ERASMUS UNIVERSITEIT ROTTERDAM
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Health Indicators of Port-Related Chemical Clusters: A Case Study of the Chemical Industry in Delfzijl

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1. Introduction

The chemical industry and ports enjoy their synergies like peas and carrots since the beginning of the Industrial Revolution. The revolutionized way of producing products in bulk required substantial amounts of inputs that most of the times weren't locally available. A lot of the raw materials had to be brought in by ships, and due to the high transport costs, a new role for the ports arose. Moving the raw materials was a costly matter so most companies decided to build their factories as close to the point of arrival as possible, namely in the ports themselves. This made ports not only a place to transfer, but a place to produce as well. Nowadays, ports still have a major role in the production/processing of chemicals. In 2012 alone, nearly 5 billion euro's of added value was created by the port-related chemical industry in the Netherlands, one of Europe's leading suppliers of chemical products. Please note that these 5 billion didn't even include the value added by the petrochemicals.

One of the main features of the chemical industry that distinguishes itself from other industries is that chemicals can serve a wide variety of purposes. For this reason, chemical companies are often found in clusters where the output of one firm can serve as the input for multiple other firms. This makes chemical clusters strong, but very interdependent. The 5 billion added value mentioned above already implied that the port-related chemical industry has a substantial economic importance for the Netherlands as a whole and probably an even bigger importance for the regions housing these clusters. It is therefore important to maintain this economic vigour and possibly even stimulate it whenever needed. To estimate whether or not action needs to be undertaken, it is important that there is a clear view of how 'healthy' such a cluster actually is. This thesis aims to identify and test if variables, identified from existing literature studies and expert interviews, are able to give an accurate view on the health of port-related chemical cluster. This is done by studying the chemical cluster located in Delfzijl.

The chemical cluster in Delfzijl added over 200 million euro's of direct value added in 2012 and directly employed 1 out of every 25 citizens in the entire municipality. Because this cluster is big, but still relatively small compared to the ones in bigger ports (e.g. Rotterdam and Antwerp) it is an excellent case study to look for these health indicators. The clusters is relatively easy to delimit and data can easier be specified in this specific cluster. Results of this thesis should be elaborated with care, since each chemical cluster has its own unique type of composition and this thesis didn't specify the natures of different chemical industries. The chemical industry of Delfzijl is specialized in the conversion of natural gas and brine into chlorines, chlorides, methanol and utilities, whereas other clusters could use very different inputs. The results can, however identify certain factors that are also likely to influence other chemical clusters.

This thesis will start with the theoretical aspects of clusters and how their 'health' should be measured. It will identify variables that were deduced from several sources in the existing literature and interviews that were recently held with experts. Secondly it will recognize and delimit the case specific chemical cluster in Delfzijl. This will be followed by empirically testing these variables and will be concluded by the recognition of key variables able to indicate the health of port-related chemical cluster.

2. Theoretical Framework

This part will lay the theoretical foundation for the study on health indicators of chemport clusters. As will be shown, clusters are basically networks of production, meaning that the performance of a cluster is synonymous to its health. Because health itself isn't measurable and the performance of a cluster is, the performance of clusters will be studied and used as the indicator of health. After the general definition of clusters used in this thesis, a step-by-step approach to construct a cluster will be shown. This will be followed by an analysis of several variables that tend to influence the overall performance of clusters as recognized by the existing literature on performance indicators of port clusters, the chemical industry and will be completed by variables derived from expert interviews. This leaves us with a multiple regression which will be tested in section 4.

Defining the Cluster

This thesis will define clusters as: 'a population of geographically concentrated and mutually related business units, associations and public(-private) organizations centred around a distinctive economic specialization' (Langen P. W., 2003).

Several notifications should be made regarding the different terms used in this definition:

- First of all the term population is used because a cluster consists of several heterogeneous companies, both competing and complementary ones.

- The second term; geographical concentration, is an arbitrary concept but by using a consistent method to define one, a situation is created where clusters can be compared over time.

- Business units will be used as a term instead of 'firms'. Some firms, especially multinationals, have various business units. Each with their own specialization. Sometimes only a small part of a firm participates in a cluster. If data of the entire firm would be included, results could become skewed and misleading. Because of this, only parts of the firm (business units) that do participate in the cluster will be included.

- The fourth and final term used is 'specialisation'. This term is used to help us delimit the cluster. Using a specialisation makes it easier to construct the borders of the cluster because business units operating in a specific specialisation can be given a AISC or ICS code (Dutch: SBI'08). These codes make it pretty straightforward to make a separation between business units that can be considered part of the cluster and business units that aren't.

Constructing the cluster

In his thesis, de Langen developed a step-by-step approach to systematically construct clusters (Langen, 2003). This approach consisted of 4 steps to systematically define and delimit a certain cluster. By using this method, the delimitation of clusters still remains somewhat arbitrary, but because of its consistency it can be used to compare clusters over time.

The first step of this method is to choose a certain economic specialisation and a broad geographical region. In his research, de Langen gives the advice to pick a broad definition of the economic specialisation. By defining the specialisation broadly, the relation between the specific cluster and its geographical region becomes clear. To illustrate this relation, we could think of an example where we could define the economic specialisation of a cluster as: 'Ship maintenance'. When we look at ship maintenance companies and the reasons why they would locate at certain areas, it's most likely that they didn't pick their current location because of geographical factors, but because most of their clients are located there. When we would define the economic specialisation much broader, sea freight transport for example, we could include maintenance plus all the other business units involved in the shipment. This way it is possible to investigate why there is sea freight transport in this specific geographic area and the geographical advantages this area offers to the cluster.

The second step is to identify all the economic activities of the cluster as recognized above. This step consists of a couple of sub-steps as well.

- The easiest way to start identifying economic activities is by looking at the presence of cluster associations. These associations can usually be used to get a quick insight in the economic activities involved in the economic specialisation. Not only private firms are involved in these kind of associations. Public parties are usually involved as well. Because of the local impact of these clusters (e.g. employment, environment) public parties also have a certain interest in the functioning of these clusters and that's why they are often part of the association as well. Not all clusters have their own association. Associations can be seen as some sort of a shortcut in identifying the economic activities. It helps identifying economic activities of a certain specialisation but isn't a necessary condition for a cluster to exist.

- The next step is to make an input-output of the cluster. Not only does this link the activities involved in the cluster, it also gives a good insight in the importance of the linkages between firms. There is, for example, a big difference between the supplier of car tires to a car manufacturer and the supplier of cafeteria food eaten by the employees at the same manufactory. The supplier of tires could easily be identified as part of the car manufactory cluster whereas the supplier of food probably wouldn't be.

-The third sub-step is a qualitative analysis of the structure of the value chain (and therefore a complementary step to the previous one). By means of interviews with (local) experts, the structure of the value chain can be revealed. Possible relations that could be overlooked when only looking at reports and statistics could be revealed as well.

