A developmental model on quantifying urban policy effectiveness in port city relations

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Abstract:

This paper is to find the role of urban policy in dealing with port city relations and corresponding methodology in quantifying policy effectiveness. In decomposing policy, we identify the key elements in the policy and further to measure its effectiveness. Firstly, we quantify non-linear relation in port city and explain why tradition quantitative methods fail to describe non-linear port city relationship. Secondly, we use improved logistic function derived from product life cycle theory (defined as a developmental model) to identify the evolving pattern in port city and depict the development phase and key elements. Thirdly, cases of Antwerp and Hamburg are used in analyzing how urban policy is effective in enhancing port city relations. It is difficult to quantify policy effectiveness thus we focus on how key elements in these policies are enhanced in promoting port city development even though port city are at different developmental phases and these policies can solve conflict between private port governance and public urban nature.

Key words: developmental, policy effectiveness, port city

Port city relation is conceptualized from three perspectives. Firstly, “Port cities are thus typical illustrations of local–globalinteractions taking place between territories, production networks,and commodity chains through physical transfers and sector-specific services”(Wang and Ducruet, 2012)[1].This concept was confirmed by both academic and empirical analysis by Hesse (2010)[2] and Jacobs et al., (2010[3], 2011[4]).In this view, port city-region relationship is defined as local-global physical commodity and service exchange. Local-global linkage is interpreted with several dimensions: local port authority, city policy makers and global terminal operator, shipping agents, carriers and investors in urban economy. In public port sector, this is more challenging that local public port management and urban planners confront with private initiated activities, e.g. operation efficiency, capital profitability driven by private owners while public policy, e.g. public interests and sustainable development, in some cases, is conflicting with above private interests. This is particularly the case in public-to-private ports (Iannone, 2012)[5].

Research into port city relations in this context draws attention to local port cities evolution in the light of economic globalization in terms of market force and international trade. Global commodity flows involve many forces. Brand-new customer need diversification provides the foundation for global sourcing activities, and promotes both the producers and consumers to find better, cheaper and faster products and services. It explains why seaborne shipping has become eminent for long distance transport over the long centuries. Moreover, the standard technique of shipping and containership in recent decades makes it easier to access to the sea and far-reaching regions in the light of globalization.Port city interplay based on seaborne shipping activities becomes more complicated with increasing frequency of global trade and are not only constrained to economic activity, but concern cultural, institutional, environmental sides. Despite the local dereliction of port–city linkages inrecent decades, maritime transport remains absolutely necessary for globalization (Ducruet and Notteboom, 2012)[6]. Trade-offs between local port authorities, local

market and global terminal owners and network actors are widely discussed (Fremont and Ducruet, 2005[7]; Fujita, 2007[8]).

Secondly, port city relation is conceptualized as public-to-private interaction (in some cases, public-to-private partnership, PPP) with initiation of formal and informal institutional arrangements. Port governance is conceptualized on institutional governance on ports and port authorities (Verhoeven and Vanoutrive, 2012)[9]. In this aspect, port city relation becomes complication and conflicts of stakeholders (Debrie and Raimbault, 2016)[10] in order to identify their impact on urban form (Graham & Marvin, 2001[11]; McKenzie, 2006[12]). This interpretation of port city relation is associated with port governance evolution in global major gateway port cities. In this process, decentralization and corporatization of port governance in most countries with private and foreign capital introduction, in some cases, i.e. China, cause interest conflict between public and private stakeholders (Cullinane and Wang, 2007)[13].

Further, port city-region relation is in association with metropolitan process (Wilmsmeier and Monios, 2016)[14] and may cause spatial tension in terms of land use, waterfront area development when both port and city expand geographically. Meanwhile, it is evidenced that coastal port cities possess dominant resources, like accessibility to international trade, preferential policy support in some case countries, especially emerging economies and early port phase in developed economies (Wang, Ng and Olivier, 2004)[15].By the year of 2000, approximately 80% of the global 25 largestcities were ports, compared to 60% in 1925 and 50% back in 1900 (Verhetsel and Sel, 2009)[16]. As a result, inequity exists widely in counties with easier access to seaborne shipping and those without (Laxe, Seoane and Montes, 2012[17]; Xu et.al. 2015[18]), and within the same country between coastal cities and inland areas (Wang and Ducruet, 2014)[19].

