The role of seaports on regional employment: empirical evidence from South Korea

ABSTRACT

This study aims to examine the seaport's influence on regional employment in all the 16 regions of Korea, including seven metropolitan areas based on panel data between 2002 and 2013. This study expands an economic model of regional unemployment from labour economics and an autoregressive model from econometrics by employing port potentials separately estimated in a Tobit model. The result indicates that port activities significantly reduce regional unemployment rates relative to the national level. The role of population, GDP and household income on unemployment rate was highlighted, whilst various determinants of port potentials were investigated on whether they stimulate port potentials.

KEYWORDS: seaports; employment; labour economics; South Korea

INTRODUCTION

Given the interwoven relationship between port and region, it may be difficult to argue that the port either solely determines the region's economy or that the region solely governs the port's vitalisation. The changing port-regional employment relationships and geography are highly related to wider processes of economic restructuring, the appearance of global chains as well as production networks (HALL and ROBBINS, 2007b). Although much literature has examined the impact of the port on its region's economy or on local employment, the link between them is still open to debate, providing a chance for further research (DUCRUET *et al.*, 2015). Some studies found that there are no strong relationships between the ports and cities. Although container volumes have increased in big cities globally over the last few decades, the correlation between container volumes and city size has considerably decreased because of regional competition and local constraints (DUCRUET and LEE, 2006). In other words, more dispersed hinterland areas act as a platform for production and consumption once the economic, infrastructural and institutional links between ports and cities have been untied, despite the fact that prior to containerisation, ports used to be closely related to an identifiable port-city and hinterland (HALL, 2008). Furthermore, DUCRUET (2009) claimed that the growth of traffic in the tertiary regions is higher than in industrial regions in advanced countries owing to globalisation. In this regard, HALL (2004) ascertained that some port studies may exaggerate the economic impact of ports.

Empirical research pertaining to the role of ports on local employment has been mostly investigated in the EU and US, and recently China and South Africa (e.g. MUSSO *et al.*, 2000; ACCIARO, 2008; HALL, 2008; FERRARI *et al.*, 2010; COTO-MILLAN *et al.*, 2010; HALL and JACOBS, 2010; BOTTASSO *et al.*, 2013; FAGEDA and GONZALEZ-AREGALL, 2014; SONG and VAN GEENHUIZEN, 2014). Since the economic and spatial development of ports varies between countries (e.g. developed vs developing; Western vs Eastern) (LEE *et al.*, 2008), the above previous port impact studies may be unable to universally reflect or explain the economic role of ports in South Korea (hereafter Korea).

The international trade of Korea has relied heavily on shipping, thereby resulting in importance of port cities such as Busan, Incheon and Gwangyang (DUCRUET *et al.*, 2012a). Busan port benefits from deep water, a large population and the government's active support, helping Busan to facilitate its city with the biggest port in Korea (FREMONT and DUCRUET, 2005). Busan had the main container and general cargo ports prior to Gwangyang port's emergence (FREMONT and DUCRUET, 2005). Incheon port has located adjacent to the DMZ (the Korean Demilitarised Zone), and with high tidal ranges and a lock gate system it has difficulty in nautical accessibility to accommodate large containerships (DUCRUET *et al.*, 2012a; FREMONT and DUCRUET, 2005). As for Gwangyang port, the government has attempted to develop it as a complex logistics hub by increasing cargoes, which can be derived from the manufacturing sectors such as the petrochemistry and steel-making industries.

Due to the increased necessity of systematic port policy implementation, the Korean government amended the port law in 1991, and adopted the 1st port master plan for the period between 1992-2001. The government expected a shortage of port facilities owing to a rapid increase of seaborne cargoes. Accordingly, it invested huge capital in port facilities, and induced port privatisation for improved efficiency. As for the 2nd port master plan for 2006-2011, the government anticipated fierce port competition in Northeast Asia, slowdown of the import/export cargo growth, and heightened uncertainty regarding transhipment cargoes. To cope with this circumstance, government policy pursued the development of the Northeast Asia logistics centric port, vitalisation of the port cluster, re-development of the old port, and expansion of cruise ports. Finally, the 3rd port master plan includes the improvement of port connectivity and hinterland connection, long-term cargo forecasts, port function re-configuration, port infra-and super-structure development and sustainable port-city development.

The ports in Korea have played a vital role in national and regional development. The ports have handled 99.8% of the import/export cargoes in Korea, which has a high level of dependence on exports (88% in 2010) (MOF, 2014). 27 of 40 national industrial complexes include ports or are located in the vicinity of the ports (MOF, 2014). Despite their important role to Korea's development and economies, there is little research that has examined the role of ports on local employment covering all the regions of Korea based on systematic and empirical evidence. Notably, DUCRUET *et al.* (2012a) examined Incheon's transformation from port gateway to global city by identifying the association between freight and urban development. They introduced Incheon's effort to facilitate freight transport and free economic zones, based on the concept of 'Pentaport'. Their study contribute to offering new knowledge about how Incheon as a port city has attempted to capture and plan the heightened and elaborated flows of goods in conjunction with the national level as a whole. FREMONT and DUCRUET (2005) revealed the emergence of a mega-port city with the case of Busan. Remarkably, they found that the development and challenges of Busan port is largely determined by local factors (e.g. local congestion, coexistence of port and urban function, port competition, government responses, governance, new infrastructures, etc). Meanwhile, Park and Seo (2016) have explored the generic economic impact of ports on the regions by employing the augmented Solow growth model in Korea. However, all these studies in the Korean context overlooked the role of ports on employment.

This paper fills that gap by utilising the theory of regional unemployment from labour economics in order to identify the impact of ports on employment, particularly its disparity against the national level. This study aims to examine the port's influence on regional employment in all the 16 regions, including seven metropolitan areas by using two empirical models, the economic model of unemployment expanded from a labour economics theory and the purely-empirical autoregressive model, on panel data between 2002 and 2013. Additionally, this study employs a Tobit model in order to examine the causation between a diverse range of port potentials antecedents and port potentials in a Korean context and also to derive estimated port potentials that represent true port activities behind observed but censored activities. By doing so, this paper reveals whether the existence of ports contributes to regional employment in Korea. Particularly, this paper focuses on testing two hypotheses: H1 Regional port activity lowers regional unemployment rates in Korea; H2 Population and household income are proportional to unemployment in the port regions of Korea, but GDP is negatively related in the port regions.

As for H1, it can be argued that the existence of the port fosters regional employment because it necessarily creates various jobs with the following related parties: terminal operator, shipping companies, ship's agent, freight forwarders, pilots, tug companies, mooring companies, state administration, warehouses, inland transport operators, ship management companies, third-party logistics service providers, ship-repair yards and so on. The activities of all those parties that are necessary for the operation and the use of port facilities will generate employment, wages and salaries, gross operation surplus and gross value added, all of which in turn affect the port-local community with a multiplier effect due to their spending (MUSSO *et al.*, 2000). This question tests the neoclassical port-city model to examine whether the presence of the port facilitates the development of regions via the use of the port, spending on relevant activities and generated income (FUJITA and MORI, 1996).

Regarding H2, the Blanchard and Katz model (BLANCHARD and KATZ, 1992), the most extensive theoretical model for regional unemployment differentials (ELHORST, 2003), argue that increasing labour supply (e.g. larger population), higher household income (e.g. higher wage) and decreasing labour demand (e.g. decreasing production) are positively associated with higher regional unemployment. These questions have been a central issue in the area of labour economics (ELHORST, 2003). However, these hypotheses were not empirically tested in the port-city context. The finding of this paper will be beneficial to port policy makers, regional planners and city planners. When they make an investment for the ports, they may refer to the results of the current study, implying that their spending on ports may facilitate regional employment and flow into the citizens' income.

The remainder of this study is as follows: Section 2 reviews relevant studies, whilst Section 3 explains the methodology this paper employed. Next, the empirical result is shown in Section 4. Finally, Section 5 displays the concluding remarks. Supplemental materials can be found in the online Appendix.

LITERATURE REVIEW

There is a lack of consensus about the definition of a port region, which makes it difficult to compare various contexts of port regions (DUCRUET, 2009). Port regions are varied in function and importance in accordance with the continental context and traffic (DUCRUET *et al.*, 2012b). DUCRUET (2009) noted that they are a multifaceted concept incorporating different realities such as the economic area around a port, the logistics area connecting the port (e.g. port hinterland) and the area where inter-port relationships take place (e.g. port ranges or port systems), or they can be ranged from a set of adjacent ports to the part of the hinterland with the most users of a given port (DUCRUET *et al.*, 2015). DUCRUET (2009, p. 43) regarded a port region "as a port system or a system of two or more ports (and terminals), located in proximity within a given area, where the given ports enjoy not only geographical proximity but also functional interdependence through sharing sea and land services". Notably, DUCRUET *et al.* (2012b) identified eight types of port regions via a non-hierarchical cluster analysis (on the basis of port throughput, population, unemployment, GDP, cargo specialisation, employment sectors): (1) deprived; (2) peripheral; (3) metropolitan; (4) industrial; (5) productive; (6) bulky; (7) transit; and (8) traditional port regions. In terms of the coverage of the port region, various academics have used different coverages. As for the current study, the definition of the port region (see Fig. A1) complies with the parameter of the administrative jurisdiction of each province where the port is located. This parameter might align with one of DUCRUET (2009)'s arguments that the port region is limited to the area where the economic impact of the port is dominant.