-The fourth and final sub-step is the analysis of location coefficients. Location coefficients can be calculated by comparing the amount of firms in a certain industry with the total amount of firms in the same region and doing the same thing for the same industry in other regions When this location coefficient is relatively high(i.e. much larger than 1) this implicates that the industry is relatively important in the specific region and it is most likely that this industry is part of the cluster.

These steps give us a good insight in the activities involved in the specialization. These activities can also be sorted by looking at their NAICS/SIC codes (SBI'08). These codes sort economic activities by giving specific numbers to specific specialisations. The longer the number, the more specified the activity is.

Now that we have identified both the economic specialization and the activities involved, we can delimit the geographic borders of the cluster. This third step could be done by using the same mathematical tool used in step 2. By looking at the share of the industry of the total economy and comparing it to the shares of the same industry at other regions we can identify relevant cluster regions. The determination of the minimum coefficient to include a region is arbitrary but the use of the location coefficient still remains a useful method to consequently delimit clusters.

This thesis, however, will use a slightly different approach due to the limited availability of data. We will use data from the Havenmonitor, a screening device developed by the Erasmus University in collaboration with the Dutch Ministry of Infrastructure & Environment to delimit our cluster geographically.

The Havenmonitor is a device that monitors the most important economic developments of ports, industries located in ports, and port regions as a whole. It divides the Netherlands in four different regions which contain the ports in that specific region. As we will see later on, 99.6% of all the employees in the port-related chemical industry in the Northern Netherlands are located within the borders of the municipality of Delfzijl. The input-output analysis of the cluster also gives us no suspicion that the cluster should be elaborated further. This is very important for the use of some variables in the model, since data are only available for the region as a whole and not for the municipality specifically. Because of this high density of employees we can use that data from the Northern Netherlands region as data for our cluster in Delfzijl.

We will therefore use the borders of the Northern Netherlands (Friesland, Groningen and Drente) as our geographical delimitation. Of course, this remains somewhat arbitrary, but because the concentration is so high, expanding the border wouldn't affect the results of this thesis significantly.

The fourth and final step is pretty much the execution of step 1, 2 and 3. Now that we have our economic specialization, the economic activities in that specialization and the geographic delimitation of the cluster we can identify the business units that are part of the cluster.

Measuring the Performance of a Cluster

The aim of this thesis is to identify variables that give a quick insight in the 'health' of a certain cluster. Health will simply be defined as the performance of a cluster in terms of value added (which will be explained later on). We won't make an entire cardinal scale from unhealthy to healthy, but rather we will look for variables that could give an instant insight in the current performance of a cluster since data on the performance itself of is always lagging.

Because clusters are basically networks of production, we will take a look at the performance of clusters and most important; the variables that influence them. First we will look at the best way to measure 'overall performance'. This part is executed in this paragraph. Then we will look at existing literature to identify the most potential and influential variables influencing the performance which is done in the next paragraph.

The most straightforward way to measure performance seems to be productivity. Productivity indeed does measure performance but only partly. If, for example, we look at two clusters with exactly the same production but one cluster has a growing population while the other one has a declining one, we could say that the former one is obviously doing better.

Two other possible ways to measure performance are inward- and outward foreign direct investments. The problem with outward foreign direct investment is that it isn't necessarily explained by the actual performance of the cluster. For example when a company is moving its production to another country because of lower wages. Investing in a foreign factory in this case doesn't mean that a cluster is performing well. On the contrary; it is a sign of a weak performing cluster, because the movement implies that another factory is either cheaper or better at producing.. Inward foreign investment is an indicator of performance but only partly since investments don't necessarily lead to a better performance.

The best and probably most complete measure of performance is the total value added by a cluster. Added value is the difference between the value of the inputs and the outputs of a certain cluster. It is important to note that this isn't the same as profit since other expenses (e.g. wages) have been deducted from profit but are in fact part of the value added. Because events in a certain year could also influence the value added in the next years, performance should be measured as all current and future added value.

The future added value, ofcourse, needs to be discounted. This can also be shown mathematically:

Net Present Value year t:

$VAp(t) = \sum_{i=1}^{n} VAi\ (t)$ where i= {1…n} p=population, n is the amount of companies.

The total cluster performance can be written as:

$CP_p(t) = VA(t) + \frac{VAp(t+1)}{1+r} + \ldots \frac{VAp(t+n)}{(1+r)^n}$

where $CP_p(t)$ is the current and discounted total performance of a cluster and r is the discount rate.

The method used in this thesis to calculate the value added in the chemical industry is copied from the Havenmonitor 2008. It is calculated by the input-output charts of the Central Bureau of Statistics. This chart divides the value added per sector(national level) by the amount of employees working in the sector (national level) and multiplies this with a region-specific coefficient. This coefficient reflects the differences in productivity per region and category of holding. It is related to the size and capital intensity of the holdings in that specific region. Finally, this number is multiplied by the amount of workers in the sector of the port/region and leaves us with total, direct value added by a sector in a specific port or region. (Nijdam, 2012)

This thesis will look for the variables that tend to influence this performance measure by means of a time-series analysis. These are the variables that we want to use as a device to instantly measure the performance (and therefore the health) of a chemical cluster.

Two major, general effects can be distinguished that influences the performance of a cluster; incumbent performance effects where value added by the business units in the cluster changes and the population effect where the amount of firms changes. In formula form:

$\Delta VA_p(t) = \Delta VAI_p(t) + \Delta VAP_p\,(t)$

$\Delta VA_p(t)$ = changes in total value added

$\Delta VAI_p(t)$ = changes in total value added caused by the incumbent effect

$\Delta VAP_p\,(t)$ = changes in total value added caused by the population effect

Both effects will be studied in this thesis.

Performance Indicators of the Chemical Industry

In the previous section we concluded that the total value added was the best way to measure the overall performance of clusters. In this section we will evaluate different variables that tend to influence the total value added and therefore influence the health of chemical clusters. These variables are deduced from existing literature on the performance of the chemical industry, including a case study of a chemical cluster located at Teesside (North England).

The first indicators are deduced from a recent study on new indicators to measure port performance. In their research, de Langen et al. distinguish three different port products: cargo transfer products, logistics products and manufacturing products. Chemical products are very often processed within ports and are therefore manufacturing products. According to their research, the best performance indicators were both the value added and the investments made in port manufacturing (Peter de Langen, 2007). Since we use value added as our overall indicator (and therefore dependant variable) we will make private inward direct investment one of our independent variables that (partially) explains the overall performance (value added). We will introduce investments in our regression with different lags, since investments in general don't affect the performance instantly but rather over time.

Three other indicators were deduced form Keith Chapman's research on Teesside's chemical industry. In his research, Chapman showed that employment at the Teesside chemical industry fell while total production remained unchanged. According to Chapman this is due to technological changes in chemical production, meaning that there is a negative relationship between production and employment. Two very important conclusions that Chapman also made were that the chemical industry was indeed very reliant on investments and that risks of territorial lock-in were increased by corporate concentration and reduced by corporate fragmentation (Chapman, 2005). The former is confirming the importance of investments as recognized by de Langen et al. while de latter gives us some insight in the case specific situation. Corporate concentration could be used as a dummy variable, but data to make the comparison is lacking since there are only data where the 'leader company' is present.

