The Economic Impact of Infrastructure Investments and Leakages: A Literature Review*

by

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Abstract

This survey is of the growing body of research investigating the economic development effects of transport infrastructure expenditures, and seaport investments in particular. Summarizing the various methodologies and empirical results, our review of this literature suggests that the estimated investment effects are generally positive and that there is considerable disagreement on the magnitude of the resulting earnings, productivity and employment benefits. The estimated impacts of seaport investments are particularly contentious. We identify cross-border investment benefit leakages as one potential determinant and find that the sparse literature on this topic delivers key insights that deserve more attention going forward.

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I. Introduction

The tremendous growth of domestic and international trade continues to outpace infrastructure investments globally. In the United States, international trade topped $3.5 trillion in 2016 and involved the transportation of over 48 million containers.[1] In contrast, U.S. infrastructure spending reached $93 billion during the same year. Data published by the Federal Reserve and Congressional Budget Office (CBO) document these differences over the past 60 years and show that U.S. transport infrastructure spending and trade as a percent of real U.S. output have been on opposite trajectories for over 50 years (see Figure 1). In 2016, U.S. exports and imports accounted for around 31% of GDP, while transport infrastructure spending (including new investments as well as maintenance expenditure) accounted for merely 1.5%. Consequently, this rapid growth in transport services has put increased pressure on an aging infrastructure network in the United States. Road and seaport congestion, such as the recent backlogs at the ports of Los Angeles and Long Beach[2], are among the many consequences of the continuous strain on transport infrastructure and have far-reaching economic consequences. Across the aisles, policy-makers have recognized the importance of infrastructure and recently floated a new proposal of a $2 trillion dollar infrastructure-spending package that would dwarf previous investments.[3]

There is a growing body of research that examines the economic development effects of expenditures in transport infrastructure. The research has grown from a public economics literature

[1] The World Bank. 2016. "World Development Indicators 2016." The World Bank. https://data.worldbank.org/

[2] Mongelluzzo, Bill. 2019. "Worsening LA-LB port congestion stalls recovery." JOC.com, February 8 2019. https://www.joc.com/port-news/us-ports/port-los-angeles/worsening-la-lb-port-congestion-stalls-recovery-further_20190208.html

[3] Ballhaus, Rebecca, and Natalie Andrews. 2019. "Democrats, Trump Agree to Aim for $2 Trillion Infrastructure Package." *Wall Street Journal*, April 30 2019. https://www.wsj.com/articles/democrats-trump-agreed-on-2-trillion-infrastructure-package-11556640992

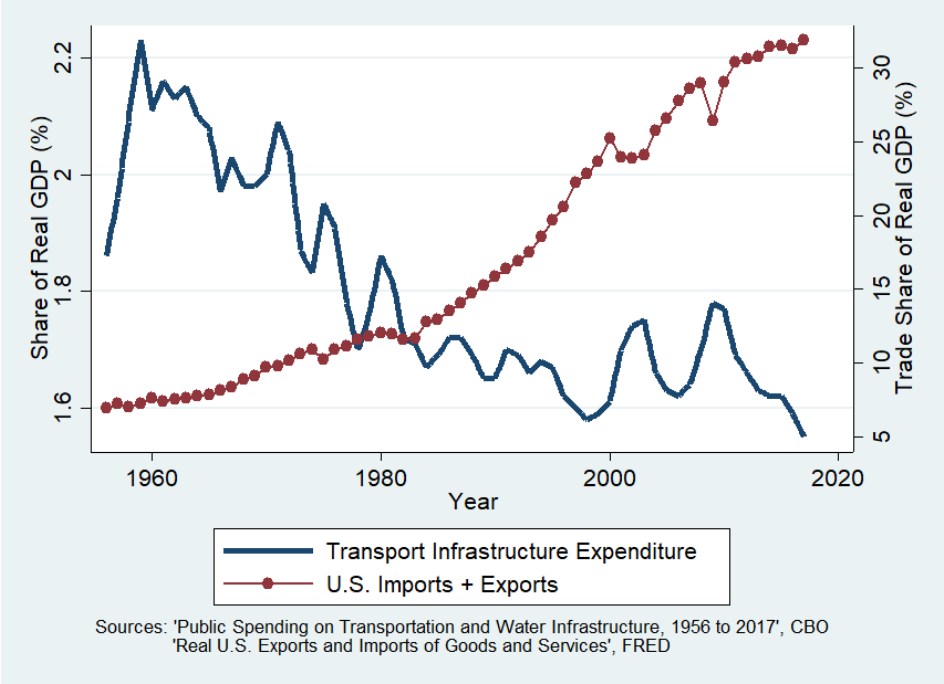

Figure 1. Figure 1. U.S. Infrastructure Spending and Trade as a Percent of GDP

that evaluates the effects of public expenditures (in general) on macroeconomic productivity and labor markets and evolved into many subfields studying the effects of specific transport infrastructure investments. While we provide a comprehensive review of the early macroeconomic literature in the online appendix, we summarize and discuss the most relevant results with respect to the economic impacts of seaport investments and their policy implications in this survey and point to three pertinent gaps that persist in the literature today.

Seaport investments can reduce transport costs and improve access to both domestic and international ports (Fujita and Mori, 1996) and can also stimulate domestic port and non-port-related sectors. Together, these can lead to a reduction in the barriers to trade and improve international competitiveness, and are particularly relevant given the current organization of economic activity. In todays urbanized economies, most centers of economic activity are port-

cities, which are critically dependent on the performance of this particular transport infrastructure (Acemoglu et al., 2005).[4]

Given the unique position of seaports within the transportation network and their distinctive characteristics, however, it is important not to extrapolate the previous findings concerning the benefits of other types of transport infrastructure on seaports. With a unique governance structure that combines public and private ownership, for example, joint investment decisions must find hybrid solutions that consider private concerns of efficiency and profitability, as well as public interests of socially desirable outcomes (Musso et al., 2006).[5] Moreover, ports represent central nodes in the global supply chain network that act as important gateways connecting a multitude of domestic and foreign markets (Notteboom and Rodrigue, 2005), but can also create important bottlenecks in these systems. Given this central position in the larger international transport infrastructure network, pricing and funding strategies critically hinge on the network externality or spatial spillover effects of such investment. More specifically, because of network externalities, the market price may fail to convey the real value of a seaport service or product, and therefore port investments may tend to be smaller than desirable, calling for inter-regional (incl. cross nations) policy coordination (Wan et al., 2016).

As international transactions and intermodal cargo shipments continue to grow, policy-makers recognize this essential position of ports in the supply chain network and consider the

[4] Historical evidence suggests that ports provide a strategic advantage that has stimulated economic development for centuries. Acemoglu et al. (2005), for example, report that "the urban expansion of western Europe was driven by cities that were Atlantic ports".

[5] For many parts of the world, seaports are viewed as primarily public goods and seaport finance continues to be largely shouldered by public entities at the local, regional, or national level (Baird 2004). The application of seaport user fees is rare and clearly contrasts the financing of international airports, which heavily depend on airport improvement fees levied on passengers and cargo (Zhang 2012).

investment risks and opportunities associated with the this rapidly growing transport sector.[6] The statistics published in the Maritime Administration's (MARAD) *U.S. Public Port Development and Expenditure Report* reveal that between 1946 and 2006 over $30 billion have been invested into capital improvements to U.S. port infrastructures (MARAD 2009). Since then, MARAD has initiated the *Strong-Ports Program* to support further capital expenditures across the U.S. seaport network consisting of over 300 points of entry and exit.[7] In the face of rapid consolidation[8] and continuous technological innovation in the transport sector[9], however, industry experts argue that the current level of U.S. public port investments falls short by about $100 billion of the required expenditure to maintain the future competitiveness of U.S. firms engaged in global markets.[10]

The CBO data presented in Figure 2 provides corroborating evidence of this potential underinvestment and shows that water transport infrastructure, in particular, has received the smallest share of U.S. public transport infrastructure investments over the last 65 years. Most recently, public capital investments on highway, railroad, and aviation infrastructures are, in fact, three to thirty times larger than new investment spending on water transport, which amounted to

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[6] MARAD. 2018a. "Port Investment and Finance." MARAD, October, 30 2018. https://www.maritime.dot.gov/ports/office-port-infrastructure-development/port-investment-and-finance

[7] MARAD 2018b. "Port Planning and Investment Toolkit." MARAD. https://www.maritime.dot.gov/ports/port-planning-and-investment-toolkit

[8] A recent example of the consolidation of the international liner shipping industry is given by the merger of three Japanese-flag carriers, now known as the Ocean Network Express (ONE), in 2017. Upon completion of this merger, the top ten global shipping lines now hold over 80 percent market share of the international seaborne cargo shipments.