Meanwhile, some academics have extensively examined the relationship between ports and cities (DUCRUET and ITOH, 2015). From the perspective of port-cities, the functions of urban and port coexist in harmony and interdependence, and share mutual goals, in particular, for economic issues (LEE *et al.*, 2008). Port-cities, pursuing load centres, service centres and world port-cities, have attempted to lure maritime-related companies, since it may upgrade cities' economies and fortify ports' competitive position in the global supply chain (JACOBS *et al.*, 2010). In turn, cities can provide the port with port-promotion support, road transport infrastructure and port-related activities.

Some studies have argued that the direct impact of ports on economies and employment at the local level has been considerably reduced owing to shifts from local to global inputs, innovative cargo handling systems that reduce dependence on labour, re-location of former port-related industries, rise of production networks, port competition and reliance on the accessibility of inland transport networks (MUSSO *et al.*, 2000; HALL, 2007a). Today, the economic advantages of ports appear more valid at national and continent levels than at infra-national levels (DUCRUET *et al.*, 2014). DUCRUET and LEE (2006) found the weakening spatial fix at the global level by investigating the diminishing correlation between port throughput and the demographic size of the port city. Other studies uncovered the weakening relationship between port growth and urban growth (JACOBS *et al.*, 2010) or limited correlation between port traffic and the concentration of maritime firms in world port-cities (JACOBS *et al.*, 2011). Remarkably, DUCRUET *et al.* (2014) uncovered that the economic impact of the port on the region is varied according to the heterogeneous commodity flows. For the European case, they found that port regions involved in both the primary sector and agricultural commodities traffic have a sound economy, whilst the port regions based on both the industrial sector and liquid bulk commodities yield lower economy with high unemployment rates.

Sometimes, cargoes simply pass through the port without stimulating employment and economic rents. For example, empirical evidence from JO and DUCRUET (2007) showed that the ports in some regions act as a mere gateway, which mainly serves inland core economic regions, resulting in low local externalities. Besides, some cities or regions located far from ports may be able to benefit from port activities due to containerisation and lowered inland transport costs (BOTASSO *et al.*, 2013). In other words, the port region may be losing its conventional port functions, which are transferring toward new regions, which is known as 'de-maritimisation' (LEE *et al.*, 2008). Interestingly, DUCRUET and ITOH (2015, p.4) pointed out that "port throughput volumes increasingly were a function of the overall centrality port nodes in the global shipping network rather than a proxy for local economic activity, especially because many of these central nodes actually emerged in less urbanised places, to avoid congestion and allow for expansion on greenfield sites". Accordingly, the urbanised places may only possess a limited function of port activities such as advanced logistics function, and move the rest of the functions to remote ports (HAYUTH, 1981). On this point, LEE *et al.* (2008) noted that future growth or decline of the port may be determined by an ability to adapt to such changes.

It should be noted that the economic impacts of ports may be likely to expand from port regions towards the entire areas of port users, whilst the provision of port-related space, opportunity costs for land use and negative externalities such as congestion and pollution may remain spatially concentrated in the local regions (MUSSO *et al.*, 2000). Development of the port requires huge space from local areas, but sometimes global port operators who receive the land allocation at the port appear to be paid less than its opportunity cost, land consumption, traffic congestion, environmental issues and coast waste costs (BENACCHIO and MUSSO, 2001). Nevertheless, the impact of ports on local regions may still remain in the port regions. Also, the locations of ports often remain proximal to urban areas (DUCRUET *et al.*, 2015). The proliferation of the port-centric logistics philosophy may help to revitalise local economies and employment by bringing more manufacturers, logistics service providers, and warehouses into the vicinity of ports. Secondly, the major expenses related to port activities can be localised into the port regions (FERRARI *et al.*, 2006). Some large port-cities still try to maintain high degrees of port activities owing to the benefits levied by ports from urbanisation economies and the tertiary sector, notwithstanding all the physical obstacles of a dense urban environment (LEE *et al.*, 2008). In this regard, HALL and JACOBS (2012) argued that most of the world's important ports are still urban, which have advantages over non-urbanised areas in terms of luring and redirecting cargoes, even when these cargoes are destined for extended hinterlands.

Despite the importance of the impact of ports on local employment due to the existence of possible imbalances between local and global benefits, few studies have examined this issue. BOTTASSO *et al.* (2013) found port throughput considerably increases the employment of the host region for manufacturing sectors, with less noticeable effect on the service industry in ten West European countries. This was based on econometrics with the estimation of a set of employment equations, enabling the consideration of persistent effects on employment, regional unobserved time-invariant heterogeneity and endogeneity of port activity. They concluded that the impact of the port on local development is weakly affected by actual volume of maritime traffic. FERRARI *et al.* (2010) appraised the impact of port activity on the local development of employment in Italian provinces by adopting a propensity score methodology, assuming that port output is correlated with the level of employment in the corresponding province. They concluded that port traffic growth has only a limited impact on local employment growth. HALL (2008) examined the effect of container ports on local benefits and port-logistics workers in major US port-cities since 1975 from the perspective of labour economics. A difference-in-difference framework was employed to investigate the relative annual earnings of workers in the port, trucking and warehouse, and he found that special earnings advantage no longer exists in port-logistics jobs in the major container port-city regions. On the other hand, ACCIARO (2008) uncovered that the employment effect created by the port industry is higher in the regional economy than the total national one. FAGEDA and GONZALEZ-AREGALL (2014) discovered that the employment level in the manufacturing industry is higher in port regions in the case of Spain with the spatial Durbin model. Also, COTO-MILLAN *et al.* (2010) searched the impact of port infrastructure on economic growth and employment in Cantabria, Spain based on econometric techniques of co-integration that may be complementary to other methods such as input-output or cost-benefit analysis, and found that an increase in port capital stock results in growth in production and in regional employment. MUSSO *et al.* (2000) conducted a case study by estimating the employment impact of the port of Genoa, Italy on its regional economy. In order to examine whether the employment impact on the regions is completely or partially port oriented in terms of probability, they developed a new methodology based on location quotients and control regions. Although the aforementioned studies examined the role of ports on local employment, there is little research for Korea. This study employs a two-stage approach in empirical analysis. It first estimates a Tobit model to discover port potentials, and then uses a one-way fixed-effect model for the main analysis. The next section explains the main methodology.

METHODOLOGY

This study develops the economic theories of unemployment into testable models, which consider censored observations and dynamic relationships, to test the following hypotheses.

H1: *Regional port activity lowers regional unemployment rates in Korea;*

H2: *Population and household income are proportional to unemployment in the port regions of Korea, but GDP is negatively related in the port regions.*

This study addresses two main methodological limitations in the previous research. First, past studies did not utilise the development in the labour economics of regional unemployment when constructing an empirical model e.g. FERRARI *et al.* (2010). Second, the censoring issue in ports throughput was not tackled e.g., BOTTASSO *et al.* (2013) or truncation was caused otherwise by dropping non-observations e.g., ACCIARO (2008). The only exception is the study by FERRARI *et al.* (2010). However, they did not discuss the issue of censored regressors raised by RIGOBON and STOKER (2007) nor did they consider the dynamic relationship. Occasionally, other studies employ non-testable methods e.g., numerical ratio analysis or non-stochastic input-output analysis as in ACCIARO (2008).

Theory and empirical models

BLANCHARD and KATZ (1992)' seminal paper presents a system of four equations to explain unemployment disparities across regions using labour economics theories (Appendix B1 in the Supplemental data online). According to ELHORST (2003), this system can be solved for a long-run equilibrium unemployment rate (u_i^*) by assuming $u_i^* = u_{it} = u_{i,t-1}$ where u_{it} is the unemployment rate of region i in time t.

$$u_i^* = \frac{a}{a(bc+g)+bd-k} x_i^s - \frac{1}{a(bc+g)+bd-k} x_i^d + \frac{ac+d}{a(bc+g)+bd-k} x_i^w \tag{1}$$

where a, b, c, d, g and k are positive coefficients.