A fourth variable is derived from recent interviews with leaders of big chemical firms in the Financial Times. The subject of these interviews was the recent development of big chemical industries moving out of Europe. One of the interviewees, Kurt Bock (CEO Basf), said: 'In the next five years we will, for the first time in history, invest more outside of Europe than Europe itself... We invest in the USA because we expect gas prices to be less than half of that of Europe' (Bock, 2014). So gas prices obviously are very important for chemical industries. Not only directly, but also because of the influence it tends to have on the investments made in the chemical industry as being said in these interviews.

Because gas is also very important for the chemical cluster in Delfzijl, as will be showed later, we include gas prices as an independent variable in our time series. The gas price used in this thesis is derived from the World Databank and is the average price of gas for industries.

The fifth variable is derived from the fourth one. In the interviews, the CEO's stated that companies were moving out of Europe because of the higher gas prices. This implicates that they could get their gas cheaper elsewhere. Since they moved to the USA, the fifth variable will be a ratio of the European gas prices compared to the gas prices in the USA.

The sixth and final variable is the amount of new business formation. An increasing amount of firms suggests that the cluster is performing well, while a declining amount suggests otherwise. This statement was developed by Schumpeter in his books *Theory of Economic Development* and *Business Cycles* (Schumpeter, 1934) and was recently applied to regional development by Fritsch who confirmed that the formation of new businesses enhanced the growth of regions in terms of added value because of amplified innovation and increased competitiveness (Fritsch, 2011).

So now we will test the following equation both partially and as a whole:

$CP_t = \beta_0 + \beta_1 Inv_{t-x} + \beta_2 Emp + \beta_3 PGas + \beta_4 GasRat + \beta_5 NBF$

Where:

CP= Direct value added year t

Inv_{t-x}= amount of money invested in year t-x

Emp= Employment in year t

PGas= Dutch industrial gas prices in year t

GasRat= Dutch industrial gas price/American industrial gas price

NBF= amount of new business formations

After the time series analysis, all variables will be compared at national and international level. If a cluster is doing well or not isn't only determined by looking at the cluster itself but by comparing it to others as well. If, for example, the value added of cluster A doubled in 4 years you could say it is doing well. If clusters in the same industry however tripled their value added, it all of a sudden becomes a poor result. Comparing results is therefore very important when measuring performance.

3. Chemical Cluster Delfzijl

Delfzijl is currently the largest port of the Northern Netherlands in terms of employment, value added and amount of firms. It employs directly over 4200 people and added 560 million euro's of direct value in 2012 (Nijdam, 2012). The chemical cluster directly employs over a thousand people and is therefore the ports largest employer. It is also accountable for 36% of the total value added in the port making it the most value adding industry as well (Nijdam, 2012). The reason why Delfzijl is interesting in particular is that the region is heavily dependent on this industry. One out every twenty-five inhabitants of the municipality of Delfzijl for example, is currently working in the chemical industry. A study of health indicators for that particular industry is therefore very relevant. Because of its importance, health indicators could be very useful for both the companies located there, as well as the local government which has a significant interest in the industry. Early recognition of a poorly performing industry makes it easier for both companies and governments to intervene/stimulate the industry.

The chemical industry of Delfzijl consists of various firms that are both inter- and intrarelated. It is a cluster where most firms are interdependent since most of them are functioning as a different part of the same supply chain. To identify which firms are part of this cluster, we will use the method that we deduced in our theoretical framework from Langen's thesis (Langen, 2003).

The first step was to choose an economic specialisation with a broad geographical region. The specialisation used in this thesis is pretty straightforward: chemistry/the chemical industry. The broad geographical region will be the Northern Netherlands as defined by Oosterhaven (J. Oosterhaven, 2010). The Northern Netherlands consists of three county's: Friesland, Groningen and Drente.

The second step in his approach was to identify all economic activities within this cluster. The easiest way to start was to look for the presence of associations in the clusters region. The chemical cluster of the Port of Delfzijl indeed has an association: Chemiepark Delfzijl. Chemiepark Delfzijl employed 1250 people in 2008 (Lambert, 2009). In the same year, 1233 were working at the entire port-related chemical industry in the entire region (Northern Netherlands). This seems like a contradiction but the reason why the Chempiepark is slightly bigger is the presence of small firms that are related to, but not really a part of, the chemical cluster. The local restaurant for example is located at the Chemiepark but won't be included in the chemical industry since it doesn't perform any chemical related activities.

The important fact that we can derive from this is that the Chemiepark can be seen as almost the entire port-related chemical industry in that region. There were only a few companies outside the Chemiepark that are also part of the chemical industry and these are included in the cluster as they were recognized during an interview with Harry Jasken, communication manager of Chemiepark (Jasken, 2014). With these companies included, the entire port related chemical industry of the Northern Netherlands almost entirely exists of the chemistry cluster in Delfzijl. This is confirmed by looking at the value added in 2008. The chemical industry in Delfzijl contributed 98,2% of total direct value added in the entiry chemical industry of the Northern Netherlands (Nijdam, 2012). Note that it is very well plausible that some important suppliers are located outside the geographical area and therefore aren't included in the analysis.

We continue by making an input/output analysis to further identify the roles of the business units enrolled in this cluster. This is shown in Appendix 1. It is important to note that one of the strengths of this cluster is that it gains gas and salt, its most important inputs, from a local resource which makes it less vulnerable to shocks from abroad (Groningen Seaports, 2014). The salt is mined by AkzoNobel itself by pumping water into the ground that absorbs the salt and turns into brine. This is done in Veendam and Windschoten, approximately 30 kilometers from Delfzijl. The gas is bought from various suppliers but the main distributer is Gasunie (Jasken, 2014).

The third step is to define the geographical borders of the cluster. The geographical border of this cluster will be the one defined in our theoretical framework: the municipality of Delfzijl. Like we showed in the previous paragraph, almost the entire port-related chemical industry is located at Chemiepark Delfzijl. Expanding this border wouldn't make any sense since the cluster we are interested in is entirely located in the municipality of Delfzijl and expanding our geographic border wouldn't affect our results.

The fourth and final step is to identify the companies enrolled in this cluster. These are derived from step 1 to 3 and are shown in appendix 2. Note that appendix 2 is an extension of appendix 1, because appendix 1 only shows the flows between the cluster while there are also other companies involved that don't necessarily manufacture chemicals (e.g. storage). These are shown in appendix 2 as well.