[9] The technological evolution of the transport sector is evidenced, for example, by the 2016 expansion of the Panama Canal, the exponential growth of container vessels, and the anticipated introduction of electric trucks at the ports of Long Beach and Los Angeles.

[10] Mongelluzzo, Bill. 2017. "US ports need more than $100 billion from investors." JOC.com, October 6, 2017. https://www.joc.com/port-news/us-ports/us-ports-need-more-100-billion-investors_20171006.html

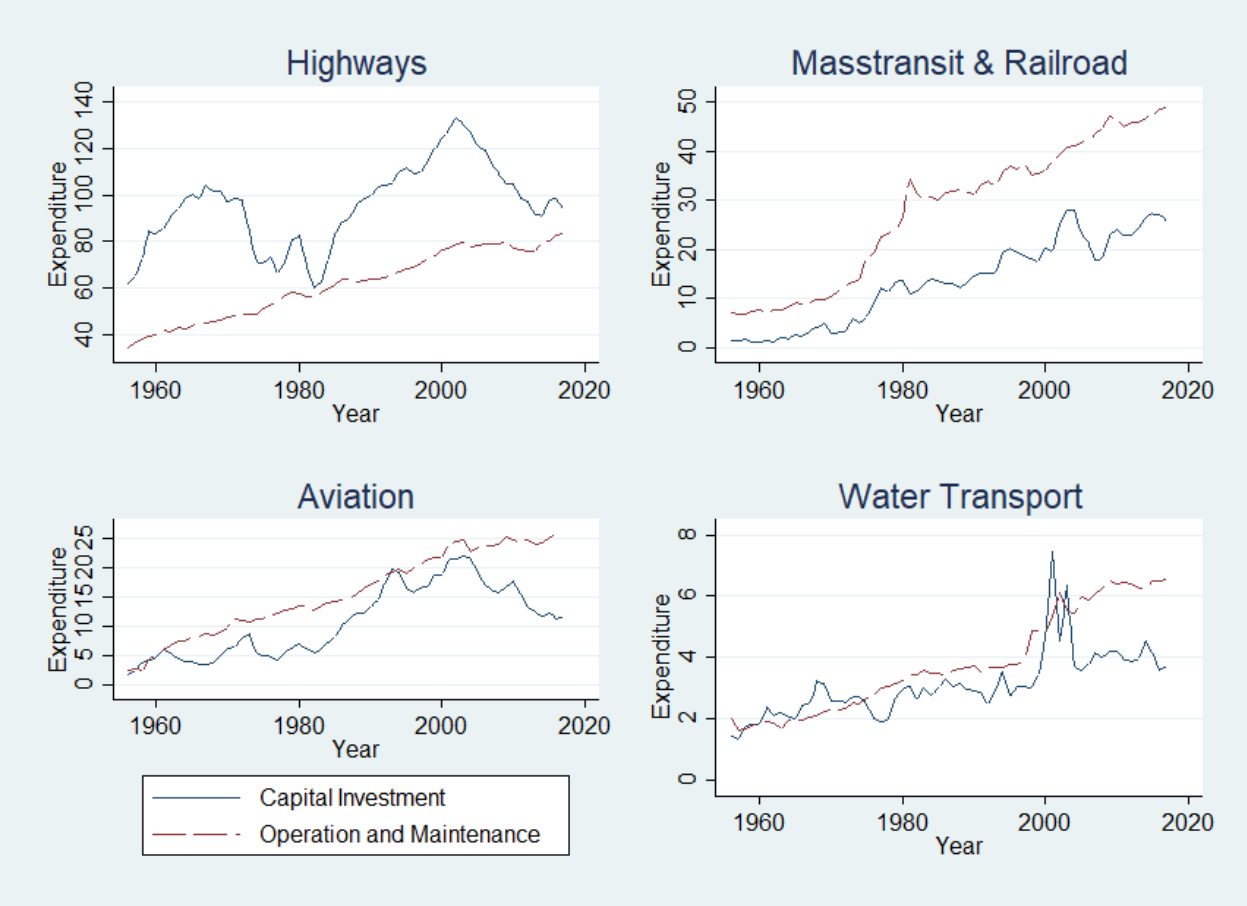

Figure 2. Public Capital Expenditure by Transport Infrastructure Type (in Bil. of 2017 U.S. $)

merely 0.05% of real U.S. GDP in 2017 – a statistic that has been slightly declining since 1956 - according to the CBO. Moreover, as Figure 2 demonstrates, the majority of this public spending was allocated towards maintenance and operation expenditures, rather than new investments.

In the context of these wide ranging transport infrastructure spending patterns and potential underinvestment in U.S. seaports, the key questions to consider are the evaluation of the potential benefits derived from public seaport expenditures as well as the distribution of these gains across national, but also foreign stakeholders. To shed light on the answers to these important questions and highlight the lessons learned from the existing research on this unique transport infrastructure, we focus in this survey on the port-related literature. Based on our findings, we divide the reviewed studies into two camps and categorize them as either port economic impact studies (Section II) or

econometric port analyses (Section III). In contrast to other transport infrastructure investments, we find that seaport investment impact estimates vary widely across this subfield of research and that the current work exhibits three important gaps of knowledge that need to be addressed. Among these gaps are (1) the shortcoming of information on the dynamics of the economic effect of public capital spending on seaport infrastructure as well as (2) the lack of investigation on the possible decreasing returns to scale from further investment into seaport infrastructure networks. Further, as part of our discussion of the potential causes for this high degree of uncertainty regarding the true seaport investment effects, we summarize the relatively scant literature on benefit leakages (Section IV) and conclude that (3) this area of research is deserving of more attention and may produce critical insights to guide future investment policy decisions (Section V).

II. Economic impact studies

Traditionally, the benefits of seaport infrastructure investments have been informed by economic impact studies, which have a long-standing history in the academic and primarily regulatory literatures.[11] Identifying the economic impacts of a variety of existing seaports in terms of output, income, employment and value-added, these studies are used to evaluate the anticipated effects from further investment and justify public expenditures.[12] Waters (1977), Kaufmann (1979) and

[11] The popularity of these impact studies has led to the development of an official *'regional port economic impact kit'* first published by MARAD in 1979 and subsequently updated until 2000. The publicly available software is based on the I-O methodology and utilizes the national U.S. input-output table in combination with regional statistics to determine inter-industry linkages and port-specific dependencies. The kit was developed to standardize and aide economic port impact analysis, facilitate the public's awareness of the linkages between ports and local economies, and ease the simulation of the expected economic effects from infrastructure investments. More recently, Dooms et al. (2015) provide a review of the I-O literature and offer guidance for an updated design of a toolkit for the evaluation of the socio-economic national and cross-border impacts of European ports.

[12] These types of impact studies are, of course, not unique to seaport infrastructures, but have been heavily used in the evaluation of airport and other infrastructure investments as well. For a brief summary of economic impact studies focused on airport infrastructure, see, for example, Zhang (2012).

Davis (1983) provide three of the earliest reviews of this literature and identify over 20 unique impact studies conducted between 1961 and 1982. Dooms et al. (2015) offer a more recent survey of this research comprised of 33 impact studies. A comparison of methodologies suggests that most of the early studies relied on economic base models based on expenditure surveys of port industries and the application of Keynesian multipliers, whereas more recent work has refined and employed I-O analyses and computable general equilibrium models (Waters 1977; Davis 1983; Benacchio and Musso, 2001; Dooms et al., 2015). The common goals underlying these impact studies are to identify the direct impact on the surveyed port industry and measure the indirect or catalytic effects resulting from the inter-industry linkages between the port industry and other goods- and service-producing sectors.