It can be seen that the regional unemployment rate is affected positively by non-wage labour supply determinants (x^s), negatively by non-wage labour demand determinants (x^d) and positively by wage-setting factors (x^w).

$$u_{it} = \beta_0 + \beta_1 x_{it}^s + \beta_2 x_{it}^d + \beta_3 x_{it}^w + \mathbf{x}_{\mathbf{it}}^{\mathbf{p}\prime} \boldsymbol{\gamma} + e_{it} \tag{2}$$

where $\mathbf{x^p}$ is a vector of exogenous port-activity variables and $\boldsymbol{\gamma}$ is a vector of coefficients.

The empirical null hypothesis is γ=0 and the alternative hypothesis is γ<0. The rejection of the null hypothesis will support that port activity reduces unemployment rates. The expected signs of β_1, β_2 and β_3 are positive, negative and positive, respectively.

Alternatively, the role of port activities can be examined in a dynamic model of unemployment. For example, BLANCHARD and KATZ (1992) used an autoregressive model of order 2, AR(2), assuming that all relevant information about labour supply, demand, wage and other activities are reflected in past unemployment rates. Port activities can be also added e.g. to an AR(2).

$$u_{it} = \beta_0 + \beta_1 u_{i,t-1} + \beta_2 u_{i,t-2} + \mathbf{x}_{\mathbf{it}}^{\mathbf{p}\prime} \boldsymbol{\gamma} + e_{it} \tag{3}$$

The null hypothesis is γ=0. Significantly negative γ would indicate that port activity reduces regional unemployment rates. β_1 and β_2 reflect the dynamics of unemployment over time.

Another important issue is how to deal with non-port regions that may have some potentials or constructed a port later in a sample period (e.g. BOTTASSO *et al.*, 2013). This occurs because the government may not allow port construction until 'port potentials' (FERRARI *et al.*, 2010) reach a certain threshold point. For example, the construction of ports may depend on a result of due-diligence of economic and social benefits. As a result, observed port activity data will be 'left-censored' although non-port regions may have the potential for port activities. This is similar to an unemployed worker with zero working hours but who may have the potential to work.

If port potential is a true and uncensored but latent variable behind observed port activity, it can be used as a regressor (x^p) in (2) and (3). Positive port potential can be interpreted as estimated port activities. Negative port potential means that the region is not ready to have a port, but its magnitude will change depending on the readiness of a region. Since less strongly negative port potential is a reflection of greater economic activities and better transport infrastructure, it can also explain varying regional unemployment.

An uncensored port potential potentially have higher explanatory power as a regressor since it maintains more information than a censored counterpart. Also, the adverse impact of a censored regressor cannot be ignored. First, removing censored observations reduces efficiency in estimation and possibly leads to a bias (RIGOBON and STOKER, 2009) since it causes truncation instead. Second, if censored observations are retained, estimates will be excessively large (RIGOBON and STOKER, 2009). Last, the use of a dummy is not generally advisable since no information is gained (RIGOBON and STOKER, 2007).

The estimation of an uncensored port potential requires a censored port activity as the dependent variable. However, a censored dependent variable alters the effective sample (RIGOBON and STOKER, 2007) and introduces distortion into statistical results (WOOLDRIDGE, 2013) when used in a linear model. Removing censored observations makes the sample not represent a whole population (GREEN, 2011) and thus provides biased estimates. A wide range of research on this issue (RIGOBON and STOKER, 2007) recommends the censored regression model, i.e. the Tobit model (GREEN, 2011).

Tobit models can address both observed but censored port activities and latent port potentials. Suppose one variable (x^p) represents port activities generated by the unobserved port potentials (x^{p*}) that are in turn decided by relevant determinants (x^L) (WOOLDRIDGE, 2013). Assuming the zero threshold point, the Tobit model is:

$$x_{it}^{p} = x_{it}^{p*} \quad \text{if } x_{it}^{p*} > 0 \qquad (4)$$
$$x_{it}^{p} = 0 \quad \text{if } x_{it}^{p*} \leq 0$$

and

$$x_{it}^{p*} = \alpha_0 + \mathbf{x}_{\mathbf{it}}^{\mathbf{L}\prime}\boldsymbol{\alpha} + \epsilon_{it} \qquad (5)$$

where $\mathbf{x}^{\mathbf{L}}$ is a vector of the determinants of port potentials, $\boldsymbol{\alpha}$ is a vector of coefficient and ε is the error term following $N(0, \sigma^2)$.

In this study, the Tobit model, equations (4) and (5), will be first estimated using the maximum likelihood estimation method (Appendix B2) to generate port potentials (x_p^*). Then, they will be used as a proxy for port activities (x^p) in equations (2) and (3).

Data

The data was obtained from the Korean Statistical Information Service operated by the Korean National Statistical Office and the Shipping and Port Integrated Data Centre managed by the Ministry of Oceans & Fisheries of Korea (MOF). Additionally, the port investment data was obtained from a public officer of MOF in person, because it is publicly unavailable. The data comprised of yearly regional data between 2002 and 2013 and has been summarised in Table A1 (Appendix A in the Supplemental data online). Korea has 16 regions including 7 metropolitan areas (ID 1 to 7). It connects to land only to the north (Fig. A1), and most of the regions have coastlines except region ID 1,3,5,6, and 10.

The sample period was chosen based on three reasons. First, Chungnam region built container ports in 2007 and Gyeongi region constructed cargo and container ports in 2012. Thus, their impacts on regional economic activities can be more easily identified. Second, the trends of economic indicators in the period may signal the significant role of regional ports on unemployment. For example, the growth rate of GDP per capita (Fig. A2) decreased overall while cargo and container throughputs (Fig. A4) rapidly increased over the sample period. It may have helped the regional unemployment rates (Fig. A3) to remain relatively stable. Last, the recent data set is supplied by the government agencies after their initiatives of providing consolidated and verified data through public platforms as described above.

Population and economic activities (Table A1) are concentrated in Seoul and the surrounding regions (ID 1, 4 and 8). The unemployment rate of Korea (Table A2) was 3.05%, on average. The regional average lies between 1.99% and 4.40%. Unemployment rates also vary over time (Fig. A3). Port activities of Korea are overall large but relatively concentrated on 4 major port regions (Table 1), Busan (ID 2), Incheon (4), Ulsan (7) and Jeonnam (13). Surface transportation infrastructure is less varied and more reflects the relative size of regions. Note that Jeju region (16) does not have motorways. Both cargo and container throughputs grow fast in the sample period (Fig. A4).

Table 1. Port activities and surface transportation of the regions of Korea.

	Cargo throughput		Container throughput		Major ports	Road		Motorway	
	Ton		ton			meter		meter	
ID	Average	2013	Average	2013	All	Average	2013	Average	2013
1	0	0	0	0	N	8,114,579	8,222,892	24,108	24,960
2	26,098,708	25,198,422	217,216,563	299,659,802	Y	2,899,115	3,101,223	37,663	51,660
3	0	0	0	0	N	2,321,334	2,626,578	93,160	97,560
4	151,630,127	109,587,483	28,098,578	37,044,525	Y	2,359,977	2,742,786	87,004	100,330
5	0	0	0	0	N	1,464,725	1,806,104	22,414	26,370
6	0	0	0	0	N	1,787,300	2,077,485	73,144	76,140
7	165,545,202	185,661,798	4,826,881	5,368,975	Y	1,822,469	1,759,781	52,411	62,840
8	16,160,375	101,126,796	1,336,574	8,124,500	N	12,802,015	12,823,774	523,347	669,270
9	38,613,826	43,745,409	78,710	41,629	N	9,393,410	10,147,244	310,296	348,840
10	0	0	0	0	N	6,581,056	6,577,856	280,776	342,840
11	78,888,004	95,917,164	345,001	935,047	N	7,508,336	7,415,156	356,430	448,520
12	16,500,283	17,936,448	864,932	674,357	N	7,540,365	8,040,244	344,919	423,360
13	188,950,862	225,811,638	26,462,404	37,393,985	Y	10,144,953	10,532,353	272,308	414,600
14	59,110,833	60,135,710	449,663	1,511,110	N	11,879,360	12,290,296	459,192	535,550
15	44,770,371	60,906,389	408,782	45,887	N	12,281,394	13,053,403	461,315	488,650
16	2,243,458	2,292,757	454,709	587,186	N	3,173,754	3,196,366	0	0
Sum	788,512,048	928,320,014	280,542,797	391,387,003	4	102,074,143	106,413,541	3,398,487	4,111,490

Note: Gyeongi region (8) built cargo and container ports in 2012. Chungnam (11) constructed container ports in 2007. 'Major ports' indicates regions with top 4 largest ports in terms of total throughput.

Port activity is not observed in some regions as seen in Table 1, Fig. A5 and A6. Specifically, 5 of 16 regions have zero port activity in the entire sample period and two additional regions partly showed zero activity. Also, 70 and 80 individual observations of cargo and container activities are zero (Fig. A7 and A8), respectively. This is typical of left-censored data with non-trivial fraction being censored since zero activity was indeed observed and reported, which supports the use of Tobit models.