To conclude: we defined our cluster by looking at the presence of an association and an expert interview. From the data provided by both the Havenmonitor and the expert interview we derived that Chemiepark Delfzijl plus a few additional firms contributed to nearly the entire value added by the total chemical industry in both Delfzijl and the Northern Netherlands. Therefore data of the port-related chemical industry of Delfzijl will be used as data of our cluster

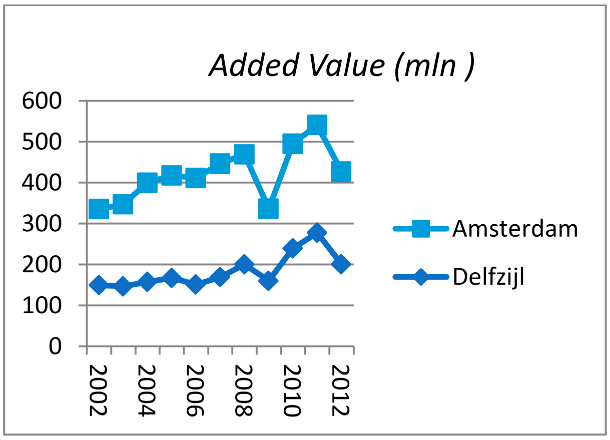
4. Data

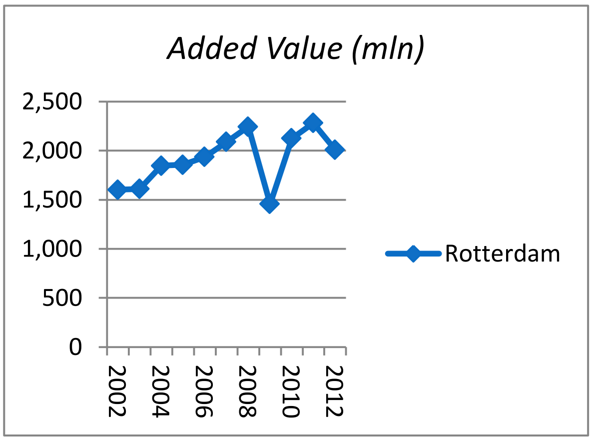
We have now identified the best way to measure the overall performance of a cluster, variables that probably tend to influence the performance of chemical clusters and the cluster which we are going to investigate. As being said before, Chemiepark Delfzijl employed nearly 100% of the employees in the entire chemical industry of both the municipality and the entire region. We will therefore use data of the entire port-related chemical industry of Delfzijl as data of the cluster, since these data are easier to obtain and the very small difference won't affect the outcomes of the result.

Direct Value Added

In figure 1 and figure 2, the performance/value added is shown of the chemical cluster of the period 2002-2012. It is shown alongside the performance of Amsterdam(figure1) and Rotterdam(figure 2), two Dutch ports which also give home to chemical clusters. The value added by the three ports seem to follow the same pattern; steadily growing from 2002 till 2008, followed by a sharp decline in 2008, again a sharp increase in 2009 followed by a sharp decrease in 2012. To test this relationship, a Pearson correlation test (two-tailed) is executed of which the results are shown in figure 117. Even though there were only 11 observations, a few significant relationships were observed. The chemical cluster of Delfzijl has a very strong, positive correlation with the chemical industry in the Port of Rotterdam (0,76). The chemical industry of Amsterdam had an even stronger correlation with its counterpart at the Port of Rotterdam (0,89). Delfzijl and Amsterdam also had a strong positive relationship, but (probably due to a lack of observation) this wasn't significant. These relationships implicate that the performance of these industries are (partly) influenced by common factors (e.g. economic circumstances). These factors will be further investigated in the next part of this chapter.

Figures 1 & 2 (Direct Added Value mln euro Amsterdam, Delfzijl, Rotterdam)



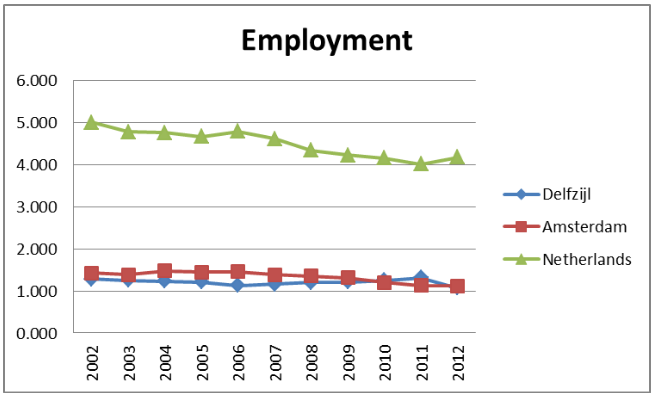


Direct Employment

According to Chapman, a negative relationship between the performance of chemical clusters and employment should exist (Chapman, 2005). The origin of this relationship lies in the fact that the chemical industry is highly influenced by technological changes. Because technological advancement is always a Pareto improvement (externalities not included), this should mean that when technological advancement occurs, the added value/employment ratio should increase. Note that this has nothing to say about absolute employment, only about the ratio.

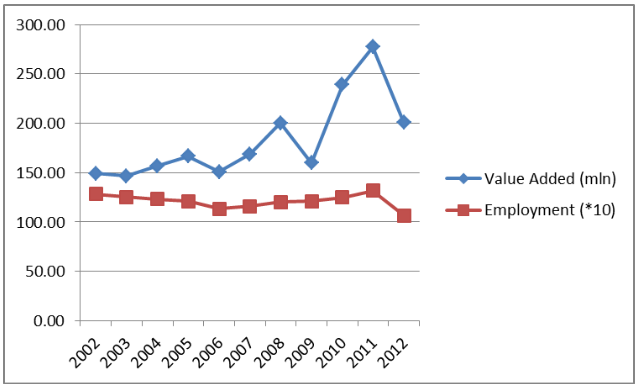
First we will look at the development of employment of the three Dutch ports in general (figure 4). The first striking observation is that employment in the chemical industry of Delfzijl is moving in the opposite direction of both the chemical industry in Rotterdam and Amsterdam. This could be due to the fact that these ports are competing in the same labour pool, meaning that an increase of the labour force in Delfzijl means a decrease of the labour force of Rotterdam and/or Amsterdam. Testing the relationship between these ports however, shows that this relation isn't an significant one(figure 101).

Figure 4 (Direct Employment chemical industry Amsterdam, Rotterdam, Delfzijl).



The relationship between employment and value added is an ambiguous one in the chemical industry. On one hand, a better performing industry is attracting more employees since the business is going well. On the other hand, a better performing chemical industry is often due to technological advancement, meaning that less employees are needed for the same amount of added value. When we look at figure 5, we can see that from 2002-2006, there is a negative relationship between added value and employment in Delfzijl, meaning that the latter effect is dominating. From 2006 and onwards however, there seems to be a positive relationship meaning that the former effect is dominating. It is therefore ambiguous if employment is useful as an predicting variable, but we will see that later on in the regression. Testing this relation indeed shows us that there isn't a clear overall relationship, but that there is a negative one from 2002-2006 (figure 102) and a positive one from 2006-2012 (figure 103). Please note that the significance level is 10% which is quite high, but is still worth mentioning since there were only 11 observations

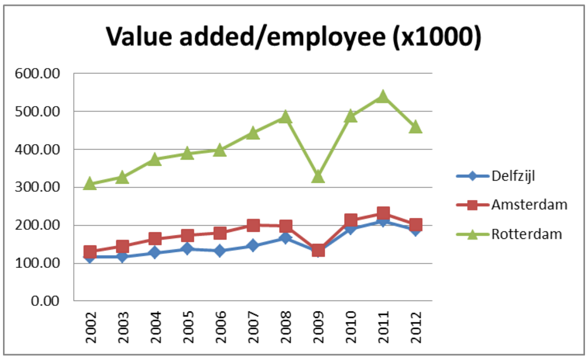
Figure 5 (Relationship Direct Value Added (mln€) and Direct Employment)



The last comparison that is relevant is the difference between the value added/employee per port (figure 6). It isn't surprising that these variables are strongly, positively correlated. It is surprising, however, that the value added/employee is almost three times as high in Rotterdam, than it is in both Amsterdam and Delfzijl. This is probably due to the scale economies that Rotterdam has over Amsterdam and Delfzijl (total value added is almost 10 times as high). Other sources that could also be the cause of this major difference are, for example, different kinds of chemical industry[1].