Thirdly, port city relation is defined from spatial function dimension as port-inland logistics nodes-city linkage. The role of port city in worldwide supply chains and

affiliated system, e.g. logistics chains, inland transport, has been widely discussed (Cullianane et.al, 2012[20]; Gripaios et.al. 1995[21]). Ports, in a result, have become more spatially dispersed and imposing new geographical economic impact on relevant stakeholders and spatial regions. In this context, the role of port with logistics delicateness and geographical reach in global trade routes and supply chain systems has "made the joint, harmonious development of ports and cities" (Haezendonck, et.al, 2014)[22]. Functional extensions of port also contribute to the new description of hinterland, i.e. extended, disconnected, fragmented hinterland has been proposed (Notteboom, 2008)[23]. Impacts of ports on far-reaching hinterland by analyzing freight distribution along major shipping routes have been researched well in above research papers. In this context, there is an increasing tendency that ports depend less on their city in terms of direct physical commodity transport, but port related tertiary sectors in port city, like logistics and warehousing, finance, packaging, etc. becomes demanding.

Above discussions on port city concepts address multi-dimensions and imply that nature and structure of port city relation have been gradually taken for granted by considerable geographers (Ducruet and Ng. 2014)[24]. Recent researches on port city relations are associated with market structure, international trade pattern, port development and urban metropolitan process and trade-off in relevant stakeholders.

1. Literature review

Institutional setting is indispensable in discoursing port city interactions from a developmental perspective. First, privatization of port governance has been popular in global ports even though fully privatized ports have not performed to expectations (Baird, 1995)[25]. According to the government's participation, such as concession and arrangements with local port authority, ports have been classified as landlord (tool port) ports and service ports. Although it's beyond the scope of this chapter to analyze efficiency of these types of ports, governance is convinced as one main factor in affecting port city growth as urban government plays an important role in deriving transport policy and port related infrastructure. For example, Japanese government subsidized ports as an incentive for port construction (Tarada, 2002)[26]

and regarded it as a tool in monetary expansion serving national economy in a wide range rather than only an individual port. The level of local government participation and the mediation into port related industry determines the benefits similarity and constraint for both parties(Pemberton, 2000)[27]. The role of port in global supply chains is subject to capital dimension and value creation dimension. For the port with participation of public private partnership (PPP), a three-hierarchical management structure may be established and isolate any intervention from government to ensure port efficiency (Table 1).

Table 1Three-hierarchical institutional structure in public to private ports

Description	State owned capital supervision	State owned capital fund	Operating company
In port related sector	Local government/urban administration	Fund	Port authority Terminal operator
Nature	Public	Public/private	Public/private
They can do	Supervise function in capital use transparency, procedure and deal with port city relation	Funding capital for infrastructure, investment and financial function	Port operating business
They cannot do	Intervention into port operation	Intervention into port operation	Capital funding

Second, Notteboom, De Langen and Jacobs (2013)[28]argued that the evolution of port growth shows great contingency and path dependence, that port authorities are often constrained by their governance structure or institutional setting when they attempt to follow new routines to cope with external environments by applying the ports of Rotterdam and Antwerp. Port development is path dependent and determined by both private investment and public planning which seems to contradict in some circumstances; this was also seen by Monios and Lambert (2012)[29] when explaining the heartland intermodal corridor in America, they argued that in port evolution, the role of the national state has been decreasing, however, local and regional authorities (governments) will devise and implement policies and other institutional attempts to secure ports development. These attempts will result in port clustering and agglomeration.

However, evaluating or quantifying the effectiveness of these attempts has become a difficulty for scholars. Pallis (2007)[30] evaluated the endorsed port policy reforms supporting an improvement to key financial indicators by analyzing the financial performance of Greek ports. Gonalez and Trujillo（2008）[31] used the DEA（Data Development Analysis）method to assess multi-port reform in Spanish container ports. A review of policies by Wang, Yu Ng and Olivier (2004)[32] also evaluated the port governance in China and their performance. Most of these papers aren't concerned with quantifying urban policies. The main reason why it's difficult to quantify these policies is that the evolution of urban port linkage has been changing, fundamentally accompanied by the deregulation of in-port governance by urban government. In other words, the effect of urban policy on ports is not that clear. Conflicts confronted by the port authority and urban government are land utilization, incompatibility of city and port development, and environment decay. "The port is geographically moving away from the city to at the same time the geographical overlap between the ports" (Wiegmans and Louwa, 2011)[33] and the city in terms of land use diminish. Van Hooydonk (2007)[34] has argued that the more value internationally that the maritime and port industry contributes to, the more energy will have to be put in embedding the port in the local community (Aarts, Daamen,Huijs and de Vries)[35]. In other words, the economy beyond the city contributes more to the ports, while the city grows as an economic unitindependent of the port. The institutional factor becomes a research interest to scholars as a useful dimension to explain port city-region dynamics (Liao andHong, 2013)[36].