Our review of the subsequent literature on this topic reveals the critical influence of these early impact studies regarding the definition and evaluation of the benefits from seaport investments. A common theme throughout this field of study suggests that the economic benefits of seaports can be summarized into three primary categories including

1) the **direct** impact on the port industries,
2) the **indirect** effects on port-related industries, and
3) the **induced** impact on port-dependent industries,

which mirrors the compartmentalization of the broader public capital benefits developed by Ciriacy-Wantrup (1955). Yochum and Argawal (1987), for example, define the direct benefits of the provision of a seaport as the economic impact on *'port-attracted'* firms, such as freight forwarders, rail and truck transport, terminal operations, vessel supply, or pilotage, which would be forgone in the absence of the port. In contrast, the authors characterize the induced benefits as the economic impact on port-dependent industries that gain from greater international market

access and reduced transport costs for exported outputs and/or imported inputs. Applying these concepts to the Port of Hampton Roads, Virginia, the authors find that the port creates 74,000 jobs, $1.37 billion in earnings, and $159.9 million in tax revenue in the Commonwealth of Virginia. DeSalvo (1994), Toh (1995), and Acciaro (2008) add to this discussion defining the indirect impacts on port-related industries as the multiplier mechanism that hinges on the inter-industry linkages determining the effects of successive rounds of expenditure.[13] However, these authors also note that greater accessibility invites import competition that may leak some of the port benefits to foreign entities and diminishes the direct effects of a port. As discussed below, these benefit leakages create a disconnect between the globally optimal level of seaport investment and domestic seaport policy solely based on the local or even national investment gains.

The estimated port-specific impacts vary widely across the related studies. While Gripaios and Gripaios (1995) report a mild effect of the Port of Plymouth on the local British economy that accounts for 0.4 percent of local employment and around 0.8 percent of sub-regional GDP, Toh (1995) estimates an economically significant effect for the Port of Singapore suggesting that one additional dollar of port revenue creates an additional $0.76 of output. In terms of employment, the estimates diverge as well. Toh (1995), for example, finds that an additional one million Singapore dollars in port revenue adds around 20 new jobs to the Singaporean economy. In the case of the Port of Hampton Roads, Virginia, Yochum and Argawal (1987) estimate that the port creates around 74,000 local jobs in port and port-dependent industries.

[13] Musso et al. (2006) categorize benefits as direct profit to investors, and micro- as well as macroeconomic impacts, where the indirect benefits are described as external macroeconomic benefits that include the 'catalytic effect' of a port on port-attracted industries relocating to the port perimeter and the Keynesian multiplier mechanism on port-dependent industries. Francou (2007) and Dooms et al. (2015) present a detailed dissection of these benefits and the various methodologies employed in port economic impact studies.

The considerable disagreement in impact estimates is one of the main criticisms against these economic impact studies and is commonly attributed to the variation in the size and economic significance of the ports under consideration, as well as the methodologies employed. The key consideration is the definition of the port impact area (Notteboom and Rodrigue, 2005) and the extent of induced benefits, which vary greatly across the respective methodologies. Similar to Waters (1977) and Davis (1983), Villaverde-Castro and Millán (1998) provide updated overview and comparison across these methodologies and categorize them into four different approaches including the previously discussed economic base approach used by Gripaios and Gripaios (1995), the Keynesian income-expenditure multiplier model, and the input-output methodology employed by Yochum and Argawal (1987) as well as Toh (1995). In addition, the authors discuss the *'models of port demand'* pioneered by DeSalvo (1994) and DeSalvo and Fuller (1988; 1995).[14] Based on this model comparison, Villaverde-Castro and Millán (1998) conclude that the I-O methodology strikes the most favorable balance between the evaluation of direct, indirect, and induced seaport benefits and apply it to the Port of Santander, Spain. The results suggest that the Port of Santander is an important driver of the local economy and creates between 17 percent and 18 percent of regional employment that is primarily driven by the induced impact of the port.[15]

More recent studies by Jung (2011), Acosta et al. (2011), and Artal-Tur et al. (2016) evaluate the economic impacts of the Ports of Busan located in Korea, and Tarifa as well as

[14] A detailed discussion of these four approaches goes beyond the scope of this literature review and would merely duplicate the summaries offered by Villaverde-Castro and Millán (1998), Benacchio and Musso (2001), García and López (2004), Francou (2007), Acciaro (2008), and Dooms et al. (2015). A more recently developed methodology is the spatial computable general equilibrium model employed by Haddad et al. (2010).

[15] The authors indicate that these employment effects are a combination of the direct port industry impact of around two percent and the indirect as well as induced industry effects of around 15 percent to 16 percent of local employment.

Cartagena situated in Spain, using a refined regional I-O technique that adjusts the national input-output table for local idiosyncrasies in port-dependencies. The authors tend to claim that the amended I-O methodology strikes the most reasonable balance between the detailed microeconomic impacts on the directly affected port industries and the resulting macroeconomic spillovers into the port-dependent regional economy. Santos et al. (2018) further adapt this regional I-O model and include national and regional statistics to circumvent persistent survey data limitations and provide a more accurate definition of the expanding port impact area. Based on these model adaptations, the estimated total employment impacts, for example, vary from 746 jobs attributed to the Port of Tarifa (Acosta et al., 2011) to 117,136 jobs attributed to the port of Lisbon, Portugal (Santos et al., 2018).

Despite the intuitive notions underlying each of these methodologies and their refinements in the more recent literature, past and present port impact studies are subject to numerous critiques. Waters (1977), Davis (1983), and Musso et al. (2000), for example, offer an extensive list of potential shortcomings that apply even in today's context. One of the primary criticisms is the inaccuracy of expenditure surveys and the implied port-dependencies across industries. Due to a significant lack of local industry data, most port impact studies are forced to rely on expenditure surveys to gather information on port-related economic activities. The central issues addressed by these surveys are industry-specific statistics regarding output, employment and wage rates, and how much of this activity is attributable to the local seaport. With response rates as low as 10 percent (Santos et al., 2018), however, many studies have to rely on the conjecture of industry-specific dependencies on a given port. Naturally, the mismeasurement of these relationships can introduce substantial bias in the overall economic impact estimates.

Waters (1977), Davis (1983), and Musso et al. (2000) further point to the rigidity of Keynesian multipliers and I-O tables as a major criticism that continues to plague port impact studies today.[16] As production and transportation technologies evolve, the assumed port-dependencies may vary not only across industries (Waters, 1977), but also over space (Musso et al., 2000) and time (Davis, 1983). The original port-city model, for example, was developed on the premise that the provision of seaport infrastructure creates a comparative advantage that drives the agglomeration of the local economy within the port area (Fujita and Mori, 1996). Given historically high transport costs and the `lock-in' effect of economies of scale (Fujita and Mori, 1996), the geographic port impact area had a comparative advantage in terms of market access and transport costs and was rather narrowly defined. Changing technologies, such as the introduction of the container and intermodal transportation, however, have altered this landscape, diluted the local impact and extended the geographic influence of port infrastructure. Nowadays, the emergence of load center networks causes an even wider spatial distribution of port-related activities and benefit spillovers that reach far beyond the local port system (Notteboom and Rodrigue, 2005). Naturally, this development has drastically changed port dependencies across space and time and points to the rigidity of the original methodologies that cannot account for this evolution, nor the dynamic effects of seaport investments, which have been studies in alternative context (see, for example, Pereira, 2000 or Pereira and Andraz, 2006).[17]

[16] Chang (1978) offers a defense of port impact studies, which argues that the intends and purposes of these studies are inherently static and obviously ill-suited for dynamic considerations.

[17] Since the estimates of the direct impact of a port have been in decline and the induced effects on regionally distributed port-dependent industries tend to rise throughout the chronological progression of the literature, the results of these I-O port impact studies provide strong evidence in support of this evolution.

Lastly, port impact studies tend to evaluate and compare the benefits of an existing seaport against the extreme counterfactual that would arise in its absence. The resulting impact approximations must be interpreted with care. The estimates do not represent elasticities of output, employment or factor prices with respect to port services and fail to shed light on the marginal effect of an investment-induced change in maritime traffic. Instead, the results indicate the average response of the local economy to having access to a seaport that is based on average, rather than marginal, inter-industry relationships (Davis, 1983). To this date, impact studies of seaport investments have ignored this important delineation.

Based on our survey we add to this list of potential criticisms the fact that many of these impact studies ignore the network characteristics of seaports that can alter the magnitude and distribution economic investment benefits (Wan et al., 2016). That is, adding a new port into a tightly knit network surely does not have the same impact on the local economy and spillover effects on the existing seaports, as a new seaport investment that significantly expands an underdeveloped national system. The consideration of the potentially diminishing returns to a network expansion and far-reaching spillover effects must play a role in policy analysis. While evidence from the literature on airport investments, for example, suggests that characteristics of the national network matter in the determination of transport investment benefits that reach across U.S. state lines (Cohen and Paul, 2003), it is clear that seaports hold a unique position as part of the port-hinterland transportation chain. Recent work by Wan et al. (2013) and Wan et al. (2018), for example, has shown that, unlike airports, the effectiveness of seaport investments hinges on the supporting inland and hinterland infrastructure. Failure to recognize these important nuances can lead to significant misjudgment of the anticipated effects from port infrastructure investments and more research is needed to address these issues.