The investigation of this cause is very interesting, but not a part of this thesis and won't therefore be further investigated.

Figure 6 (Direct Value Added/Employee, Amsterdam, Rotterdam, Delfzijl)



To conclude: there isn't a clear relationship between employment and total value added. The relationship can be both positve or negative, depending on which effect (attractive sector vs. technological replacement) is dominating.

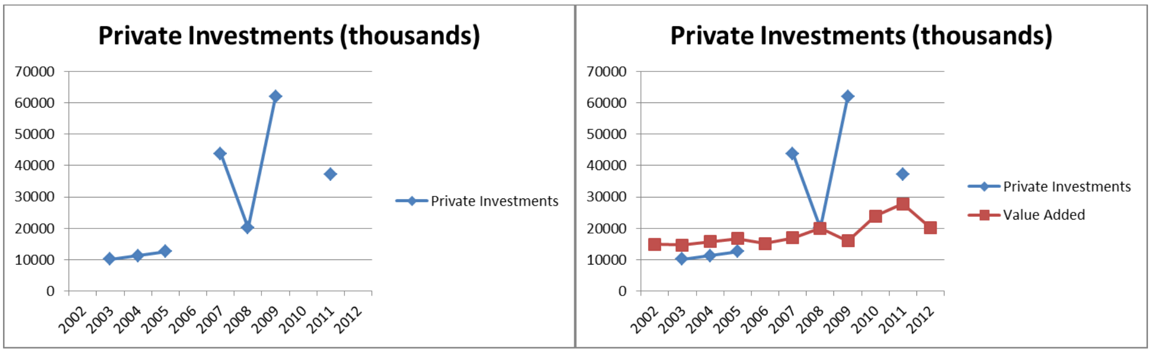
Investments

As being said before, the chemical industry is an industry with a relatively high capital/labour ratio. Technological advancements therefore have a bigger impact on the chemical industry than less capital-intensive industries. For this reason we believe that the performance of a chemical industry is heavily influenced by investments. The problem of collecting data for investments in

[1] The chemical industry in Delfzijl is using salt as one of its major inputs, while the chemical industry in both Rotterdam and Amsterdam could use other inputs

clusters is that it is often classified. The Central Bureau of Statistics does collect the data, but only reports them when they believe it is a reliable observation. For this reason, some holes in the data appear, since the statistics bureau doesn't believe they have a reliable view on the investments in these years. Another handicap of this thesis is that investments in port related industries were only measured from 2000 and onwards. On the time of writing, there were only 7 reliable observations available, meaning that the significance of results could be low. They will still be included because results could show signs of relationships (e.g. the lag of investments on the value added) that could be investigated when more data becomes available. Figure 7 shows the relationship between private investments and Total Added Value over time.

Figure 7(Private investments & Private investments compared to Direct Value added)



When looking at these graphs, we can spot a slight lag of the private investments behind the total value added which seems logic since production is only increasing when the investments are being used, not being made. This is confirmed by testing the correlation of different lags (figure 104), where there wasn't even a near significant relationship between value added and private investments without a lag, while the relationship between investments lagging one year and value added was over 99%. Unfortunate, these lags couldn't be elaborated much further, because data of total value added was only available until 2012.

The expert interviews mentioned in the framework suggested that investments were heavily reliant on the prices of gas. Higher gas prices would reduce profitability and would therefore implicate a lower return on investment, leading to less investments over time. When we look at the relationship between these variables in SPSS we can spot a significant relationship between gas prices with a lag of one year and investments (figure 105). Once again, the lags couldn't be elaborated further due to a lack of data, but the relationship between gas prices and investments are significant.

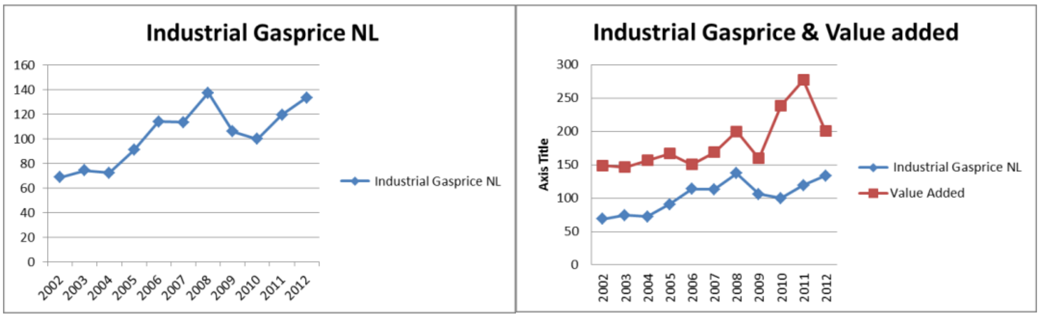
When we look at the causality of these variables, we can see that the price of gas has an influence on the amount of investments in that specific area and that investments increase the value added by the cluster. Both gas prices and investments will be included in the model, because the price of gas has two effects on the performance of a cluster: first, it has an influence on the costs which will be shown in the next paragraph. Second, it has a significant leverage on the investments which also tends to influence the performance.

Gas prices

This variable was derived from the trend that big chemical companies were moving from Europe to (mostly) US. During interviews, the CEO's of these companies stated that gas prices were almost twice as high in Europe as compared to the US. The reason why gas is particularly relevant for this cluster is that this cluster is heavily reliant on gas as it is one of its main inputs. This is shown in the input-output analysis in Appendix 1. The fact that gas is obtained at a local resource isn't relevant for the performance of the cluster by means of price. The cluster in Delfzijl is less vulnerable for foreign shocks, but when gas prices are high and the value added by the cluster isn't profitable enough, gas will probably be transported to other places since its opportunity costs have become too high.