Port city relation is not always positive. With spatial expansion of port, land use and limited space become geographical constrains for both city and port. Land is scarce and expensive in traditional port cities that have evolved from core inner city areas. The mere expansion of the port is often extremely difficult or politically contested (Flämig and Hesse, 2011)[37]. This congestion includes land use and traffic volume, e.g., the relevant logistics transportation and available infrastructure, increasing labor in

the port-related industry and urban population, land cargo logistics and urban transportation, etc. In some cases, environmental issues related to the port also draw the attention of literature. Although ports produce comparatively less direct air pollution, relocation and concentration of production factors exert negative pressure on local environment with intention to decrease transport cost and get easier access to the port. This is worse in waterway pollution and river ports with less purifying access compared to seaports. Developing economies are even worse with recent demanding needs for port growth, developed regions, "the port–city interface. European port authorities, who often act as a 'landlord' for these locations and companies, logically have a very protective attitude towards these areas, particularly when it comes to the 'environmental space' that allows companies to freely run and expand their business" (Daamen and Vries, 2013)[38].Additionally, pollution from the port also intensifies the relationship between the urban residents and the port authority.

Urban ports still possess advantages over other non-urbanized locations when it comes to attract and redirect cargo flows even when these cargo flows are destined for extended hinterlands. A new and dynamic relationship conceptualizes the role of human agency and institutional structures (Hall and Jacobs, 2012)[39]. Port authorities generally focus on the development of the local port area and play a minor role in the development of port hinterlands, whereas other players, e.g. shippers, forwarders, and barge and rail operators, have always been involved in the port-hinterland connection and have contributed to the port network (Den Berg and De Langen, 2011).[40]

2 Traditional model on port city relations

Relationship between the port and city is complicated with the rise of ports. The observed cases show that role of port-city goes beyond as a hinterland, while the

role of the ports in local economy also transforms. The growth of the port and localeconomy doesn't necessarily synchronize. Ports firstly are to satisfy the trade needs of a city. Traditional economics assumes that local economy (Y) (refers to a city in this part) is composed of two units:

- Domestic economy (Y_d): all products are produced and exchanged within the city, in other words, the production factors are within the city.
- Trade economy (Y_t): some products will be traded from (and to) the area beyond the city and can't be produced within the city. The need for trade promotes ports: Then we'll have

$$Y = Y_d + Y_t \quad (Y_d, Y_t, Y \geq 0) \qquad \text{Eq. 1}$$

If we suppose that all the cities are isolated and the production factors can satisfy all needs of the city, then Y=Y_d, which means there is no trade (refers to international trade in this part that all products for trading will be through port) for a city. Domestic economy is determined by the total economy, and then we'll have

$$Y_d = a + bY \qquad \text{Eq. 2}$$

(a: constant, when b=0, then Y_d=a, a represents the volume of domestic economy in total city economy when Y=0; b: trade coefficient,$a, b \geq 0$)

$$Y_d = a + b(Y_d + Y_t) \qquad \text{Eq. 3}$$

$$\frac{1}{1-b} = \frac{Y_d}{a + bY_d} \qquad \text{Eq. 4}$$

If we combine Eq.18 and Eq.19, we'll get

$$Y = \frac{Y_t + a}{1-b} \qquad \text{Eq. 5}$$

If we suppose there is a needfor a city to trade, then the first derivative of (Eq. 7)

$$\mathrm{dy} = \frac{dY_t}{d(1-b)} \quad \text{Eq. 6}$$

$Y^{'}$: the growth of local economy (Y);$Y_d^{'}$: the growth of domestic local economy (Y_d)

If we combine Eq. 22 and Eq. 24, we'll get

$$Y^{'} = Y_t^{'} \frac{Y_d}{a + bY_t} \quad \text{Eq. 7}$$

From (Eq. 8), we come into some basic conclusions:

(1) There is a positive relationship between $Y^{'}$ and $Y_t^{'}$ which means growth of total economy is synchronized with growth of the trade of a city. The increasing trade growth rate will bring fast growth of urban economy.