III. Econometric analyses

The inability to adjust port-dependencies over time, lack of cohesion of findings across impact studies, challenges of defining the proper port impact area and accounting for the seaport-hinterland network characteristics, and limitations regarding insights on the marginal effects of changes in seaport services continue to restrict I-O analyses. In response to these persistent criticisms, a number of studies have moved away from the I-O analysis and explored alternative empirical strategies to evaluate the economic impact of a port. While the empirical methodologies and port areas in these studies continue to vary greatly, the econometric analyses tend to produce employment and/or output elasticities with respect to port investments and port throughput that ease the comparison and improve policy guidance. In general, the literature suggests economically and statistically significant direct employment effects, mixed responses in output, and considerable domestic spillovers arising from port investments and port services.

Early examples of this parallel strand of literature on the economic impact of seaports include studies by Musso et al. (2000) and Acciaro (2008), who develop and employ a model that is based on location coefficients. These coefficients determine an industry's probability of port-dependency via a comparison of location quotients across port and non-port areas. Musso et al. (2000) and Acciaro (2008) find evidence in support of a significant increase in employment ranging from 8 percent to 20 percent of all municipal jobs resulting from the ports of Sardinia and Geneo, respectively.

In terms of the marginal investment effect, alternative empirical approaches evaluate the changes in employment outcomes in response to maritime traffic. The applied methodologies include the Generalized Method of Moments (GMM) system estimator developed by Blundell and Bond (1998) (Bottasso et al., 2013), an autoregressive model (Seo and Park, 2018), and a two-step

Tobit procedure to circumvent sample selection bias among port provinces (Ferrari et al., 2010). Despite these differences in econometric specification, the findings are generalizable. Port services arising from infrastructure investments stimulate regional employment. Within Europe, a 1 percent rise in maritime traffic increases service sector employment by 0.02 percent (Ferrari et al., 2010). Bottasso et al. (2013) translate this into a finding that a one million ton increase in port throughput raises European regional employment by 0.0006 percent. Seo and Park (2018) estimate that South Korean port services significantly reduce regional unemployment relative to the national level, while Friedt (2018) produces evidence that a 1 percent increase in U.S. port service raises Floridian county-level employment by about 0.06 percent, on average, with varying effects across industries.

In terms of output, the results vary by geographic region as well as methodology. Whereas studies focused on the economic impact of Asian ports consistently document an economically and statistically significant influence of ports on regional output, the output effects of European ports are more controversial and sensitive to sample selection and econometric specification. A spatial econometric panel data analysis on 621 European regions presented by Bottasso et al. (2014) suggests that a 10 percent increase in port throughput raises regional GDP by 0.03 percent. In contrast, a similar spatial econometric analysis on 47 Spanish provinces by Arbués et al. (2015) produces evidence of negative direct output effect arising from port infrastructure. In the case of Germany, Breidenbach and Mitze (2016) find negligible port effects on regional GDP per capita when controlling for the potential endogeneity of maritime traffic via an instrumental variables' technique that exploits exogenous variation in historic port locations.

Evidence on the economic impact arising from Asian ports provides a more positive outlook on port investments. Song and van Geenhuizen (2014) as well as Shan et al. (2014) investigate the role of seaports in the Chinese economic development. Ports are found to stimulate

output and output growth. Estimates suggest that a 1 percent increase in port infrastructure, for example, raises average Chinese regional output by 0.13 percent to 0.19 percent (Song and van Geenhuizen, 2014), whereas a 1 percent increase in Chinese port throughput raises local port-city output per capita growth by 0.76 percentage points (Shan et al., 2014). The former results, however, are subject to significant heterogeneity across Chinese regions with elasticity estimates ranging from 0.09 percent for the Central Chinese region to 1.43 percent for the Yangtze River Delta. In the case Korea, the results are roughly consistent with this evidence from China. South Korean ports boost regional output growth, albeit this positive impact is limited to the largest ports in terms of bulk cargo and container throughput (Park and Seo, 2016).

What drives this controversy over these diverging estimates in output in response to European, Chinese and Korean port investments? In line with our previous criticisms, one might argue that the network characteristics and pre-investment level of development vary across these countries/regions leading to various marginal rates of return on investment and contradictory output elasticity estimates. Additional explanations are well-grounded in the New Economic Geography (NEG) theory and supported by recent trends in the maritime transport sector. First, NEG theory suggests that port-driven transport costs play a critical role in the determination of competing agglomeration and dispersion forces that influence the location of economic activity (Fujita and Mori, 1996; Fujita and Thisse, 2006). Naturally, traffic demand and infrastructure expenditure are subject to this geographic distribution of economic activity leading to the simultaneous determination of urban development and infrastructure investments and services (Fujita and Mori, 1996; Fujita and Thisse, 2006). Subject to this endogeneity, traditional empirical analyses of various transport infrastructure investments tend to be biased and require innovative

strategies to properly identify their true economic impacts (Fernald, 1999; Chandra and Thompson, 2000; Duranton and Turner, 2012; Breidenbach and Mitze, 2016; Friedt, 2018).

Second, the NEG theory demonstrates that a port-induced reduction in transport costs and the ensuing redistribution of economic activity may disperse port investment benefits across a wider geographic region (Fujita and Mori, 1996; Fujita and Thisse, 2006). Eroding the local economic impact, it is challenging to empirically identify the port effects at the proper level of geographic disaggregation. This, of course, revitalizes one of the original criticisms that censures the ill definition of port impact areas (Davis, 1983; Ducruet et al., 2012).

Recently, however, the difficulty of defining the proper impact area has been exacerbated by several developments in the maritime transport and port industries. In addition to the concerns over the endogeneity infrastructure investments and the peripheral redistribution of port-induced economic activity, the port integration in global value chains (Robinson, 2002) and regionalization and de-maritimization of ports has seen a relocation of direct port activity towards the hinterland (Notteboom and Rodrigue, 2005). Nowadays, vast distribution networks reap significant benefits from increasing port investments and services, so that the "external spill-over effects of ports are expanding from the local port system towards a much larger international economic system. As such, the regionalization phase enhances a situation where port benefits are likely to 'leak' to users in inland locations" (Notteboom and Rodrigue, 2005, p. 17) making it challenging to estimate the true impact of seaport investments. The containerization of international cargo and other innovations in intermodal transport magnify these developments (Ducruet and Notteboom, 2012). As the facilitation of containerized cargo is more capital-intensive than traditional modes of maritime shipping and ports transform into transshipment hubs, rather than ports of final destination, the benefits of port investments evaporate from the local port industry and shift

towards the end users of containerized cargo enjoying cost savings from the reduction in freight rates (Cohen and Monaco, 2008).

Due to reduction in transport costs, these beneficiaries are likely to be located at great distances from the investment location and original seaport of entry or exit. Empirically, this dispersion of investment benefits manifests itself in considerable spatial output and employment spillover effects arising from seaport activity that tend to exceed the direct local impacts (Villaverde-Castro and Milán, 1998; Cohen and Monaco, 2008; Bottasso et al., 2014; Song and van Geenhuizen, 2014; Fageda and Gonzalez-Aregall, 2017). Across Europe, Bottasso et al. (2014), for example, find that a 10 percent increase in port throughput raises GDP in proximate regions by 0.17 percent, relative to the previously indicated 0.03 percent in the home region.

To ease the comparison across these econometric studies, we provide a condensed overview of this literature in Table 1. We differentiate studies by methodology, type of infrastructure, time horizon under consideration and geographic area of study. Moreover, we document whether the researchers consider the presence of domestic spatial spillovers in their analyses and offer brief description of the primary findings, rather than a single statistic that cannot be compared across studies.

IV Leakages

From a regulatory perspective, the distribution of these port investment benefits (i.e. gains in efficiency and transport cost reductions, greater reliability and frequency of service, and/or increases in output and employment) is critical to the investment decision-making process. When the costs of congestion and environmental pollution, for example, are borne by local port municipalities, while benefits from vessel efficiency gains and lower transport costs are enjoyed across the larger, global economy, cost-benefit analyses may be unfavorable and the national

infrastructure network may suffer from the chronic underinvestment (see Figures 1 and 2). As a result, the governance over port activities and funding decisions for further port investments are guided by a complex set of competing municipal, regional, and national interests that are difficult to disentangle and align (Merk and Notteboom, 2013). A review of public U.S. spending patterns across the federal and state/local governments provides evidence in support of this argument. Figure 3 differentiates the share of federal and state/local government spending on transport and water infrastructure that is spend on new investments (rather than operations and maintenance). Given the rise in investment benefit spillovers across local and state boundaries, the data clearly show that state and local municipalities are less inclined to invest in new transport infrastructure relative to the federal government and that these public U.S. spending patterns have become more distinct over the last 65 years. As local economies have become more connected with national and international markets, state and local government spending on new capital investments, for example, has fallen from almost 60% of all infrastructure spending in 1956 to less than 40% by 2017. Unsurprisingly, aviation and water transport infrastructure with the greatest potential of investment benefit spillovers beyond local or state boundaries exhibit the smallest shares of state and/or local government spending in 2017 (see Figure 4).