The development of gas prices are shown in figure 8. These are mainly determined by the price of oil because most gas contracts are indexed by the price of oil (Nuon, 2013). Remarkable is the fact that it doubled in 6 years(2002-2006), dropped 29% in the next 2 years, only to rise 35% again in the next two years. When we look at the relation between these variables in SPSS, we can see a strong, positive relationship with a significance level of 11% (figure 107). Once again, this is probably due to a lack of data rather than a lacking relationship. Both the interviews and the data implicate the existence of this relationship. The remarkable thing about this relation is that it is a positive one, while a negative one was expected since it is a cost rather than a benefit. A possible reason for this positive relationship might be that when the margins used by the chemical industry remain the same, and the costs of the inputs rise, the sales prices also rise, resulting in a bigger net profit and also more value added. This reason, however can't be sustainable, because customers eventually will replace the now more expensive products with cheaper substitutes. This is also one of the reasons why companies are currently moving out of Europe and to the USA. Whether this relation is really positive will be seen in the regression (because when other variables are included, this relationship can turn out to be negative as is expected).

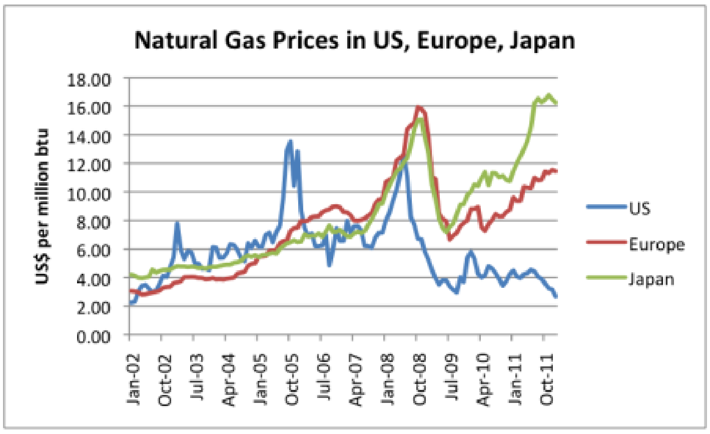
Figure 8 (Industrial Gasprice ($/100.000 btu) & Direct Value Added)



Gas price ratio

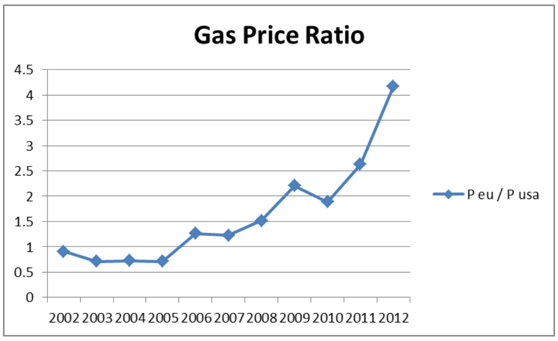
Not only the price of the gas used by the chemical industry is important to its performance. The relative gas price is very important as well, because significantly cheaper gas at other sites could mean a shift of investments and industrial activity. When we look at the development of the gas prices in figure 9, we can see that from 2008 and onwards, prices started to deviate from each other. Gerard van Harten (CEO Dow Chemical) referred to the fact that the US was investing in mining a new type of gas: shale gas, which was mined by fracking a certain type of stone that people weren't able to frack before.

Figure 9 (Natural Gas Prices US, Europe, Japen ($/mln btu) (World Bank, 2014)



The gas price ratio was deduced from the data collected by the world bank. Figure 10 shows the development of this ratio from the past 12 years.

Figure 10 (Gas Price Ratio Europe/USA)

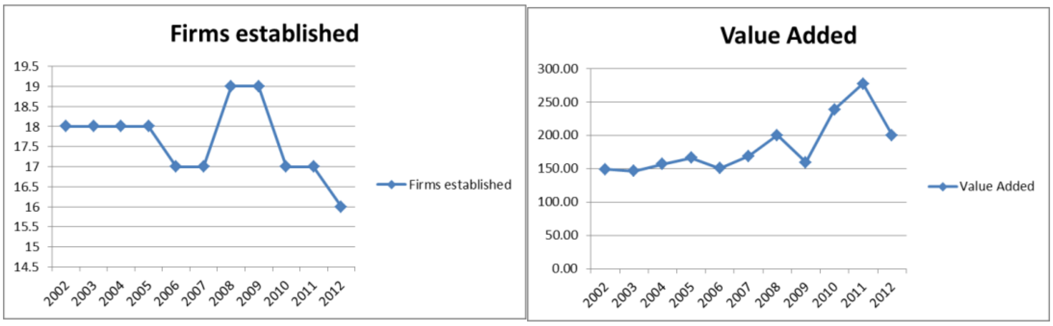


As can be seen in figure 10, the gas price ratio four folded in 10 years time, which means that investing in gas-related chemical industry in Europe became less and less attractive over time as stated by van Harten. When we look at the relationship between the gas-price ratio and the development of the investments in Delfzijl, we can see that this this ratio has indeed an significant effect on the amount of investments with a lag of 2 years made in the chemical industry of Delfzijl (figure 109). This means that both the gas price and the gas price ratio are influencing the amount of investments and therefore the total value added. There is, ofcourse no direct effect of the gas price ratio on the total value added, because it is only relevant for the amount of investments made. It doesn't influence the costs of producing directly, only indirectly because of the investments mentioned earlier.

New Business Formation

The final variable we suspect as an indicator of the health of a cluster is the amount of new businesses that are established. This is simply measured by looking at the amount of port-related chemical companies that are established in the Northern Netherlands as recognized by the Havenmonitor. The evolution is shown in figure 11.

Figure 11 (Firms Established & Direct Value Added)



Even with some lags, no significant relation between the amount of businesses and total value added was found. This is counterfactual to our believe that more businesses implied more value added. This could be due to the fact that the port related chemical industry in Delfzijl only houses 16 companies and is therefore much more vulnerable to 'random shocks' compared to bigger clusters. By random shocks we mean that when, for some reason, one company leaves or moves to the cluster, the amount of firms immediately rises by 6%. This 6% sounds like a substantial increase, but is still just one firm more/less. So due to its size, new business formation won't probably be a good indicator of the health of this particular cluster.

The Model

In the previous section of this part, we tested if the variables we identified in the theoretical framework had a significant relationship with the total value added by a clusters. By doing this, we tested if they were useful as a possible indicator of the health of a cluster. Note that this didn't necessarily implied causality, but that these relationships could still be very useful. In this thesis, we are basically trying to develop some sort of a thermometer that can give an instant view of the health of a cluster. Thermometers themselves also give a quick view on the health of a person without saying anything about the cause of it and are still very useful.

Performing a regression is done for the sake of two particular reasons. The first reason is that it can further investigate causal relationships between the variables and the health of a cluster. Causality isn't a necessary condition for an indicator to be good, but is essential for policy makers that try to increase/stimulate the overall performance. The second reason is that several factors combined could be a more accurate indicator than the variables individually.