(2) There is a positive relationship between $Y^{'}$ andY_d, the volume of domestic economy of a city (rather than the growth rate) will accelerate the growth of a local economy.

(3) There is a negative relationship between *a* and $Y^{'}$ which means the bigger percentage of the domestic production in a total economy, the slower of local economy growth.

(4) There is a negative relationship between *b* and $Y^{'}$which means the more dependence on trade will decelerate the growth of a local economy.

(5) There is a negative relationship between $Y^{'}$ and Y_t which means the absolute volume of trade will undermine the growth of local economy.

Because Y_d, a and b will interplay in our function, we'll get $Y^{'} \approx Y_t^{'}.f$, $(f \geq 0)$)which means there is always a positive relationship between the growth rate of total city economy and trade, in other words, the growth of trade volume of a port will certainly increase the total production of a city economy. Port cities play a fundamental role in connecting the sea and hinterland they serve, exercising

complex and profound influence on both sides they connect through transshipmentof goods, services, labor flow and capital, etc.(Tan, 2007)[41]

As for the imitation of above traditional methods in analyzing port city relationship, firstly, relationship is not necessarily a linear correlation. Multi factors contribute to port city growth and their development path shows a variety. Secondly, traditional methods don't illustrate an evolutionary and dynamic pattern of port city. Therefore, we introduce a developmental model in next section to illustrate the developmental phase of port city relationship and research and analyze the role of urban policy in building a more dynamic port city linkage.

3 Logistic function

The Logistic Function by Pierre Francois first depicts population growth. A generalized logistic curve can model the "S-shaped" behavior (abbreviated S-curve) of growth of some populations and a simple logistic function was defined by the formula (Dong, 2007)[42].

$$P_t = \frac{1}{1 + e^{-t}}$$ Eq. 8

The variable P might be considered to denote a population, where *e* is Euler's number and the variable t might be thought of as time. The application of Logistic function covers a large range of fields, including demography, economics, and geography. We apply this function in this section to illustrate the growth of port and city with the purpose of: (a) calculating the maximized capacity for port and city growth, supposing both ports and cities have a maximum capacity for growth, given the same conditions; (b) describing the evolution process for our targets from the S-curve and drawing a clear time line for each stage of port development. We revise the functions as:

$$Y = \frac{c}{1 + e^{b - k(t - 1995)}} \quad \text{Eq. 9}$$

Where Y is function; C represents the container throughput; b represents the maximized predicted container throughput; k is parameter; t is time (year).

Container throughput data for the ports of Antwerp and Hamburg are collected from 1985 to 2011, maximized iteration times of30, and parameter and SSCON reaches of 1.00E-008 are designed. By using SPSS software, non-linear regression analysis of the data are calculated.

3.1 Primary results

The calculation process is given in Table23. The results show high goodness for fit (both are above 0.9) for the two ports. Logistic function(s) for the two ports are given in Figure 2.

Table 2Logistic function calculation process and results by using SPSS software

	Hamburg				Antwerp				
Iteration results	iterations convergence	parameter c	b	k	iterations convergence	parameter c	b	k	
	1.0	99.086	10.000	1.500	.120	1.0	163.315	10.000	1.500	.120
	1.1	71.072	12.343	2.627	.094	1.1	281.193	13.749	2.313	.024
	2.0	71.072	12.343	2.627	.094	1.2	29.657	9.983	2.196	.096
	2.1	158.714	5.335	2.626	.161	2.0	29.657	9.983	2.196	.096
	……					2.1	5.639	12.730	3.267	.128
						……				
						8.0	4.494	13.705	3.454	.133
	10.0	11.583	10.422	3.338	.172	8.1	4.494	13.704	3.454	.133
	10.1	11.583	10.422	3.338	.172					
	Run stopped after 22 model evaluations and 10 derivative evaluations. Iterations have been stopped because the relative reduction between successive residual sums of squares (SS) is at maximum: SSCON = 1.00E-008					Run stopped after 17 model evaluations and 8 derivative evaluations. Iterations have been stopped because the relative reduction between successive residual sums of squares (SS) is at maximum: SSCON = 1.00E-008				
	Hamburg					Antwerp				
Predicted parameter	C=10.422; B=3.338; K=0.172					C=13.704; B=3.454; K=0.133				
Residuals	R^2 = 1 -（residual SS / corrected SS）= .946					R^2 = 1 -（residual SS /（corrected SS）= .975				
function	y = y =$10.422/(1+e^{(3.338-0.172*(t-1985))})$					y =$13.704/(1+e^{(3.454-0.132*(t-1985))})$				

Note: all throughputs in the procession are in thousand million tons. *Source:* throughputs data were from http://www.oecd.org.