In addition to these distributional challenges at the domestic level, port and other transport investments create geographic benefit spillovers that are not confined within national boundaries. Examples of international benefit leakages are plentiful and perhaps most pronounced across well-integrated countries, such as the member states of the European Union. Baird (2004), for example, claims that the value added of a given seaport tends to be based on a narrowly defined geographic

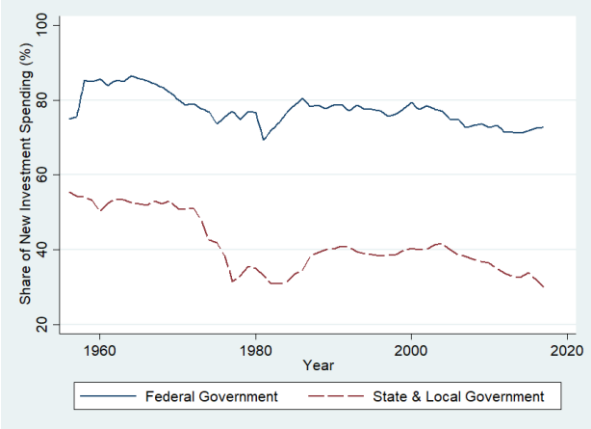

Figure 3. Transport Infrastructure Spending Share of New Capital Investment by Entity

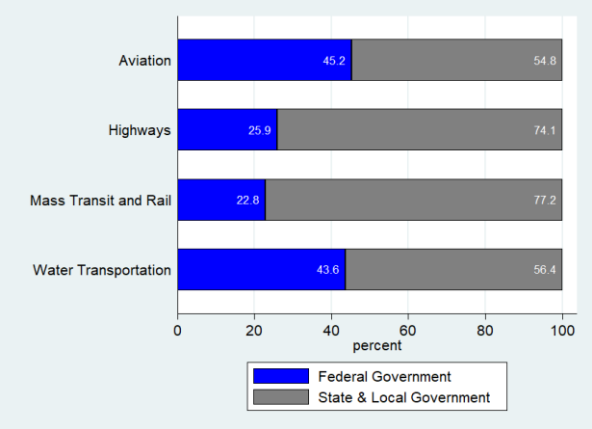

Figure 4. Transport Infrastructure Spending Share by Transport Mode

area, while investment benefits are bound to leak across international borders. In the case of Germany, the author cites that in 2001 about 44 percent of all container traffic handled by major seaports, Hamburg and Bremerhaven, were transshipments with final destinations outside of Germany. The author concludes "any cost-benefit analysis that considers only the local, or national impacts should be regarded as insufficient […] (and) should have their impacts evaluated across the region as a whole." (p. 389).

Similarly, in an OECD report on the competitiveness of Rotterdam and Amsterdam in the global environment of port-cities, Merk and Notteboom (2013) remark that "Rotterdam and Amsterdam can be considered ports that have significance for the whole of Europe. […] Most of their hinterlands are located outside the Netherlands, with Rotterdam being the main port for large parts of Germany, as well as a major port for Central Europe and Eastern Europe, Switzerland and northern Italy. Exporting and importing firms in these regions benefit from the efficient operations of both the port of Rotterdam and Amsterdam." (p.9) As such, port investments are becoming a matter of international concern, where the distribution of investment benefits across national and international stakeholders must be weighed against the domestic opportunity costs of such public expenditures. Musso et al. (2006) note that in response to these complexities there is a trend

towards greater private funding of port investments in part, because public port investments have not yielded the societal benefits originally anticipated.

While many of these studies enhance our understanding of the true geographic dispersion of economic impacts derived from seaports and other transport infrastructures, they have largely failed to differentiate between regional and cross-country spillovers or distinguish between domestic and foreign beneficiaries. In fact, throughout our review of the vast literature on the economic impact of various public capital expenditures and growing research on spatial spillovers (summarized in the Online Appendix), we find that the consideration of benefit leakages to foreign stakeholders has played a very limited role. Laird et al. (2005) summarize part of this literature and conclude that "at this time there is no definitive modelling system that captures all network effects, so the full scale of the economic impact of a project when price does not equal marginal social costs is not yet fully resolved." (p. 543) Addressing this concern and major gap in the literature, our review of the more recent research suggests that there are a handful of studies that make note of the possibility of cross-border benefit leakages and quantify these international benefit spillovers. The analysis and review of this specific literature, however, is complicated by the fact that the definition of what constitutes benefit leakages varies greatly across this sparse set of research.

In one of the earliest studies acknowledging the possibility of investment benefit leakages, Margolis (1957), for example, equates leakages with lost benefits due to greater import competition. In contrast, Goss (1990), Munnell (1992), and Chandra and Thomson (2000) vaguely define transport infrastructure investment leakages as mere spatial benefit spillovers that accrue to economic agents located in non-investment areas. Similarly, Rephann and Isserman (1994) refer to these benefit spillovers as interregional leakages. While each of these studies have advanced

our understanding of the distribution of public investment benefits, none clearly differentiates between national and international spillovers and pinpoints cross-border benefit leakages.

A more careful definition of investment benefit leakages separates domestic spatial benefit spillovers from international ones and isolates the focus on the latter. We define *`investment benefit leakages'* as transportation cost savings and the ensuing economic benefits from transport infrastructure investments that are removed from the overall national economic benefits via foreign shipper's profits, foreign shareholders' returns and/or benefits to foreign nations. This definition corresponds with the elaborations by Notteboom and Rodrigue (2005), who describe benefit leakages as "the external spill-over effects of ports [that] are expanding from the local port system towards a much larger international economic system. As such, the regionalization phase enhances a situation where port benefits are likely to 'leak' to users in inland locations" (p. 17)

There are several mechanisms that contribute to the wide distribution of seaport investment benefits and drive potential benefit leakages overseas. First, seaport investments and the resulting cost savings might accrue to international shippers who face limited competitive pressure to pass these savings on to domestic consumers or exporters in the form of lower transport costs (Dekker, 2005). In reality, however, this mechanism may be relatively insignificant. International shipping has a longstanding history of boom and bust cycles, where investments in newer, larger vessels lead to frequent periods of over-capacity and highly competitive shipping markets, where many firms struggle to earn positive profits.[18]

If international and domestic carriers, indeed, pass on port cost savings through a reduction in transport costs, investment benefits may still leak to international stakeholders through five

[18] Nam, In-Soo. 2017. "Hanjin Shipping Is Declared Bankrupt." *Wall Street Journal*, February 16 2017. https://www.wsj.com/articles/hanjin-shipping-is-declared-bankrupt-1487296151

primary channels highlighted in the previous literature. First, given the widening of the port impact area, there is a disconnect between the local costs of a port and the local versus far spread benefits of port investment. Benacchio and Musso (2001) argue that "port services show a decreasing payback of labour and an increasing return on capital investment. While the former is located within the local economy, the latter […] seldom comes either from the local economy or even from the country itself" (p. 27). As such, the additional return on capital through port investments is likely to leak across borders to foreign capital owners. Given the prevalence of vertical integration, which leads to the international ownership of firms, this global distribution of benefits from local port investments is becoming increasingly likely.

Second, a reduction in port costs typically reduce shipping rates on the entire round trip of international carriers. As such, not only the share of domestic products on a given round trip experience a reduction in trade costs, but also the share of international goods (Laing, 1977; Friedt and Wilson, forthcoming).

Thirdly, publicly traded domestic exporters benefitting from transport cost reductions may be partially owned by foreign shareholders earning higher returns in response to the seaport investment. Fourthly, the reduction in transport cost not only creates greater access for domestic firms in international markets, but also raises competitive pressures for these and other domestic firms through foreign import competition. Margolis (1957) raises this concern in the context of more broadly defined transport infrastructure investments and a number of international trade theories highlight this mechanism in terms of increasing import competition arising from a reduction in international trade costs (see, for example, Krugman, 1980; 1981 or Melitz, 2003).