The regression below shows the hypothetical relationship between the variables we recognized and the total value added. Some variables have been added with some lags, as identified in the previous part.

$$ValAdd_t = \beta_0 + \beta_1 Inv_{t-1} + \beta_1 Inv_{t-2} + \beta_2 Emp + \beta_3 PGas + \beta_3 PGas_{t-2} + \beta_4 GasRat_{t-3} + \beta_5 NBF$$

First we made a regression with all variables separately on the total value added. These results are shown in figure 110. There were significant relationships between total value added and investments(lagging one year), and gas prices (lagging two years). Gas prices without a lag was nearly significant with a probability of 5.8%

The regression that was most noteworthy was the one where the total value added is predicted by a constant plus the investments with the lag of one year. This is shown in figure 12. Both the constant and the investments have a highly significant, positive effect on the value added in a cluster. This variable by itself also manages to explain 94 percent of the variance of the value added. The coefficient of the investments implies that the total value added rises with 1.57 euro's for every euro invested in the previous year. The probability of the F-statistic was also 0.0003, meaning that the model as a whole was also significant.

Figure 12.

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.38E+08	5780718.	23.82595	0.0000
INVESTMENTSLAG1	1.569548	0.171489	9.152480	0.0003
R-squared	0.943673	Mean dependent var		1.82E+08

When adding a second lag to the model (2 years), we can see that this second variable is highly insignificant, meaning that it is not usefull in predicting the performance of the cluster (figure 111).

Because we saw a significant relationship between both investments(-1) and Gasprices(-2) with value added we will test if the relationship between investments and value added can be explained by the gasprices itself. This is done in figure 112. As can be seen in the figure, the gasprices(-2) have a significant effect on the amount of investments(-1). When both variables are used in the same model however, the effect of gasprices(-2) on value added becomes highly insignificant while investments(-1) remains significant (figure 113), meaning that only the investments(-1) influences the value added.

This leaves us with the model where both gasprices and investments(-1) significantly influence the performance of clusters. This model has a probability(F) of 0.001677, while the single regression with investments(-1) had a probability(F) of 0.000261. The former model has a higher R^2, meaning that it is better at predicting the total value added by the cluster (figure 114) even though it is slightly less significant as a model (while still significant). Because the aim of this model is to identify relationships rather than trying to infer causality, we include gasprices as well, even though they aren't significant. This leaves us with the following model:

Value $Added_t$ (mln)= 147.8 + 1.71*Investments(-1) – 1.61*Gasprice ($/mmbtu)

The model didn't suffer from auto-nor partial correlation (figure 115). The residuals were homoskedastically spread (figure 116) and had a normal distribution (figure 117).

The real values and predicted values are shown in figure 13. Because some investments were classified (and were therefore calculated as 0, while they actually were present) these observations have been removed and the new comparison is shown in figure 14. As can be see, this regression is now much more precise compared to the previous one.

Figure 13(Direct Value added & predicted value)

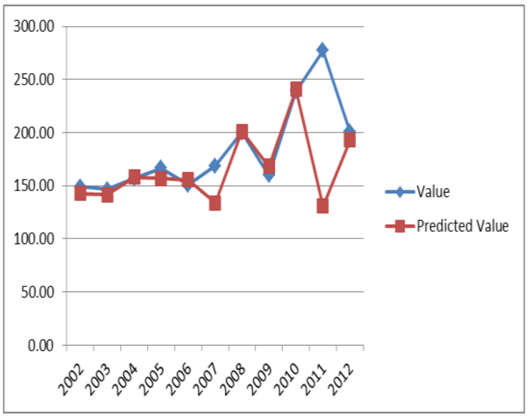
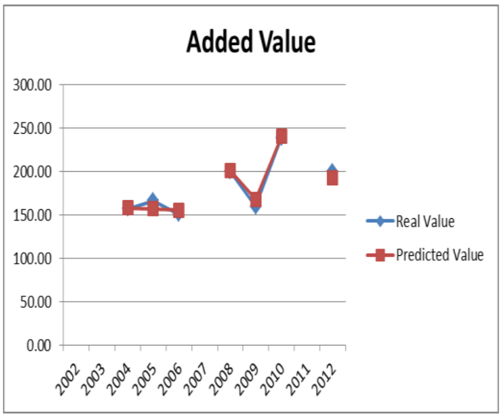


Figure 14 (Direct Value Added predictions)



This regression enables us to make accurate predictions about the direct value that will be added in year t, because it lags one year behind on investments and gas prices are widely available. Other indicators are gas prices with a lag of 2 years, investments with a lag of one year and current gas prices individually. As being said before, gas prices(-2) have a significant effect on the investments made in the upcoming year (investments-1) and investments(-1) have a significant influence on the value added in the year afterwards. This means that the earliest way to identify (big) changes in the health of this port-related chemical cluster is a change in the gasprice, which will affect the health two years later. A more precise indicator which can be observed one year later is the amount of private investments made in the cluster. These effects are shown the year after. The most accurate display of the health of a cluster is the use of the regression developed above where both the investments(-1) and current gas prices have a direct influence on the current performance/health of the cluster.

5. Conclusion

The economic importance of chemical clusters is comprehensive at both national and regional level. Due to its importance, it is meaningful for both companies and policy makers to have a clear view on the health of such a cluster. This thesis used the port-related chemical industry in Delfzijl as a case study to measure such 'health' and find indicators that are able to give an accurate, instant view on how well such a cluster is performing. The best way to define the health of a relation is to look at the performance of a cluster, since clusters are basically networks of production. The most accurate way to measure performance is by looking at the value added by a certain cluster in a given year.

The chemical cluster of Delfzijl mainly uses natural gas and brine as its main raw material inputs. Because of this attribute, it's performance is significantly influenced by gas prices. The first way in which gas prices tend to influence the performance of a cluster is its influence on the investments made in the chemical cluster. Gas prices have a significant relationship with these investments which in their turn have a significant influence on the performance of the cluster. Current gas prices also have a significant effect, because it is used as one of the main inputs. An increase in price implies an increase in the costs of that cluster and therefore a decrease in the value added by that specific cluster. The advantages of using the gas prices as an indicator is that they are very easily obtainable and because the net effect takes two years to occur, policy makers are able to intervene on time whenever needed. The most accurate way to have an instant view on the health of a chemical cluster is to look at the regression stated below:

Value Added$_t$ (mln)= 147.8 + 1.71*Investments(-1) – 1.61*Gasprice ($/mmbtu)

A major handicap of this research is the short period over which the data is collected. Detailed data were only available from 2002 and onwards. On top of that, some data of one of the most important variable: investments, were sometimes missing, because information on investments was often classified and therefore unavailable. The amount of observations for the conclusions we have derived was sufficient, but more observations are needed to further investigate other variables. Another observation that should be made is that this thesis did only partial research on the causality of variables. Since we're basically building a thermometer which measures the wellbeing of a cluster, we are more interested in the ability of this thermometer to measure accurately, rather than giving the exact cause of a probable illness. Once again, some causality has been recognized, but further research needs to be done when more data becomes available. The results of this thesis can be used for other port-related chemical clusters as well, as long as gas is used as one of the main inputs and conclusions are dealt with caution. The regression, of course is useless, since every cluster is a unique one, but the general relationship between gas prices, investments and value added can be seen generic one.

Figure 101 (correlation employments).