The maximized predicted container throughputs for the ports of Hamburg and Antwerp are 1.0422 and 1.3704 billion tons (Figure 1).

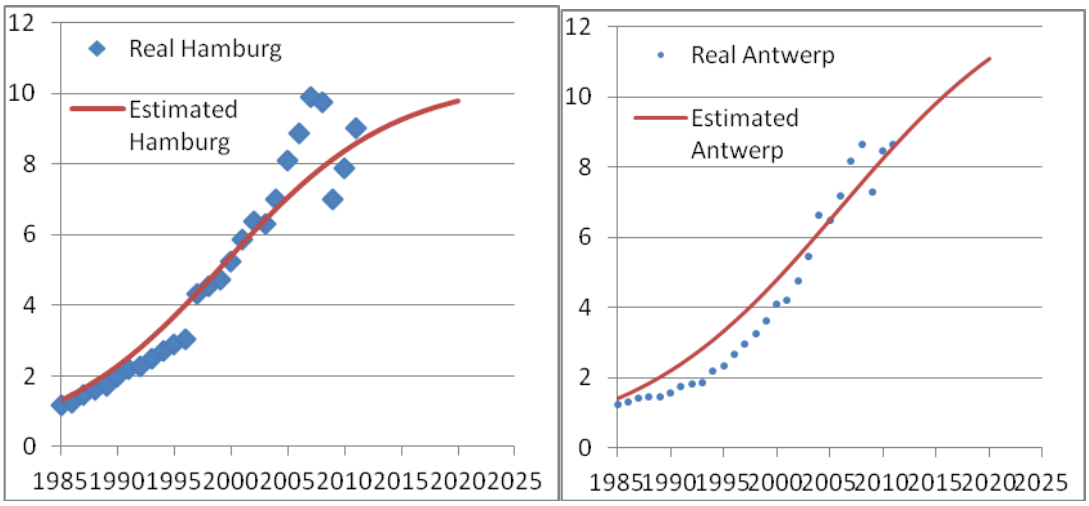


Figure1 Estimated and real throughput for the ports of Antwerp and Hamburg

4A developmental model on ports

The results show the estimated growth pattern for the two ports but if we want to identify their developing stages, we need to further process these results. Therefore, we introduce the FMSR model for the ports growth to illustrate port growth in a **F**ast, **M**oderate, **S**low growth and **R**ecovery order.

$^{\Delta Y}/_{t}$: Growth rate of port (if $^{\Delta Y}/_{t}$>0, it means the port has a fast growth rate)

$\Delta(^{\Delta Y}/_{t})$: The first derivative of t with respect to Y (if $\Delta(^{\Delta Y}/_{t}$>0, it means the port has accelerating growth; if $\Delta(^{\Delta Y}/_{t})$<0, it means the port has decelerating growth)

$\Delta\left[\Delta(^{\Delta Y}/_{t})\right]$: The second derivative of t with respect to Y (if $\Delta\left[\Delta(^{\Delta Y}/_{t})\right]$>0, it means a rate of accelerating growth; if$\Delta\left[\Delta(^{\Delta Y}/_{t})\right]$<0, it means a rate of decelerating growth)

The evolution stages of the two ports are given inTable 3.

Table 3FMSR model results for the port(s) of Antwerp and Hamburg

Period	Hamburg				Antwerp			
	Year	△Y/t	△ (△Y/t)	△[△ (△Y/t)]	Year	△Y/t	△ (△Y/t)	△[△ (△Y/t)]
Period F	1985–1991	>0	>0	>0	1985–1994	>0	>0	>0
Period M	1991–2000	>0	>0	<0	1994–2007	>0	>0	<0
Period S	2000–2010	>0	<0	<0	2007–2019	>0	<0	<0
PeriodR	2010–2015	>0	<0	>0				

Note: period F: fast growth; period M: moderate growth; period S: slow growth; period R: recovery.