Lastly, the domestic distribution of internationally traded products may be facilitated by international intermediaries. Even if seaport investments lead to transport cost reductions and

domestic shareholders holistically own domestic exporters, international intermediaries may capture the cost savings from reduced transport costs and do not extend price reductions to final domestic consumers or exporters. Recent work by Donaldson and Atkin (2015) provides considerable evidence in support of this hypothesis. Estimating the effects of reductions in international trade barriers, such as port costs, on final goods' prices in Ethiopia and Nigeria relative to the United States, the authors find that consumers in remote locations of these developing countries experience very small price reductions, while most of the gains accrue to intermediaries. Of course, these findings are based on developing countries and are contrasted to the U.S. experience in response to falling international trade costs.

Direct empirical evidence of the benefit leakages from seaport or more broadly defined transport infrastructure investments is surprisingly sparse and the differentiation of the underlying mechanisms driving these leakages is virtually non-existent. Moreover, the few estimates we evidence are based on varying empirical methodologies and exclusively centered on European investments, such as the Trans-European Transport Network (TEN-T) projects, whose hall mark is a transnational investment approach. To the best of our knowledge, the first of these estimates are presented by Van Exel et al. (2002), who emphasize the importance of taking account of the cross-border network effects and European Value Added in the evaluation of supranational infrastructure investments. The authors exemplify the merit of their methodology through three previously conducted TEN-T impact studies. For these projects, the estimates suggest that transport infrastructure benefits, evaluated from a supranational perspective, exceed national estimates by 25 percent for a high-speed rail network connecting Paris-Brussels-Köln-Amsterdam-London, 50 percent for a rail link between the ports of Rotterdam (Netherlands) and Antwerp (Belgium), and 140 percent in case of an expansion of the port of Rotterdam. Van Exel et al. (2002)

base these estimates of European Value Added (EVA) calculations. According to the authors, EVA is comprised of multiple criteria, including for example transport efficiency, social cohesion and economic development, among others. Calculations, however, are solely based on the criteria that can be monetarized, such as strategic mobility, which is a function of population weighted travel times and GDP weighted travel costs, or economic development, measured in GDP growth rate changes.

Gutiérrez et al. (2011) also focus on one of the TEN-T projects, but take a different approach methodologically. In their study, the authors gage the benefit leakages to the construction of the motorway from Gdansk to Vienna (in the west) and Bratislava (in the east) via a novel accessibility indicator, which measures the accessibility improvements due to the highway investment in highway and non-highway regions. Unlike Chandra and Thompson (2000) and others, however, the authors argue that it is necessary to differentiate benefit spillovers between those which are of fundamentally national interest and those which are of international interest. Defining regions affected by the motorway at the European NUTS 3 level, Gutiérrez et al. (2011) find significant benefit leakages, in terms of accessibility improvements, outside of the national borders ranging from 1.4 percent to 35.9 percent of national gains depending on the motorway segment under consideration. Intuitively, motorway sections closer to the borders produce greater accessibility gains and potential benefit leakages than interior infrastructure investments.

In the case of Spain, Lopez et al. (2009) investigate the domestic and international effects of the Spanish Strategic Transport Infrastructure Plan (PEIT) implemented from 2005-2020. The specifics of this transport investment plan involve the construction of around 5000km of high capacity roads (HCR) and 6000km of high-speed rail (HSR). Similar to Gutiérrez et al. (2011), the

authors measure cross-border effects via an accessibility indicator[19] and find economically significant gains domestically and in the neighboring countries of France and Portugal. Cross-border accessibility gains from the HCR investments range from 1.15 percent to 4.10 percent for Portugal and average 2.03 percent gains in network efficient accessibility. For France, these cross-border gains range from 0.45 percent to 2.60 percent and average 1.48 percent resulting from the improved road network. On average, cross-border benefit leakages amount to 1.80 percent, which in comparison to the domestic roadway accessibility gains for Spain (2.6 percent), are very significant.

In the case of rail, Lopez et al. (2009) find that the cross-border accessibility gains are much larger and average 17.23 percent for Portugal and 23.51 percent for France. The population weighted average cross-border benefit leakages, measured in terms of the network-efficiency-accessibility gain, from HSR are 20.21 percent and considerable given the average domestic gains of 34.52 percent for Spain. Based on our own calculations in terms of leakages, Lopez and co-authors' estimates suggest that 37 percent of the total rail and 41 percent of the total road investment benefits accrue outside of Spain to the neighboring regions of France and Portugal.

The most comprehensive study of European transport investment benefit leakages was done by Bröcker et al. (2010), who develop a Spatial Computable General Equilibrium (SCGE) framework and apply the model to a list of 22 high priority road and railway projects under the

[19] Specifically, Lopez et al. (2009) develop the network efficiency accessibility indicator, which measures the accessibility of node i as the travel time between node i and any node j on the actual transport network, relative to the ideal (as the crow flies) travel time between these two nodes. This efficiency measure is weighted by the population of region j and divided by total population spread across the entire network. Cross-border accessibility gains, or benefit leakages, are measured as the percentage change in network efficiency accessibility indicator for international regions in France and Portugal due to the Spanish PIET investment.

TEN-T initiative. According to the authors, SCGE models have several advantages including a relaxation of the perfect competition assumption underlying cost-benefit analysis and the ability to simulate direct and indirect economic impacts under several competing policy alternatives. Most importantly, however, the SCGE model accounts for domestic and international distribution of transport infrastructure benefits.[20] Based on the simulations comparing the status-quo scenario to the fully funded and implemented TEN-T project under consideration, Bröcker et al. (2010) find varying rates of return on investment and significant EU and non-EU benefit leakages.

Domestically, the investing countries capture 40 percent to 105 percent of the total welfare gains from TEN-T investment projects and earn a return on investment ranging from 0.01 percent to 18.47 percent per year. Non-investing EU member states experience benefit leakages representing -5 percent to 55 percent of the overall welfare gains. In fact, seven of the 22 projects evaluated produce international benefit spillovers to EU members in excess of 20 percent of total welfare gains. Based on the authors' findings, simple calculations suggest that non-EU non-investing countries also gain from benefit leakages, with estimates ranging from -1 percent to 28 percent of the overall welfare effect. In absolute terms, investment benefit leakages to non-investment EU members can reach as high as 342.5 million euros per year, while the maximum benefit leakages to non-EU members could exceed 270 million euros per year.

Aside from the aforementioned findings by Van Exel et al. (2002), concrete evidence of the international benefit leakages from seaports investments is largely non-existent. Two noteworthy exceptions include Merk et al. (2013) and Santos et al. (2018), who investigate the regional economic impact of European seaports through a regional I-O methodology and allude to

[20] One downside of the model is the restrictive factor immobility, which suppresses the agglomeration forces often described in the aforementioned new economic geography literature (see, for example, Fujita and Mori, 1996).

the potential seaport investment benefit leakages. A comprehensive evaluation of leakages, however, is missing from both of these studies.

Merk et al. (2013) quantify the interregional spillovers arising from four major seaports in north-west Europe including Rotterdam, Hamburg, Le Havre, and Antwerp. The authors take a regional I-O approach at the relevant port area and calculate the industry-specific backward linkages, captured by the so-called Leontief multipliers. In terms of the aggregate effects, the calculations suggest that the ports of Le Havre and Hamburg have the largest impact relative to the ports of Rotterdam and Antwerp – a finding that is consistent across industries as well. Breaking these impacts down across regions, the authors find that the port of Rotterdam exercises significant influence over the port region of Antwerp and the cross-border Flanders' region in general. The port of Antwerp has comparatively smaller supranational effects. Unfortunately, the authors do not provide international spillover estimates for the ports of Hamburg or Le Havre, although sizeable national spillovers are indicative of the potential cross-border leakages.

In a similar study, Santos et al. (2018) estimate the port multiplier effects for Portuguese seaports via the regional I-O methodology and find that the port multiplier of Leixões is significantly smaller than the estimated parameter for Lisbon. The authors explain their finding through the geographic location of the port Leixões in close proximity to the Spanish region of Galicia and allude to seaport benefit leakages across the Portuguese-Spanish border. Specific estimates of the leakages, however, are not provided, since the I-O methodology critically hinges on domestic input-output tables.

Conclusion

Our overview of the current state of knowledge on the economic impact of seaport infrastructure investments and the cross-border distribution of the ensuing seaport investment benefits clearly

indicates that there are considerable gaps remaining in this literature. In comparison to the research that quantifies the economic development effects of other transport infrastructure investments, estimates concerning the net benefits of seaport capital expenditures produce a wide range of plausible impacts. The lack of cohesion in methodology, data, and study area within and across impact and econometric studies that quantify the economic development effects of seaport infrastructure complicate the comparison and prevent the formation of clear policy guidance.