For the empirical unemployment models in equations (2) and (3), relative unemployment rates will be used as the dependent variable following BLANCHARD and KATZ (1992). A national average of unemployment rates of each year is deducted from regional unemployment rates to calculate the relative rates and control for the national trend in unemployment. Regarding three independent variables in the economic model, first, labour supply is represented by population size since the impacts of other candidates such as participation, migration and commuting are not clearly agreed upon in the literature (ELHORST, 2003). Second, labour demand is approximated by gross regional domestic production (GRDP) since higher economic production essentially requires more workers. Third, wage is represented by household income supposing that most of household income is paid in the form of wage.

For the Tobit model in equations (4) and (5), cargo throughput and container throughput are separately tested. The former represents more traditional port activities such as handling of bulk (wet and dry) cargoes, whilst the latter is the output of capital-intensive modern port activities such as handling of twenty or forty feet standardised containers. Thus, their impacts on unemployment can be different. Passenger traffic data was intentionally excluded since a considerable share of passenger traffic tends to be related to transit passengers (BOTTASSO *et al.*, 2013). On the other hand, the length of road and motorway control the effects of other transportation networks, because these transport infrastructures may positively or negatively affect port potentials. For example, a well-developed regional motorway network may either reduce the need for a port or facilitate port construction and development. In addition, four different dummies are used: major ports, major cargo and container ports and one for the regions near Seoul that accounts for their asymmetric presence in the Korean economy. Port infrastructure variables, e.g., the size of berth and yard, are not employed since they may not represent port potentials of non-port regions.

RESULTS

Tobit model of port potentials – equation (4) and (5)

The descriptive statistics of two port activity variables (x^p) and two determinants of port potentials (x^L) are presented in Table A3. A strong correlation between cargo and container throughputs should not be a concern since they are separately estimated. None of the series have a unit root and thus spurious regression would not happen.

Granger causality tests (Table A4) justify the causation implied in the Tobit model since road length significantly leads to cargo throughput and just marginally insignificantly causes the changes in container throughput at the 10% significance level. However, motorway does not have any causal relationship. On the other hand, the strong role of cargo throughput in causing container throughput may be the result of traditional port activities leading to modern activities.

The estimation results of the Tobit models with cargo throughout (Table 2) confirm the general significance of independent variables. For example, road length positively affects cargo port potentials. However, motorway length negatively or does not affect them. The models with container port activities (Table 3) show similar results with slightly different significance. This result confirms the difference of traditional port activities and infrastructure (cargo ports and road) from capital-intensive ones (container ports and motorway) in determining port potentials. On the other hand, the positive impact of major port dummies may reflect the relative size of the four largest ports. Being a capital or its neighbourhood reduces port potentials. Although this may be country-specific since the Korean capital, Seoul is located inland, near Incheon port. It indicates that proximity to economic activities is important in deciding port potentials.

Table 2. Tobit models of port potentials: cargo throughput.

Variable		Model 1	Model 2	Model 3	Model 4
Constant	coef	-66.6525 ***	-139.7813 ***	-138.6636 ***	-109.8854 ***
	s.e.	*20.2687*	*19.3657*	*16.7517*	*18.5737*
	p value	0.0010	0.0000	0.0000	0.0000
Road length	coef	5.2268 ***	10.0604 ***	10.0651 ***	8.1141 ***
	s.e.	*1.3882*	*1.3095*	*1.1348*	*1.2651*
	p-value	0.0002	0.0000	0.0000	0.0000
Motorway length	coef	-0.4989	-1.0442 ***	-0.9561 ***	-0.9312 ***
	s.e.	*0.3231*	*0.2571*	*0.2257*	*0.2718*
	p-value	0.1226	0.0000	0.0000	0.0006
Major ports	coef		18.9332 ***	19.3898 ***	
	s.e.		*1.9056*	*1.6851*	
	p-value		0.0000	0.0000	
Major cargo ports	coef				12.8143 ***
	s.e.				*2.4297*
	p-value				0.0000
Major container ports	coef				6.7638 ***
	s.e.				*2.3099*
	p-value				0.0034
Regions near Seoul	coef			-10.5650 ***	
	s.e.			1.7183	
	p-value			0.0000	
Log likelihood		-543.7265	-496.3206	-477.9046	-509.6191
Schwarz criterion		5.7733	5.3069	5.1425	5.4728

Note: ‘Major cargo ports’ is a dummy for Incheon (ID 4), Ulsan (7) and Jeonnam (13) and ‘Major container ports’ is a dummy for Busan (ID 2), Incheon (4) and Jeonnam (13). coef is the values of the coefficients of the regression models. *** indicates significance at 1% level.

Table 3. Tobit model of port potentials: container throughput.

Variable		Model 1	Model 2	Model 3	Model 4
Constant	coef	-26.3857	-100.2482 ***	-99.9061 ***	-66.2161 ***
	s.e.	19.5307	16.0576	14.6189	15.9480
	p-value	0.1767	0.0000	0.0000	0.0000
Road length	coef	2.4999 *	7.3889 ***	7.4135 ***	5.1473 ***
	s.e.	1.3379	1.0850	0.9892	1.0863
	p-value	0.0617	0.0000	0.0000	0.0000
Motorway length	coef	-0.6300 **	-1.1480 ***	-1.0878 ***	-1.0144 ***
	s.e.	0.3111	0.2096	0.1931	0.2338
	p-value	0.0429	0.0000	0.0000	0.0000
Major ports	coef		19.4074 ***	19.7367 ***	
	s.e.		1.5818	1.4684	
	p-value		0.0000	0.0000	
Major cargo ports	coef				9.7514 ***
	s.e.				2.0846
	p-value				0.0000
Major container ports	coef				10.7202 ***
	s.e.				1.9799
	p-value				0.0000
Regions near Seoul	coef			-6.8804 ***	
	s.e.			1.4712	
	p-value			0.0000	
Log likelihood		-503.5252	-437.3550	-426.3375	-457.3601
Schwarz criterion		5.3546	4.6927	4.6053	4.9285

Note: ***,** and * indicate significance at 1%, 5% and 10% levels, respectively.

In both results, Model 3 is the best fit with the lowest Schwarz Information Criterion. The estimated port potentials are calculated from this and used as proxies for port activity variables in the next section. Their descriptive statistics are summarised in Table A5. Strong correlation indicates that two types of port potentials are more closely linked than observed between port activities.

On the other hand, maximum port potentials are larger than observed port activities. It possibly shows that some regions do not fully realise port potentials. Also, it could indicate that right-censoring, i.e. censoring from above, may have affected the observed port activities possibly due to physical limitation e.g. handling capacity. However, no distinctive threshold where a large proportion of right-censored values are located is found in Fig. A5 and A6. Although an artificial censoring limit can be set at or above the maximum observed value, it may invalidate estimation results by affecting conditional means and residuals.

Models of unemployment – equation (2) and (3)

The four economic variables (Table A6) are measured against national average (unemployment rate) or aggregates (population, GDP and household income) following BLANCHARD and KATZ (1992) to control nation-wide economic shocks. High correlation exists between population, GDP and household income as expected from economic variables. However, no corrective measures are introduced because all variables are supported by economic theories and correlation itself does not cause a bias in estimation. Table A7 shows that three independent variables Granger-cause unemployment rates at the 10% significance level. They support the specification of the economic model of unemployment in equation (2).

Finally, the economic models of unemployment are estimated (Table 4). First, cargo port activities significantly reduce unemployment rates. 1% more cargo throughput (in ton) reduces the unemployment rate by 0.08% points relative to the national level. The impact seems quite substantial considering the already low and stable employment rate of Korea (Fig. A3) and fast-growing port activities (Fig. A4). For example, 25% relative increase of cargo throughput over 10 years contributes to a 2% point total decrease or 0.2% point annual decrease in the relative unemployment rate.

Second, capital-intensive container port activities are not able to reduce unemployment rate unlike labour-intensive cargo port activities. Third, the impacts of population and GDP are as expected in economic theories, but only population is statistically significant. Last, the negative relationship of income to unemployment, although not significant with cargo throughput, is consistent with the literature since higher wages may be paid as compensation for higher living costs in more prosperous regions (ELHORST, 2003).

Table 4. Economic model of unemployment rates and port activities.