For the port of Hamburg, from the year of 1985 to 1991, it enjoyed a fast growth, while in 1991 to 2000, although the port kept increasing, the growth rate was slower; from 2000 to 2010, the port suffered a decelerating growth but still maintained an increasing trend. The estimated results show that in the period of 2010 to 2015 the situation for the port will recover from the previous period. Thus, we can define the evolution of the port of Hamburg as, fast growth phase, moderate growth phase, decay and recovery phases. These four stages constitute a full development cycle of a port, in the years ahead we can estimate a new fast growth stage is coming without any external and unexpected turbulence.In comparison, the port of Antwerp experienced three phases: the years of 1985–1994 are the fast growth phase, the years between 1994 and 2007 are the moderate growth phases, and from 2007 to 2019, we will find a longer decay phase for the port. Compared with the port of Hamburg, the port of Antwerp stays longer time for each phase. Another concern is that there is no clue that Antwerp has recovered from the slow growth phase, in other words, the port of Antwerp will experience a longer slow growth phase in contrast to the port of Hamburg in the years ahead (Figure 2).

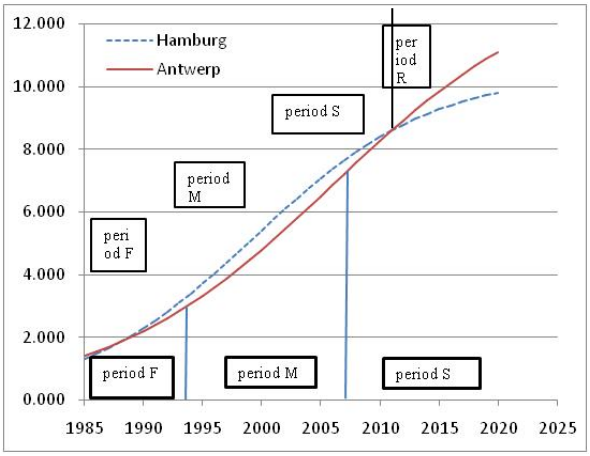


Figure 2FMSR model for the port(s) of Antwerp and Hamburg

5A developmental model on cities

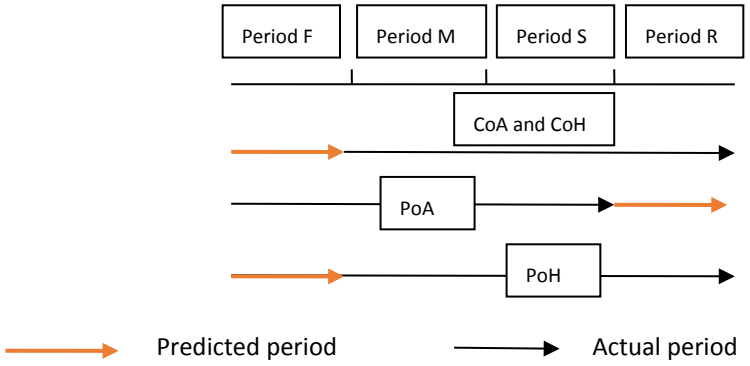
The measurement of a city employs multi indicators, Northmam (1979)[43]proposed that initial, acceleration and terminal phases for a city development based on demographical principle by using Logistic function. A similar methodology by Chen and Zhou (2005)[44]was proposedin analyzing coastal urbanization development. In this section, we adopt a similar methodology with above section in defining city developmental phases in two case cities. Shown by table 4, the cities of Hamburg and Antwerp show high contingency in terms of the economic growth. Both cities experienced three periods from moderate growth to recovery. However, Antwerp took a shorter time in experiencing each phase, with each averagely eight years, while in comparison, Hamburg took 13.7 years. Another fact revealed by Table 24 is that if each phase for both cities and ports is in a sequential order, the cities of Antwerp and Hamburg are more advanced compared with the ports' development. Secondly, although both entered into the recovery phase, the port of Antwerp stayed in the period of S, while the port of Hamburg entered into the period of R, therefore if we suppose that there exists an interplay between port cities and ports, the city of Hamburg will welcome the period of F soon, while Antwerp will stay in the period of R for longer, as the port of Antwerp will still be in the period of S.The reason behind the difference is that local municipal policy impacts on the port. We

decompose urban policy by proposing the case of Antwerp to find out what factors embedded in the policy will impact the interface between the port and city (Figure 3).