The data on public capital expenditures, particularly those on U.S. water transport infrastructure, reflect this high degree of uncertainty regarding the net investment benefits. Over the past 65 years, U.S. public spending on transport infrastructure has been declining as a share of overall GDP and new capital investment spending has significantly fallen relative to operations and maintenance expenditures. The latter trend is particularly pronounced for state and local governmental infrastructure spending, which suffers from unfavorable local cost-benefit analysis that ignore far-reaching benefit spillovers.

Our review indicates that there is a general lack of consideration of these spatial benefit spillovers from seaport investments, and in particular with respect to the differentiation between domestic spillovers and international investment benefit leakages. While recent advances in the quantification of the cross-border economic impacts of European road and railway investments have been made through the application of accessibility indicators and spatial computable general equilibrium models, much remains to be learned about investment benefit leakages in alternative geographic settings and seaport investments in particular. Moreover, researchers and policy makers would benefit from the application of a wider range of empirical techniques able to quantify the domestic marginal benefits and differentiate these estimates from international marginal benefit leakages of an additional dollar invested into transport infrastructure.

Main References

Acciaro, M., 2008. The role of ports in the development of Mediterranean islands: the case of Sardinia. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, pp.295-323.

Acemoglu, D., Johnson, S. and Robinson, J., 2005. The rise of Europe: Atlantic trade, institutional change, and economic growth. *American economic review*, *95*(3), pp.546-579.

Acosta, M., Coronado, D. and del Mar Cerbán, M., 2011. The Economic Impact of the Port of Tarifa (Spain) in 2007 and the Forecast for 2015. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, pp.243-263.

Artal-Tur, A., Gómez-Fuster, J.M., Navarro-Azorín, J.M. and Ramos-Parreño, J.M., 2016. Estimating the economic impact of a port through regional input–output tables: Case study of the Port of Cartagena (Spain). *Maritime Economics & Logistics*, *18*(4), pp.371-390.

Atkin, D. and Donaldson, D., 2015. *Who's getting globalized? The size and implications of intra-national trade costs* (No. w21439). National Bureau of Economic Research.

Baird*, A.J., 2004. Public goods and the public financing of major European seaports. *Maritime Policy & Management*, *31*(4), pp.375-391.

Benacchio, M. and Musso, E. 2001. Ports and Economic Impact: main changes, assessment approaches and distribution disequilibrium. Transporti Europei (Quarterly Journal of Transport Law, Economics and Engineering), 7 (17), pp. 25-36.

Blundell, R. and Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), pp.115-143.

Bottasso, A., Conti, M., Ferrari, C., Merk, O. and Tei, A., 2013. The impact of port throughput on local employment: Evidence from a panel of European regions. *Transport Policy*, *27*, pp.32-38.

Bottasso, A., Conti, M., Ferrari, C. and Tei, A., 2014. Ports and regional development: a spatial analysis on a panel of European regions. *Transportation Research Part A: Policy and Practice*, *65*, pp.44-55.

Breidenbach, P. and Mitze, T., 2016. The Long Shadow of Port Infrastructure in Germany: Cause or Consequence of Regional Economic Prosperity?. *Growth and Change*, *47*(3), pp.378-392.

Bröcker, J., Korzhenevych, A. and Schürmann, C., 2010. Assessing spatial equity and efficiency impacts of transport infrastructure projects. *Transportation Research Part B: Methodological*, *44*(7), pp.795-811.

Castro, J.V. and Millán, P.C., 1998. Port economic impact: methodologies and application to the port of Santander. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, pp.159-179.

Chandra, A. and Thompson, E., 2000. Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system. *Regional Science and Urban Economics*, *30*(4), pp.457-490.

Ciriacy-Wantrup, S.V., 1955. Benefit-cost analysis and public resource development. *Journal of Farm Economics*, *37*(4), pp.676-689.

Cohen, J.P. and Paul, C.J.M., 2003. Airport infrastructure spillovers in a network system. *Journal of Urban Economics*, *54*(3), pp.459-473.

Cohen, Jeffrey, and Kristen Monaco. "Ports and highways infrastructure: an analysis of intra-and interstate spillovers." *International Regional Science Review* 31, no. 3 (2008): 257-274.

Davis, H.C., 1983. Regional port impact studies: a critique and suggested methodology. *Transportation Journal*, pp.61-71.

Dekker, S., 2005. Port Investment – Towards and Integrated Planning of Port Capacity. Delft, The Netherlands TRAIL Research School, TRAIL Thesis Series, no. T2005/5

DeSalvo, J.S., 1994. Measuring the direct impacts of a port. *Transportation Journal*, pp.33-42.

DeSalvo, J.S. and Fuller, D.L., 1988. *The economic impact of the port of Tampa*. Center for Economic and Management Research, University of South Florida.

DeSalvo, J.S. and Fuller, D.L., 1995. The role of price elasticities of demand in the economic impact of a port. *Review of Regional Studies*, *25*(1), pp.13-35.

Dooms, M., Haezendonck, E. and Verbeke, A., 2015. Towards a meta-analysis and toolkit for port-related socio-economic impacts: a review of socio-economic impact studies conducted for seaports. *Maritime Policy & Management*, *42*(5), pp.459-480.

DOT/Bureau of Transportation Statistics, Freight Facts and Figures 2015, Figure 2-9 U.S. International Merchandise Trade Value and Weight by Transportation Mode: 2014.

Ducruet, C. and Notteboom, T., 2012. The worldwide maritime network of container shipping: spatial structure and regional dynamics. *Global networks*, *12*(3), pp.395-423.

Ducruet, C., Itoh, H. and Joly, O., 2012, May. Material flows and local economic structure: port-region linkages in Europe, Japan, and the United States.

Fageda, X. and Gonzalez-Aregall, M., 2017. Do all transport modes impact on industrial employment? Empirical evidence from the Spanish regions. *Transport Policy*, *55*, pp.70-78.

Fernald, J.G., 1999. Roads to prosperity? Assessing the link between public capital and productivity. *American economic review*, *89*(3), pp.619-638.

Ferrari, C., Percoco, M. and Tedeschi, A., 2010. Ports and local development: evidence from Italy. *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti*, pp.9-30.

Francou, B., Carrera-Gómez, G., Coto-Millán, P., Castanedo-Galán, J. and Pesquera, M.A., 2007. Economic impact study: Application to ports. In *Essays on Transport Economics* (pp. 147-157). Physica-Verlag HD.

Friedt, F., 2018. Natural Disasters, Trade, and Local Factor Prices: The Urban Equilibrium Effect of Rerouted Trade. *Trade, and Local Factor Prices: The Urban Equilibrium Effect of Rerouted Trade (July 15, 2018)*.

Friedt, F. and Wilson, W.W., Forthcoming. Trade, Transport Costs and Trade Imbalances: An Empirical Examination of International Markets and Backhauls. *Canadian Journal of Economics.*

Fujita, M. and Mori, T., 1996. The role of ports in the making of major cities: self-agglomeration and hub-effect. *Journal of development Economics*, *49*(1), pp.93-120.

Fujita, M. and Thisse, J.F., 2006. Globalization and the evolution of the supply chain: who gains and who loses?. *International Economic Review*, *47*(3), pp.811-836.

García, J.P. and López, G.G., 2004. Ports economic impact: Literature review and alternative proposal. *Journal of Maritime Research*, *1*(3), pp.85-104.

Goss, R.O., 1990. Economic policies and seaports: are port authorities necessary?. *Maritime Policy & Management*, *17*(4), pp.257-271.

Gripaios, P. and Gripaios, R., 1995. The impact of a port on its local economy: the case of Plymouth. *Maritime Policy and Management*, *22*(1), pp.13-23.

Gutiérrez, J., Condeço-Melhorado, A., López, E. and Monzón, A., 2011. Evaluating the European added value of TEN-T projects: a methodological proposal based on spatial spillovers, accessibility and GIS. *Journal of Transport Geography*, *19*(4), pp.840-850.

Haddad, E.A., Hewings, G.J., Perobelli, F.S. and dos Santos, R.A., 2010. Regional effects of port infrastructure: a spatial CGE application to Brazil. *International Regional Science Review*, *33*(3), pp.239-263.

Jung, B.M., 2011. Economic contribution of ports to the local economies in Korea. *The Asian Journal of Shipping and Logistics*, *27*(1), pp.1-30.

Kaufmann, G., 1979. Port Impact Studies: Comparison and Evaluation of Existing Method. *Vancouver, British Columbia, School of Community and Regional Planning* (Doctoral dissertation, MA Thesis).