		Port potentials		Actual handling (non-Tobit)	
Variable		Cargo	Container	Cargo	Container
Constant	coef	0.0300	0.0589 **	0.0418	0.0462 *
	s.e.	0.0304	0.0254	0.0322	0.0253
	p-value	0.3255	0.0212	0.1961	0.0695
Port activities	coef	-0.0008 **	0.0000	-0.0001	0.0003 ***
	s.e.	0.0003	0.0001	0.0001	0.0001
	p-value	0.0128	0.7479	0.4954	0.0059
Population	coef	0.0345 **	0.0474 ***	0.0427 ***	0.0503 ***
	s.e.	0.0140	0.0135	0.0142	0.0133
	p-value	0.0144	0.0006	0.0030	0.0002
GDP	coef	-0.0092	-0.0029	-0.0074	-0.0105
	s.e.	0.0065	0.0067	0.0066	0.0070
	p-value	0.1612	0.6637	0.2662	0.1363
Income	coef	-0.0174	-0.0250 **	-0.0217 *	-0.0236 *
	s.e.	0.0123	0.0126	0.0124	0.0124
	p-value	0.1595	0.0491	0.0819	0.0585
Log likelihood		848.1052	953.0903	844.8983	957.2064
Schwarz criterion		-8.2868	-8.0266	-8.2534	-8.0633

Note: 'Actual handing' column contains the estimation results of the model with actual handling data without using Tobit models. 'Cargo' and 'Container' indicate whether port activities are represented by cargo or container port potentials. One-way cross-section (region) fixed-effect models are used based on the redundant fixed-effect tests and the Hausman tests.

The estimation results of the autoregressive models of unemployment in equation (3) in Table 5 strongly support the findings in Table 4. The port potentials in terms of both cargo and container throughputs even more significantly decrease relative regional unemployment rates. The estimated impacts become slightly smaller with cargo throughput but larger with container throughput. Specifically, 1% higher cargo and container port potentials are associated with 0.05% and 0.08% point lower relative regional unemployment rates, respectively.

Table 5. Autoregressive model of unemployment rates and port activities.

		Port potentials		Actual handling (non-Tobit)	
Variable		Cargo	Container	Cargo	Container
Constant	coef	0.0045 *	0.0045 **	0.0005	-0.0011 *
	s.e.	0.0023	0.0022	0.0013	0.0007
	p-value	0.0562	0.0405	0.6868	0.0882
Port activities	coef	-0.0005 *	-0.0008 **	0.0000	0.0001 *
	s.e.	0.0003	0.0004	0.0001	0.0001
	p-value	0.0553	0.0398	0.6834	0.0741
Unemployment	coef	0.5883 ***	0.5856 ***	0.6126 ***	0.6033 ***
rates_{t-1}	s.e.	0.0781	0.0780	0.0778	0.0773
	p-value	0.0000	0.0000	0.0000	0.0000
Unemployment	coef	-0.1617 **	-0.1600 **	-0.1620 **	-0.1782 **
rates_{t-2}	s.e.	0.0680	0.0680	0.0691	0.0685
	p-value	0.0186	0.0197	0.0203	0.0101
Log likelihood		873.2279	873.5377	871.2771	872.9602
Schwarz criterion		-8.5759	-8.5791	-8.5555	-8.5731

Note: The lag length of unemployment rates is determined by Schwarz criterion. One-way cross-section (region) fixed-effect models are used based on the redundant fixed-effect tests and the Hausman tests.

On the other hand, the benefits of using uncensored port potentials against censored actual handling data (non-Tobit) are clearer when the results are compared between left- and right-panels in Table 4 and 5. The negative relationship between the port activities and regional unemployment rates is observed only with port potentials in both of the economic and the autoregressive models. Also, port potentials contribute to the greater explanatory power of the models in terms of larger log likelihood and lower information criteria values, except in the economic model with container data.

Robustness tests

The impact of port activities should be still significant even after adding new independent variables. First, the number of university graduates is for the quality of the workforce. Second, the number of patents represents the level of technology. Last, the amount of port investment is for related government expenditure. They are all measured relative to national aggregates and in logarithm. Three variables are tested in both models of unemployment (Table A8 and A9). The results support the findings in this study.

CONCLUDING REMARKS

This study examined the port's influence on local employment in all the 16 regions of Korea by using the economic model of unemployment from labour economics and the pure-empirical autoregressive model on panel data between 2002 and 2013. In addition, this study employed Tobit models in order to estimate unobservable port potentials using relevant determinants, which also overcome the issue of censored port activity data.

The result indicates that port activities, represented by port potentials from the Tobit models, statistically significantly reduce the regional unemployment rates of Korea where unemployment rates were already low and stable. It would be plausible that the results are treated as an estimation of the port's total impact on local employment (as a sum of the direct, indirect and induced employment). In the economic model, which controls for labour supply, demand and wage, the impact of cargo port activities is estimated to be a 0.08% point reduction in unemployment rate relative to the national level per 1% more cargo throughput. For example, if cargo throughput increases by 25% over 10 years, it will contribute a total 2% point or annually 0.2% point lower relative unemployment rate. In the autoregressive models, it is a 0.05% point lower unemployment rate per 1% increase in cargo throughput. On the other hand, the effects of capital-intensive container port activities are not significant in the economic models. However, the autoregressive models, which control for entire non-port activities, show their impact reaches a 0.08% point lower relative unemployment rate per 1% more container throughput. This result is consistent with FAGEDA and GONZALEZ-AREGALL (2014)'s finding that employment in the manufacturing sector is positively affected by the availability of transport infrastructure such as ports. It should be noted that some prior studies found higher unemployment near the port in US (GROBAR, 2008). These conflicting results might be attributed to a fact that the impacts of ports varies according to geographic scale, context, space and time (HALL, 2004).

The findings of the significance of the port activities in unemployment are robust in more general specifications when tested with other economic variables that represent the quality of the labour force, the amount of port investment, and the level of technology. The former two variables are not significant in the extended models, but the level of technology significantly increases unemployment. Although some studies empirically found port investment to have a positive impact on economic growth (SONG and VAN GEENHUIZEN, 2014), counter-intuitively, our result shows that there is no positive impact of port investment on unemployment level. A viable explanation would be that the port investment stimulates employment in terms of a port construction or facility expansion in the short term. In turn, it affects the port-cities' employment and production costs in the long term. It seems that the influence of the port investment on unemployment level might be mediated by other factors (e.g. port-related logistics activities or actual employment for port-related jobs). Alternatively, it may show that port potentials are technically inclusive of port investment.

In the Tobit model, it is discovered that the road length has a positive impact on port potentials, whereas motorway length negatively or does not affect cargo port potentials. In general, well-developed land transport infrastructure helps the occurrence of regional economic growth via enhanced accessibility for multi-modal transport chains. However, our result indicates that this land transport infrastructure does not necessarily stimulate port potential. The possible explanation would be that motorway networks might decrease the need for cargo ports, because the well-structured motor networks may encourage shippers or logistics service providers to use other transport modes (e.g. inland transport). Regardless of the findings from the main analysis, it is worth noting here that the transport of cargoes in Korea significantly relies on trucking, rather than the short-sea shipping or rail. Accordingly, traffic congestion has been prevalent. The Busan port (and city) especially suffers severe and chronic traffic congestion (FREMONT and DUCRUET, 2005) even after the opening of

Busan New port. Therefore, Busan port authority has tried to alleviate this issue by constructing wider roads to and from the port. To solve this issue in a sustainable way in the long term, the central government keeps encouraging the use of short-sea shipping and rail for domestic transportation of the cargoes.

Finally, the finding indicates that in general, ports located in Busan, Incheon, Jeonnam, Ulsan, and near-Seoul regions have a competitive advantage in terms of cargo and container throughput over other ports. Such regions are regarded as relatively developed urban areas in terms of the economies in Korea.

The results of this study deserve attention from port policy decision makers in order to take advantage of the existence of the port for higher level of employment, since the finding suggests that the role of ports on local employment appears to be positive. Accordingly, their appropriate decision regarding port development may lead to low unemployment rates, which are indeed beneficial to port-cities.

Despite its implications, this study has some limitations. Firstly, a lack of the same data set does not allow us to conduct useful comparisons between countries (e.g. Japan or China). Accordingly, this needs further investigation in future research. Secondly, ports can generate both positive and negative impacts on corresponding regions, so estimating *ex post* equilibrium between them would be interesting. Thirdly, in terms of methodology, the dynamic relationship between regions such as spill-over effects is not fully examined although autoregressive models are used. This may require the use of multivariate autoregressive models in future data analysis. Finally, future studies could employ the Free Economic Zone (FEZ) as well as various types of zones as a possible control variable, because such various zones may help explain the port potentials. Note also that there are many other types of zones such as Free Economic Zone (FEZ), Free Trade Zone (FTZ), Foreign Exclusive Industrial Complex (FEIC), Customers/Tariff Free Zone (CFZ/TFZ), and Foreign Investment Zone (FIZ) in Korea (for details, see DUCRUET, 2007; INVESTKOREA, 2016).

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Appendix A

Table A1. Basic statistics of the regions of Korea.