Table 4FMSR model for the cities of Antwerp and Hamburg

Hamburg					Antwerp			
	Year	ΔY/t	Δ (ΔY/t)	Δ[Δ (ΔY/t)]	Year	ΔY/t	Δ (ΔY/t)	Δ[Δ (ΔY/t)]
Period M	1985-1988	>0	>0	<0	1985–1995	>0	>0	<0
Period S	1988-1997	>0	<0	<0	1995–2010	>0	<0	<0
Period R	1997-2020	>0	<0	>0	2010–2019	>0	<0	>0

Note: GDP data of the two cities are from http://www.oecd.org



CoA: city of Antwerp; CoH: city of Hamburg; PoA: port of Antwerp; PoH: port of Hamburg

Figure 3FMSR model of Antwerp and Hamburg

6A case on developmental model in port city relations

As the second largest city in Belgium and the largest city in the Flanders region, economic structure and employment of Antwerp fit to its port function, but the port governance structure does not fit the economic reality, as there is no metropolitan governance in Belgian cities (De Decker 1999[45]; Loopmans 2007[46]). Van Hamme and Strale (2012)[47] analyzed Antwerp and its three-level governance structure: region, province and municipalities. They stated that "its municipality benefits from a broad

autonomy and sets its own urban and economic policy while receiving European, federal and regional funds in various domains, the provincial level has almost no competence in economic matters; it is limited to economic promotion." The Antwerp Port Authority, an autonomous municipal structure, administers dock construction and other major infrastructure. To adjust to the challenge brought by globalization, Antwerp shifts towards entrepreneurial policies (Van Hamme and Strale, 2012)[48], which means that the municipality undertakes more work in opening markets, attracts FDI and enhances the role of the city in the European and global city network. It's difficult to quantify which policy reinforces port development. Therefore, we have undertaken a decomposition of urban government policy to see what factors will enhance port growth when the municipality tries to promote local economic development.

The following table (Table 5) timelines the FMSR model in more details. The comparatively long period was divided into two short phases so that the port and city are in the same time span.

Table 1Urban policy in port city dynamics

Port\city	Period M 1985–1995	Period S 1995–2007	Period S 2007–2010	Period R 2010–2019
Period F (1985–1994)	P(land, governance)			
Period M （1994–2007）		P(labor and FDI)		
Period S （2007–2010）			P(city brand)	
Period S （2010–2019）				P(knowledge industry)

From 1985 to 1995, the city of Antwerp maintained a moderate growth, while the port witnessed fast growth. The fast growth of the port indicates that it was physically expanding in terms of both land area and maritime infrastructure, and more direct economic interaction with the local government. Two factors can be

found in the Antwerpen policy in that period: land use and governance. The port of Antwerp is a landlord port, “which implies the port authority leases the land to private port operators on the basis of long-term concession agreements. Before 1997 the port authority was a city department. The port authority was corporatized in January 1997; the former municipal port authority was transformed to an autonomous municipal port authority with only one shareholder, i.e. the municipality. The competencies were transferred from the city to the port and the new port authority gained financial independence”. The governance reform liberalized the port of Antwerp to actlike a private company and gained a first-mover effect in market competition. Totaling 66.5 million m^2 of the whole city, the port of Antwerp accounts for 72% of the total surface area, leaving 18.9 million m^2 for other business activities. The sufficient land resource provides a support for spatial expansion of the port. These two factors sustained nearly 10 years’ fast growth for the port, however, although port growth would contribute to the local economy, it didn’t drive the city of Antwerp enough, as we can see that port land use and port governance liberalization didn’t induce an economy boom, and instead, the city stepped into a long slow growth phase.

The changing context drives the municipality to adjust their policy. By analyzing the policies during this period, we find that their priority is to stimulate local economy. At this phase, the port already contributes to majority share of the local economy. The destiny of the port and city has been linked to a closer direction. From 1995 to 2007, the city stepped into a slow growth, while the port maintained a moderate development. From the perspective of the city, its priority was to stimulate local economy. In 2006, a new 15-year Strategic Spatial Structure Plan was published after three years of development. The city of Antwerp states that “it (the plan) acts as the single plan that guides all urban development activities by all agencies in the city. Considerable progress has been made on many aspects including city center re-population and re-densification, improving public transport and increasing green community space and facilities” (the city of Antwerp, 2000)[49]. The city outlined labor

attraction and FDI as two factors that can boom local economy. In2006, 50 international projects were constructed in Antwerp, accounting for 27% of the total national projects, compared with 33 projects in Brussels regions. According to the Financial Times' report, Flanders was the most attractive European region for foreign investment in 2007, next to London. The increasing jobattraction and FDI also boost port development. After the fast growth period of the port, the land and port governance was no longer the priority for the port, while the labor shortage and lack of relative expertise and possible international cooperation, e.g. shipping lines becomes imperative. The municipal policy was initiated firstly to promote local economy but also local port also benefited from its positive impacts. The direct local policy shifted towards a softer approach that sustained port development, e.g.labor introduction and FDI growth. These factors prompted the city to recover from the slow development and contributed to the increasing automation of the port operation management and decreasing dependence on labor-intense business.

