.113 | -0.115 | -0.0513 |
|  |  | (-1.27) | (-1.26) | (-1.29) | (-0.60) |
|  | *IW* | -0.103 | -0.101 | -0.103 | -0.0613 |
|  |  | (-1.56) | (-1.53) | (-1.58) | (-1.03) |
|  | *Island* | -0.161 | -0.165 | -0.159 | -0.245 |
|  |  | (-1.15) | (-1.18) | (-1.15) | (-1.88) |
|  | *\_cons* | **-12.72\*** | **-12.14\*** | **-13.20\*** | -7.043 |
|  |  | (-2.30) | (-2.15) | (-2.42) | (-0.77) |
|  |  |  |  |  |  |
|  | *sigma\_u* |  | 0.0115 |  | 0.1067 |
|  | *sigma\_e* | 0.1845 | 0.1697 | 0.1845 | 0.1663 |
|  | *rho* |  | 0.0046 |  | 0.2916 |
|  |  |  |  |  |  |
|  | *N* | 502 | 502 | 502 | 502 |

*Notes*: \*: *p* < 0.05, \*\*: *p* < 0.01, \*\*\*: *p* < 0.001; for the ML estimator, the statistic denotes the z score.

The factors are mentioned in previous studies, while the present results can be viewed as a diagnostic tool.

▲ denotes the regression results that are favored.

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