ID		Area	Near Seoul	Population		Gross regional domestic production (GRDP)		Gross household income	
		km²		Capita		1m Won		1m Won	
		2013		Average	2013	Average	2013	Average	2013
1	Seoul	605	Y	10,200,507	10,143,645	255,784,446	320,230,208	152,712,766	188,697,379
2	Busan	770	N	3,601,520	3,527,635	57,195,863	69,986,887	44,059,554	57,086,416
3	Daegu	884	N	2,507,452	2,501,588	35,029,272	44,845,694	29,859,579	38,472,740
4	Incheon	1,041	Y	2,691,923	2,879,782	51,384,371	64,677,934	31,085,179	42,905,244
5	Gwangju	501	N	1,427,828	1,472,910	22,668,759	29,646,229	17,079,215	22,312,645
6	Daejeon	540	N	1,477,794	1,532,811	24,161,056	32,229,626	18,310,677	24,161,137
7	Ulsan	1,061	N	1,107,691	1,156,480	52,636,923	67,701,404	17,111,585	22,158,374
8	Gyeongi	10,173	Y	11,175,962	12,234,630	223,857,048	313,243,261	139,714,345	187,616,681
9	Gangwon	16,830	N	1,523,172	1,542,263	27,395,522	34,789,957	16,798,896	21,124,279
10	Chungbuk	7,407	N	1,521,593	1,572,732	33,727,341	46,735,318	17,686,313	22,914,576
11	Chungnam	8,670	N	2,020,928	2,169,784	66,350,353	97,183,921	23,604,445	32,589,346
12	Jeonbuk	8,066	N	1,885,881	1,872,965	32,020,437	42,252,801	21,348,456	27,222,040
13	Jeonnam	12,304	N	1,948,309	1,907,172	50,090,640	61,095,327	20,989,830	25,800,490
14	Gyeongbuk	19,029	N	2,696,887	2,699,440	69,334,608	88,552,710	31,048,252	38,834,913
15	Gyeongnam	10,537	N	3,222,113	3,333,820	75,679,128	101,015,865	38,408,808	49,155,539
16	Jeju	1,849	N	565,169	593,806	9,665,784	13,113,512	6,902,689	9,288,566
	Sum	100,267		49,574,729	51,141,463	1,086,981,549	1,427,300,654	626,720,587	810,340,367

Table A2. Regional statistics of unemployment of Korea.

ID	Economically active population		Unemployed		Unemployment rate		Relative unemployment rate	
	000		000		decimal		decimal	
	Average	2013	Average	2013	Average	2013	Average	2013
1	3,103.4	3,213.0	225.9	209.9	0.0440	0.0396	0.0134	0.0116
2	1,229.3	1,236.3	66.9	65.7	0.0398	0.0384	0.0092	0.0105
3	813.4	836.5	47.3	41.2	0.0390	0.0333	0.0084	0.0054
4	805.0	858.7	59.1	62.7	0.0442	0.0417	0.0137	0.0138
5	473.5	513.3	24.7	21.0	0.0374	0.0288	0.0068	0.0009
6	482.7	516.7	27.0	23.3	0.0382	0.0307	0.0077	0.0028
7	343.1	371.9	16.4	11.8	0.0309	0.0212	0.0004	-0.0067
8	3,403.3	3,815.5	192.2	183.9	0.0347	0.0298	0.0041	0.0019
9	491.3	533.2	13.9	16.8	0.0201	0.0235	-0.0104	-0.0044
10	480.8	505.9	16.8	16.4	0.0232	0.0207	-0.0073	-0.0072
11	568.6	641.3	25.6	32.8	0.0255	0.0280	-0.0050	0.0001
12	590.0	613.9	19.7	17.5	0.0231	0.0196	-0.0075	-0.0083
13	518.5	548.4	19.0	19.6	0.0202	0.0210	-0.0103	-0.0069
14	771.8	815.7	34.3	44.7	0.0245	0.0313	-0.0060	0.0033
15	962.8	1,050.2	37.3	34.0	0.0241	0.0206	-0.0064	-0.0073
16	134.6	151.9	5.8	5.7	0.0199	0.0184	-0.0107	-0.0095
Average	948.3	1013.9	52.0	50.4	0.0305	0.0279	0.0000	0.0000

Note: 'Economically active' means either employed or actively seeking jobs. Unemployment rate is calculated as the unemployed divided by economically active population. Relative unemployment rate is measured against national average.

Table A3. Descriptive statistics of port activity variables and the determinants of port potential.

	Cargo throughput	Container throughput	Road	Motorway
Unit	ln(ton)	ln(ton)	ln(meter)	ln(meter)
Mean	11.2048	8.4805	15.4114	11.1105
Median	17.0357	11.5510	15.7152	11.9202
Maximum	19.2382	19.5182	16.4165	13.4139
Minimum	0.0000	0.0000	13.9969	0.0000
Standard deviation	8.5691	7.4933	0.7677	3.0695
Correlation				
Cargo throughput	1.0000	0.8605	0.2440	0.0277
Container throughput	0.8605	1.0000	0.0451	-0.0993
Road	0.2440	0.0451	1.0000	0.4019
Motorway	0.0277	-0.0993	0.4019	1.0000
Unit Root[1]	0.0610	0.0000	0.0000	0.0546

Note: [1]p values are obtained from Levin, Lin and Chu t tests. The null hypothesis (H_0) assumes the existence of unit roots.

Table A4. Pairwise Granger causality tests: port potential variables.

Null hypothesis (H_0)	p-value
Container throughput does not Granger Cause Cargo throughput	0.9993
Cargo throughput does not Granger Cause Container throughput	0.0005
Road length does not Granger Cause Cargo throughput	0.0815
Cargo throughput does not Granger Cause Road length	0.5845
Motorway length does not Granger Cause Cargo throughput	0.4031
Cargo throughput does not Granger Cause Motorway length	0.3079
Road length does not Granger Cause Container throughput	0.1174
Container throughput does not Granger Cause Road length	0.2791
Motorway length does not Granger Cause Container throughput	0.4274
Container throughput does not Granger Cause Motorway length	0.4243
Motorway length does not Granger Cause Road length	0.8217
Road length does not Granger Cause Motorway length	0.8624

Note: p-values (probability values) lower than 0.05 and 0.1 reject the null hypothesis at 5% and 10% significance level, respectively.

Table A5. Descriptive statistics of port potentials from Tobit models.

	Cargo port potentials	Container port potentials
Unit	ln(ton)	ln(ton)
Mean	8.6977	5.9035
Median	8.6820	4.2603
Maximum	31.3597	26.0841
Minimum	-7.0793	-6.8160
Standard Deviation	9.1470	8.4004
Correlation		
Cargo	1.0000	0.9624
Container	0.9624	1.0000
Unit root	0.0000	0.0000

Table A6. Descriptive statistics of economic variables: regional average relative to national level.

	Unemployment rate	Population	GDP	Household income
unit	*1*	*2*	*2*	*2*
Mean	0.0000	-3.0778	-3.1166	-3.1194
Median	-0.0019	-3.2099	-3.0643	-3.3287
Maximum	0.0185	-1.4303	-1.3782	-1.3762
Minimum	-0.0174	-4.4825	-4.7737	-4.5574
Standard deviation	0.0092	0.7284	0.7918	0.7562
Correlation				
Unemployment rate	1.0000	0.4691	0.3468	0.5032
Household income	0.5032	1.0000	0.9381	0.9924
GDP	0.3468	0.9227	1.00000	0.9381
Population	0.4691	0.9924	0.9227	1.0000
Unit Root	0.0012	0.0000	0.0105	0.0000

Note: [1]Unemployment rates are measured as (regional rates - national rates) at time t. [2]Household income, GDP and population are measured as (log(regional level) - log(aggregate level)) at time t, so they are negative values

Table A7. Pairwise Granger causality tests: economic variables.

Null hypothesis (H_0)	p-value
Income does not Granger Cause Unemployment rate	0.0460
Unemployment rate does not Granger Cause Income	0.0627
GDP does not Granger Cause Unemployment rate	0.0874
Unemployment rate does not Granger Cause GDP	0.1652
Population does not Granger Cause Unemployment rate	0.0582
Unemployment rate does not Granger Cause Population	0.1928
GDP does not Granger Cause Income	0.6128
Income does not Granger Cause GDP	0.2244
Population does not Granger Cause Income	0.6281
Income does not Granger Cause Population	0.0043

Table A8. Economic model of unemployment rates and port activities: robustness test.

This table summarises the results with the economic model of unemployment when three new variables are added. Port activities are still significant with cargo port activities and to an even stronger degree with container port activities. The number of patents is the only significant newly-added variable. Its positive impact on unemployment indicates more advanced technological decreases labour demand. This finding supports the results in Table 4.