From 2007 to 2010, both the city and the port were in a volatile situation. The city was facing a slow growth in terms of GDP generation, while after 22 years of a fast and moderate growth, the port was facing a fluctuating growth problem. The increasing rate of the port was as slow as that in the period S despite of expanding throughput capacity. In this period, port city developments share similar pattern. But we don't find more policies directly targeted at the port despite of the high similarity in their growth. From the perspective of the municipality, it seeks more economic engines by building a "city brand". More concrete methods are adopted in building an attractive economic climate for Antwerp. The construction of a more attractive and fashionable image is a secondary objective (Van Hamme, Strale, 2012)[50].The city seeks for more efforts from the institutional side. The efforts cover a wide range, e.g. planning tools and urban planning, high-rise construction, mobility, taxation, investment support and expansion of knowledge clusters. In this period, the

improved image of the city becomes more attractive for the relative factors that can indirectly contribute to for the port development rather than the direct policy stimulation. The reason behind this is that at this phase, relationship between the port and the city has seen a separating tendency spatially, economically and institutionally. Although the city still plays an important role in terms of immediate hinterland for the port, distance hinterland becomes a more critical role in the port growth.

From 2010 to 2019, the city is predicted to recover from a slow growth, while the port will suffer from a slow growth due to the volatile world economy. The port deals with the cargo from all over the world. The recovery of the port depends more on the world economy recovery than the urban economy. Therefore, we see a more rapid recovery process of the city. In this period, the city focuses more on its knowledge industry cluster. In 2010, the University of Antwerp enrolled more than 8500 students and four knowledge centers were established, and most students choose management and maritime as their majors. Centers are an incubation center for small firms and a scientific center. The maritime course teaching is widely taughtin the most high education institutions, e.g. the Antwerp Maritime Academy, Institute of Transport and Maritime Management Antwerp and Antwerp/Flanders Port Training Centre. These maritime-related training programs sustain the port development. The developmental phase for the port and the city is the recovery phase in 2019.

7 Conclusion

Port city-region dynamics follows a “self-reinforcing pattern” and is autocatalytic and self-evident (Cahoon, et al, 2013)[51]. As researched by Fujita (1996)[52], self-organization of ports cities generates a complex, hierarchical urban system in a self-

organizing manner. A developmental model on evolving port city relations is helpful in identifying key phases and factors contributing to the pattern. As development is associated with specific geographical territory, it is necessary to address methodology in quantifying developments cross cases.

Our research follows the concept of life cycle by using FMSR phases to depict and compare port and city developments in cases. Relationship in ports city illustrated by Logistic function in these examples reveals that city growth is generally ahead of the port in development. However, this conclusion may be only partially effective due to the following reasons: (a) that the cases of Antwerp and Hamburg are spatially and functionally similar. Both ports focus on importing containers, while the cargoes exported from the two areas are relatively overlooked. If we integrated more types of ports, such as the ports in Asia depending more on exports, the relationship found between port-cities could change. (b) This section applied container throughput and urban GDP as output to describing growth. If we changed this indicator, for example, by using the profit of the port and urban taxation, we may see a closer relationship in the port-city. This relationship depends on the correlation and interplay between the indicators. (c) If we extend our data to a longer period.It would show a more complete life cycle for the port-city and the conclusions will be more convincing.

We further address the role of urban policy in port city dynamics in the case study of Antwerp and notice that urban policies are mostly direct with the ports at the early developmental phase of the port, such as the land usage and port governance and the manner in which seaport is shaped. However, with the expansion of the port handling capacity and liberalization of the port governance, urban policies are effective in directive sides, e.g.local economic policy;even so, some urban policies have been devised to solve the conflicts between the port-cities, such as the shortage of labor and environment protection. The shift of policy concern adjusts to the relationship transition between the port-cities that require less intervention from local governments to the port. Another concern is that the growth of the port

and city doesn't overlap and the duration in the individual phase varies. The effectiveness of a continual policy will vary as well. Policy decomposition is to look at what factors in the urban policy will benefit the port growth rather than the overall policy. Therefore, the factors embedded in the policy can be identified, while the continual impact of the policy is yet to be quantified by other modeling methods.

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