Krugman, P., 1980. Scale economies, product differentiation, and the pattern of trade. *The American Economic Review*, *70*(5), pp.950-959.

Krugman, P.R., 1981. Intraindustry specialization and the gains from trade. *Journal of political Economy*, *89*(5), pp.959-973.

Laing, E.T., 1977. The distribution of benefits from port investment. *Maritime Policy and Management*, *4*(3), pp.141-154.

Laird, J.J., Nellthorp, J. and Mackie, P.J., 2005. Network effects and total economic impact in transport appraisal. *Transport policy*, *12*(6), pp.537-544.

Lopez, E., Monzón, A., Ortega, E. and Mancebo Quintana, S., 2009. Assessment of cross-border spillover effects of national transport infrastructure plans: an accessibility approach. *Transport Reviews*, *29*(4), pp.515-536.

Margolis, J., 1957. Secondary benefits, external economies, and the justification of public investment. *The Review of Economics and Statistics*, pp.284-291.

MARAD, USDOT. "US Public Port Development Expenditure Report (FYs 2006 & 2007-2011)." *US Department of Transportation, Maritime Administration, Office of Intermodal System Development* (2009).

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. *econometrica*, *71*(6), pp.1695-1725.

Merk, Olaf M., Walter JJ Manshanden, and Martijn I. Dröes. "Inter-regional spillovers of seaports: the case of North-West Europe." *International Journal of Transport Economics/Rivista internazionale di economia dei trasporti* (2013): 401-417.

Merk, O. and Notteboom, T., 2013. The competitiveness of global port-cities. *Synthesis report. Paris: OECD*.

Munnell, A.H., 1992. Policy watch: infrastructure investment and economic growth. *Journal of economic perspectives*, *6*(4), pp.189-198.

Musso, E., Benacchio, M. and Ferrari, C., 2000. Ports and employment in port cities. *International Journal of Maritime Economics*, *2*(4), pp.283-311.

Musso, E., Ferrari, C. and Benacchio, M., 2006. Port investment: profitability, economic impact and financing. *Research in Transportation Economics*, *16*, pp.171-218.

Notteboom*, T.E. and Rodrigue, J.P., 2005. Port regionalization: towards a new phase in port development. *Maritime Policy & Management*, *32*(3), pp.297-313.

Park, J.S. and Seo, Y.J., 2016. The impact of seaports on the regional economies in South Korea: Panel evidence from the augmented Solow model. *Transportation Research Part E: Logistics and Transportation Review*, *85*, pp.107-119.

Pereira, A.M., 2000. Is all public capital created equal?. *Review of Economics and Statistics*, *82*(3), pp.513-518.

Pereira, A.M. and Andraz, J.M., 2006. Public investment in transportation infrastructures and regional asymmetries in Portugal. *The Annals of Regional Science*, *40*(4), pp.803-817.

Rephann, T. and Isserman, A., 1994. New highways as economic development tools: An evaluation using quasi-experimental matching methods. *Regional Science and Urban Economics*, *24*(6), pp.723-751.

Robinson, R., 2002. Ports as elements in value-driven chain systems: the new paradigm. *Maritime Policy & Management*, *29*(3), pp.241-255.

Santos, A.M., Salvador, R., Dias, J.C.Q. and Soares, C.G., 2018. Assessment of port economic impacts on regional economy with a case study on the Port of Lisbon. *Maritime Policy & Management*, *45*(5), pp.684-698.

Seo, Y.J. and Park, J.S., 2018. The role of seaports in regional employment: evidence from South Korea. *Regional Studies*, *52*(1), pp.80-92.

Shan, J., Yu, M. and Lee, C.Y., 2014. An empirical investigation of the seaport's economic impact: Evidence from major ports in China. *Transportation Research Part E: Logistics and Transportation Review*, *69*, pp.41-53.

Song, L. and van Geenhuizen, M., 2014. Port infrastructure investment and regional economic growth in China: Panel evidence in port regions and provinces. *Transport Policy*, *36*, pp.173-183.

Toh, R.S., Phang, S.Y. and Khan, H., 1995. Port Multipliers for Singapore: Impact on Income, Output, and Employment. *Journal of Asian Business*, *11*(1), p.1.

van Exel, J., Rienstra, S., Gommers, M., Pearman, A. and Tsamboulas, D., 2002. EU involvement in TEN development: network effects and European value added. *Transport policy*, *9*(4), pp.299-311.

Wan, Y., Zhang, A. and Yuen, A.C., 2013. Urban road congestion, capacity expansion and port competition: empirical analysis of US container ports. *Maritime Policy & Management*, *40*(5), pp.417-438.

Wan, Y., Basso, L.J. and Zhang, A., 2016. Strategic investments in accessibility under port competition and inter-regional coordination. *Transportation Research Part B: Methodological*, *93*, pp.102-125.

Wan, Y., Zhang, A. and Li, K.X., 2018. Port competition with accessibility and congestion: a theoretical framework and literature review on empirical studies. *Maritime Policy & Management*, *45*(2), pp.239-259.

Waters, R.C., 1977. Port economic impact studies: practice and assessment. *Transportation Journal*, pp.14-18.

Yochum, G.R. and Agarwal, V.B., 1987. Economic impact of a port on a regional economy: note. *Growth and Change*, *18*(3), pp.74-87.

Zhang, A., 2012. Airport improvement fees, benefit spillovers, and land value capture mechanisms. In *Value capture and land policies* (pp. 323-348). Lincoln Institute of Land Policy Cambridge, MA.

Table 1: Econometric Studies of the Economic Impact of Seaports

Source	Methodology	Type of Infrastructure	Area of Study	Spatial Spillovers	Time Horizon	Summary
Cohen and Monaco (2008)	Cost function	Seaport and highway	U.S. State - Manufacturing	Y - Contiguity	1984-1996	Manufacturing costs decline with in-state port and highway investments (elasticities: -0.043 and -0.189). Out-of-state port investments raise manufacturing cost.
Ferrari et al. (2010)	Employment equation	Port throughput	Italy - Provinces	N	2000-2006	Elasticity estimates of total and service sector employment wrt to maritime traffic range from 0.015 to 0.022.
Bottasso et al. (2013)	Employment equation	Port throughput	EU Regions - Industry	N	2000-2006	Elasticity estimates of total, service, and industry employment wrt to maritime traffic range from 0.00017 to 0.001 depending on seaport organizational structure.
Bottasso et al. (2014)	Spatial Output Model	Port throughput	EU Regions	Y - Distance	1998-2009	Elasticity estimates of output wrt maritime traffic range from 0.069 to 0.021, while spillover effects exceed direct impacts.
Shan et al. (2014)	Output growth equation	Port throughput	China - Port city	Y - Contiguity	2003-2010	A 1% increase in local seaport throughput raises output growth by 0.024-0.065 % points and exhibits positive spillover effects (0.094 to 0.185 % points).
Song and van Geenhuizen (2014)	Production function	Transport infrastructures	China - Port regions	Y - Contiguity	1999-2010	Elasticity estimates of output wrt to local seaport infrastructure range from 0.093 in the Center to 1.428 in the Yangtze River Delta region and create largely positive spillover effects.

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Source	Methodology	Type of Infrastructure	Area of Study	Weight Matrix	Time Horizon	Summary
Breidenbach and Mitze (2016)	Production function	Port infrastructure	Germany - NUTS 3	N	1991-2008	The OLS estimates provide evidence of a positive correlation between port location and per capita income, whereas the IV estimates do not produce any evidence of a causal port effect on output.
Park and Seo (2016)	Augmented Solow growth model	Port throughput	Korea - Regions	N	2000-2013	The esitmates suggest that Korean cargo ports only stimulate regional growth if throughput reaches a critical mass of around 115 million tons per year. For these larger ports, a 1% increase in throughput raises output growth by 0.028 % points.
Fageda and Gonzalez-Aregall (2017)	Spatial employment equation	Multiple transport infrastructures	Spain - NUTS 3	Y - Multiple	1995-2008	Total elasticity estimates of manufacturing employment wrt port throughput range from 0.242 to 0.755 and are driven by significant direct effects (0.292-0.361).
Friedt (2018)	Urban equilibrium model	Port throughput	U.S. County - Industry	Y - Multiple	2003-2007	Primary elasticity estimates of employment, land values, and wages wrt port throughput equal 0.033, 0.049, and -0.011, respectively. Seaport throughput causes interindustry reallocation towards transport sectors and creates spatial spillovers, which vary by geographic and economic characteristics.