Variable		Cargo	Container
Constant	coef	0.0440	0.0439
	s.e.	0.0305	0.0304
	p-value	0.1513	0.1509
Port activities (cargo or container)	coef	-0.0008 **	-0.0011 ***
	s.e.	0.0003	0.0004
	p-value	0.0156	0.0091
Population	coef	0.0425 ***	0.0437 ***
	s.e.	0.0163	0.0162
	p-value	0.0100	0.0078
GDP	coef	-0.0129 *	-0.0134 **
	s.e.	0.0066	0.0066
	p-value	0.0505	0.0430
Income	coef	-0.0276 **	-0.0280 **
	s.e.	0.0132	0.0132
	p-value	0.0384	0.0350
Graduates	coef	0.0064	0.0061
	s.e.	0.0049	0.0049
	p-value	0.1932	0.2173
Patents	coef	0.0018 **	0.0017 **
	s.e.	0.0008	0.0008
	p-value	0.0300	0.0357
Port investment	coef	0.0009	0.0009
	s.e.	0.0006	0.0006
	p-value	0.1448	0.1493
Log likelihood		853.0359	853.5806
Schwarz criterion		-8.2560	-8.2617

Table A9. Autoregressive model of unemployment rates and port activities: robustness test.

This table summarises the results with the autoregressive model of unemployment when three new variables are added. All of the newly-added variables are insignificant while the significance of port activities is maintained. This also supports the findings in Table 5.

Variable		Cargo	Container
Constant	coef	0.0181	0.0173
	s.e.	0.0140	0.0139
	p-value	0.1966	0.2152
Port activities (cargo or container)	coef	-0.0005 *	-0.0007 *
	s.e.	0.0003	0.0004
	p-value	0.0915	0.0707
Unemployment rate$_{t-1}$	coef	0.5756 ***	0.5743 ***
	s.e.	0.0795	0.0794
	p-value	0.0000	0.0000
Unemployment rate$_{t-2}$	coef	-0.1711 **	-0.1690 **
	s.e.	0.0690	0.0689
	p-value	0.0141	0.0153
Graduates	coef	0.0029	0.0028
	s.e.	0.0040	0.0040
	p-value	0.4715	0.4953
Patents	coef	0.0002	0.0002
	s.e.	0.0007	0.0007
	p-value	0.7218	0.7920
Port investment	coef	0.0006	0.0006
	s.e.	0.0005	0.0005
	p-value	0.2747	0.2794
Log likelihood		874.1820	874.4201
Schwarz criterion		-8.5036	-8.5061

Fig. A1. Sampled regions of Korea.

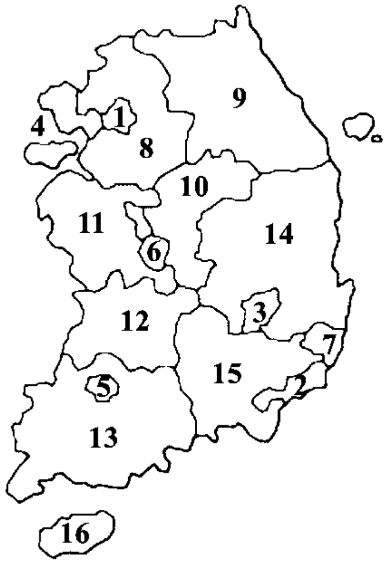
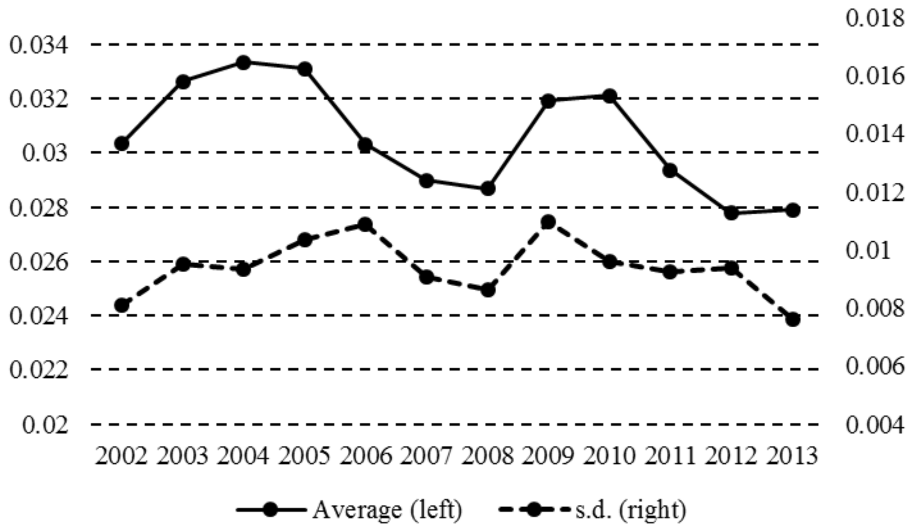


Fig. A2. Growth rate of GDP per capita of Korea: 2002-2013.

Fig. A3. Unemployment rates in Korea: 2002-2013.



Note: 'Average' is the regional average unemployment rates and 's.d.' is their standard deviations.

Fig. A4. Cargo and container throughputs in Korea: 2002-2013.

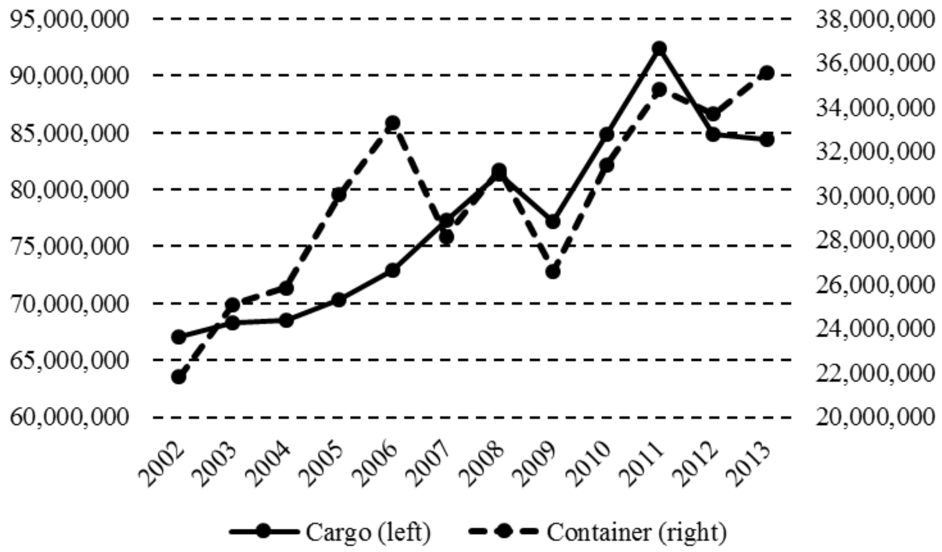


Fig. A5. Regional average of cargo throughput.

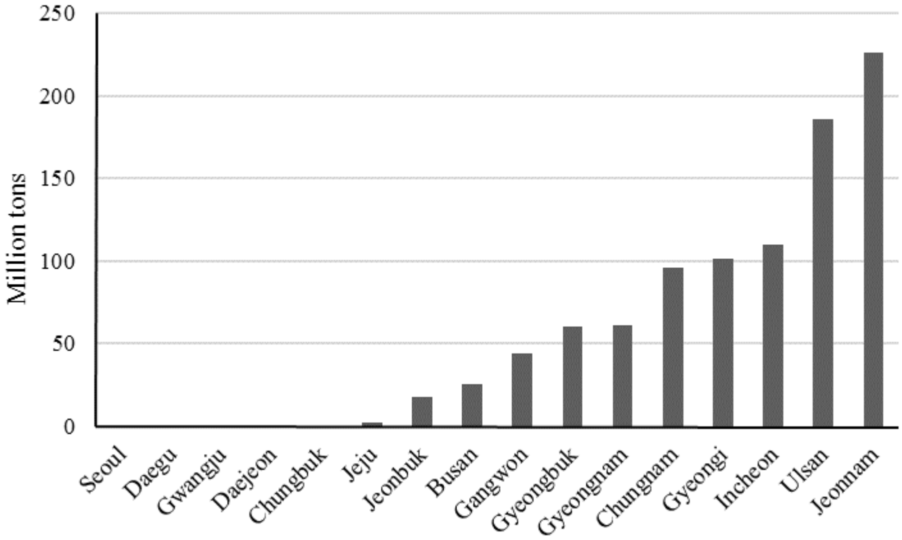


Fig. A6. Regional average of container throughput.

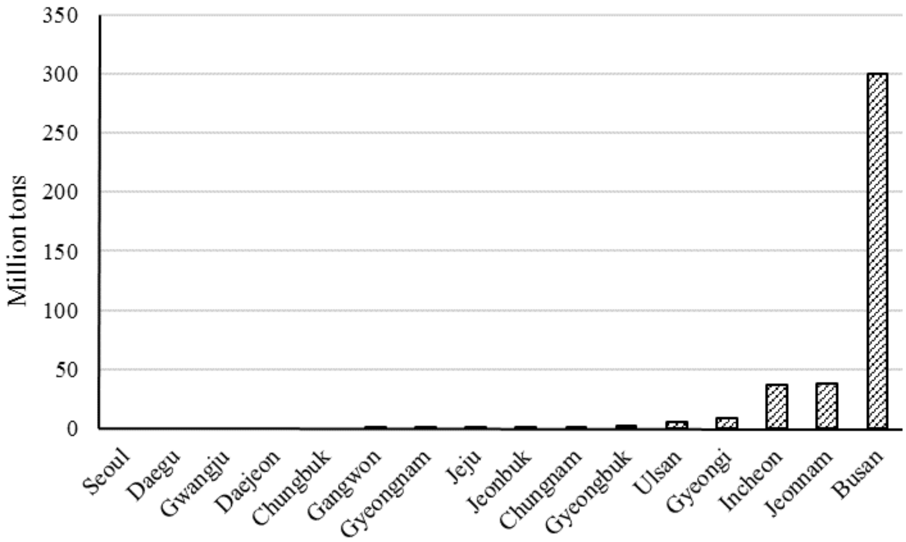
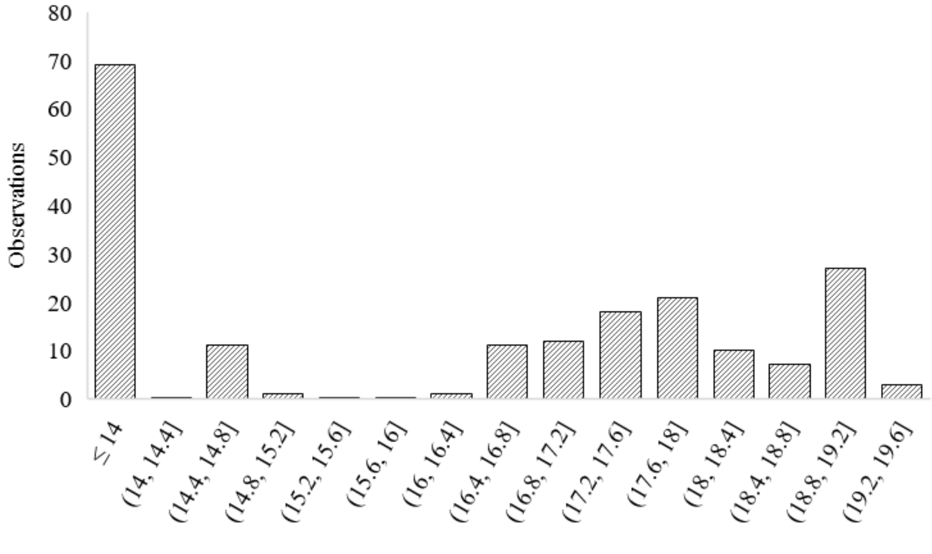
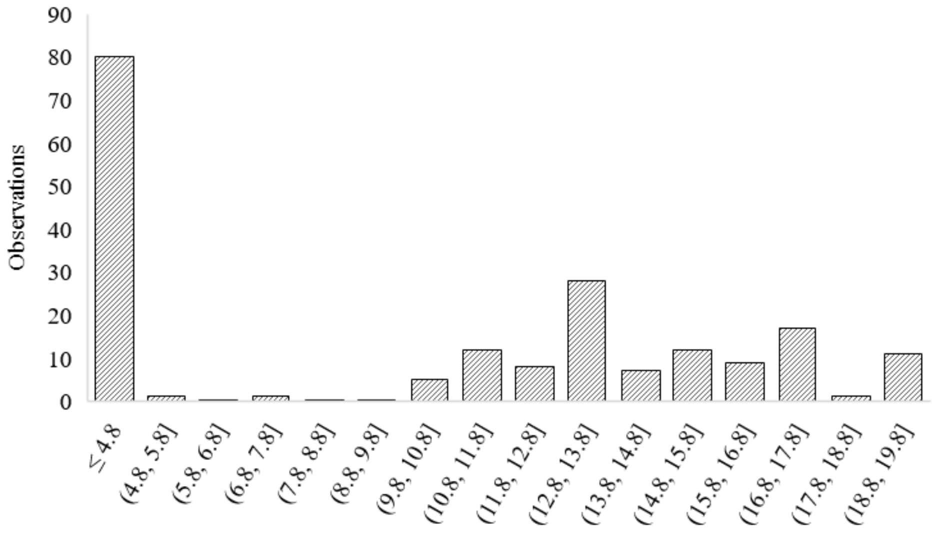


Fig. A7. Histogram of individual observations of cargo throughput, ln(ton).



Note: the leftmost bin only includes the observations of zero port activity.

Fig. A8. Histogram of individual observations of container throughput, ln(ton).



Note: the leftmost bin only includes the observations of zero port activity.

Appendix B

B1. Blanchard and Katz model

BLANCHARD and KATZ (1992) present a system of four equations to explain unemployment disparities across regions using labour economics theories. First, short-run labour demand in a region i at time t is:

$$w_{it} = -a(n_{it} - u_{it}) + z_{it} \tag{B6}$$

Wage (w) and the labour force (n), the summation of the employed and the unemployed, are measured in a logarithm relative to national counterpart. Unemployment rate (u) is measured as regional less national unemployment rate where both are measured as a ratio of unemployment (U) over employment (E). Then, the term (n-u) is approximately equal to a log employment[1]. This equation denotes a negative relationship between wage (w) and employment (n-u) e.g. a higher wage is associated with lower labour demand. z is the intercept which evolves separately in equation (B(B9). *a* is a positive coefficient.

Second, a wage-setting equation is based on the negative relationship between wage and unemployment implying that higher unemployment is associated with lower wage.

$$w_{it} = -bu_{it} + x_i^w \tag{B7}$$

where x^w denotes exogenous wage-setting factors and b is a positive coefficient.

Third, the change in labour supply (n) depends positively on wage but negatively on unemployment.

$$n_{i,t+1} - n_{it} = cw_{it} - gu_{it} + x_i^s + e_{i,t+1}^s \tag{B8}$$

where x^s represents all other region-specific factors, c and g are positive coefficients and e^s is the error term.

Last, the long-run movement in z is:

$$z_{i,t+1} - z_{it} = -dw_{it} - ku_{it} + x_i^d + e_{i,t+1}^d \tag{B9}$$

where x^d is a region-specific exogenous factor, d and k are positive coefficients and e^d is the error term. For instance, higher wage or unemployment reduces z.

B2. The maximum likelihood estimation of Tobit model

The probability distributions of x^p in Equation (4) and (5) are:

$$prob\left(x_{it}^p = 0 \middle| \mathbf{x}_{it}^{\mathbf{L}}\right) = prob\left(x_{it}^{p*} \le 0 \middle| \mathbf{x}_{it}^{\mathbf{L}}\right) = prob\left(z' = \frac{x_{it}^{p*} - \mathbf{x}_{it}^{\mathbf{L}'}\boldsymbol{\alpha}}{\sigma} \le \frac{\mathbf{x}_{it}^{\mathbf{L}'}\boldsymbol{\alpha}}{\sigma}\right) \tag{B10}$$

---

[1] $n = ln\,L$, $u = \frac{U}{E} \cong ln\left(1 + \frac{U}{E}\right) = ln\left(\frac{L}{E}\right) = lnL - lnE$ and thus $(n - u) \cong lnE$

$$= \Phi\left(-\frac{\mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right) = 1 - \Phi\left(\frac{\mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right)$$

and

$$prob\left(x_{it}^{p} > 0 \middle| \mathbf{x_{it}^{L}}\right) = prob\left(x_{it}^{p*} > 0 \middle| \mathbf{x_{it}^{L}}\right) = 1 - \Phi\left(-\frac{\mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right) = \Phi\left(\frac{\mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right) \qquad \text{(B11)}$$

where z´ is a standard normal variable and Φ is its cumulative distribution function. The individual likelihood function is a combination of (B10) and (B11). Using a dummy (D_{it}) that has a value of 1 if $x^p>0$ and otherwise zero (WOOLDRIDGE, 2013):

$$L_i = \left[\frac{1}{\sigma}\phi\left(\frac{x_{it}^{p} - \mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right)\right]^{D_{it}} \left[1 - \Phi\left(\frac{\mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right)\right]^{1-D_{it}} \qquad \text{(B12)}$$

Then, the log likelihood function for the entire sample is:

$$lnL = \sum_{t=1}^{T}\sum_{i=1}^{N} D_{it} ln\left[\frac{1}{\sigma}\phi\left(\frac{x_{it}^{p} - \mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right)\right] + (1 - D_{it}) ln\left[1 - \Phi\left(\frac{\mathbf{x_{it}^{L'}}\boldsymbol{\alpha}}{\sigma}\right)\right] \qquad \text{(B13)}$$

where N is the sample size and T is the number of observations. Then, the maximum likelihood estimation method can be used.