Correlations

		Delfzijl	Amsterdam	Rotterdam
Delfzijl	Pearson Correlation	1	.011	.009
	Sig. (2-tailed)		.974	.978
	N	11	11	11
Amsterdam	Pearson Correlation	.011	1	.876**
	Sig. (2-tailed)	.974		.000
	N	11	11	11
Rotterdam	Pearson Correlation	.009	.876**	1
	Sig. (2-tailed)	.978	.000	
	N	11	11	11

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 102 (correlation value added/employment)

Correlations

		Addedvalue	Employment
Addedvalue	Pearson Correlation	1	-.851
	Sig. (2-tailed)		.149
	N	4	4
Employment	Pearson Correlation	-.851	1
	Sig. (2-tailed)	.149	
	N	4	4

Figure 103 (correlation value added/employment)

Correlations

		Addedvalue	Employment
Addedvalue	Pearson Correlation	1	.670
	Sig. (2-tailed)		.099
	N	7	7
Employment	Pearson Correlation	.670	1
	Sig. (2-tailed)	.099	
	N	7	7

Figure 104 (correlation Investments with lags en Value Added)

Correlations

		Investment	ValueAdded
Investment (no lag)	Pearson Correlation	1	.217
	Sig. (2-tailed)		.606
	N	8	8
ValueAdded	Pearson Correlation	.217	1
	Sig. (2-tailed)	.606	
	N	8	11

Correlations

		Investment	ValueAdded
Investment (lag 1 year)	Pearson Correlation	1	.971**
	Sig. (2-tailed)		.000
	N	7	7
ValueAdded	Pearson Correlation	.971**	1
	Sig. (2-tailed)	.000	
	N	7	11

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		Investment	ValueAdded
Investment (lag 2 years)	Pearson Correlation	1	.639
	Sig. (2-tailed)		.172
	N	8	6
ValueAdded	Pearson Correlation	.639	1
	Sig. (2-tailed)	.172	
	N	6	11

Figure 105 (Correlation gasprice en investments).

Correlations

		Investments	GasPrice
Investments	Pearson Correlation	1	.894**
	Sig. (2-tailed)		.007
	N	7	7
GasPrice (lag 1 year)	Pearson Correlation	.894**	1
	Sig. (2-tailed)	.007	
	N	7	11

Figure 107 (Correlation Value Added en Gas price)

Correlations

		ValueAdded	GasPrice
ValueAdded	Pearson Correlation	1	.510
	Sig. (2-tailed)		.109
	N	11	11
GasPrice	Pearson Correlation	.510	1
	Sig. (2-tailed)	.109	
	N	11	11

Figure 109 (Correlation gas-prijs ratio / Investments)

Correlations

		GPratio	Investments
GasPrice ratio (lag 2 years)	Pearson Correlation	1	.918**
	Sig. (2-tailed)		.010
	N	11	6
Investments	Pearson Correlation	.918**	1
	Sig. (2-tailed)	.010	
	N	6	8

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 110. Single Regressions

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.38E+08	5780718.	23.82595	0.0000
INVESTMENTSLAG1	1.569548	0.171489	9.152480	0.0003
R-squared	0.943673	Mean dependent var		1.82E+08

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.53E+08	30743606	4.963735	0.0077
INVESTMENTSLAG2	1542.681	929.0986	1.660406	0.1722
R-squared	0.408017	Mean dependent var		1.94E+08

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-22723888	2.33E+08	-0.097681	0.9243
EMPLOYMENT	1.70E+08	1.92E+08	0.886737	0.3983
R-squared	0.080347	Mean dependent var		1.83E+08

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.23E+08	29718370	4.145999	0.0025
GASPRICE	7592068.	3497204.	2.170897	0.0580
R-squared	0.343679	Mean dependent var		1.83E+08

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.17E+08	21607879	5.427840	0.0004
GASPRICELAG2	9951876.	2966857.	3.354350	0.0085
R-squared	0.555592	Mean dependent var		1.83E+08

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.33E+08	32717118	4.060853	0.0028
GPRATIOLAG3	45722475	27700964	1.650573	0.1332
R-squared	0.232370	Mean dependent var		1.83E+08

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.81E+08	2.50E+08	1.921322	0.0869
NBF	-16864894	14167916	-1.190358	0.2644
R-squared	0.136024	Mean dependent var		1.83E+08

Figure 111

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.43E+08	13660622	10.48907	0.0605
INVESTMENTSLAG1	1.667014	0.304862	5.468102	0.1152
INVESTMENTSLAG2	-395.0144	467.6932	-0.844602	0.5535
R-squared	0.967694	Mean dependent var		1.79E+08

Figure 112

Dependent Variable: INVESTMENTSLAG1
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GASPRICELAG2	4156221.	399846.8	10.39453	0.0000
R-squared	0.825367	Mean dependent var		28177571

Figure 113

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.43E+08	8600298.	16.59939	0.0001
GASPRICELAG2	-2122887.	2606983.	-0.814308	0.4612
INVESTMENTSLAG1	1.928752	0.475517	4.056115	0.0154
R-squared	0.951683	Mean dependent var		1.82E+08

Figure 114

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.48E+08	9893575.	14.93909	0.0001
INVESTMENTSLAG1	1.709475	0.199403	8.572953	0.0010
GASPRICE	-1609271.	1313114.	-1.225538	0.2876

R-squared	0.959050	Mean dependent var	1.82E+08
Adjusted R-squared	0.938574	S.D. dependent var	32289000
S.E. of regression	8002566.	Akaike info criterion	34.92595
Sum squared resid	2.56E+14	Schwarz criterion	34.90277
Log likelihood	-119.2408	Hannan-Quinn criter.	34.63943
F-statistic	46.83959	Durbin-Watson stat	2.447393
Prob(F-statistic)	0.001677		

Dependent Variable: VALUEADDED
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.38E+08	5780718.	23.82595	0.0000
INVESTMENTSLAG1	1.569548	0.171489	9.152480	0.0003

R-squared	0.943673	Mean dependent var	1.82E+08
Adjusted R-squared	0.932408	S.D. dependent var	32289000
S.E. of regression	8394644.	Akaike info criterion	34.95904
Sum squared resid	3.52E+14	Schwarz criterion	34.94359
Log likelihood	-120.3566	Hannan-Quinn criter.	34.76803
F-statistic	83.76789	Durbin-Watson stat	2.316888
Prob(F-statistic)	0.000261		

Figure 114 (correlogram of residuals)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.156	-0.156	0.2556	0.613
		2	0.008	-0.017	0.2564	0.880
		3	-0.127	-0.132	0.5102	0.917
		4	-0.321	-0.378	2.6789	0.613
		5	-0.016	-0.180	2.6874	0.748
		6	-0.139	-0.279	3.8996	0.690

Figure 116

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.543293	Prob. F(2,4)	0.6184
Obs*R-squared	1.495325	Prob. Chi-Square(2)	0.4735
Scaled explained SS	0.237037	Prob. Chi-Square(2)	0.8882

Figure 117

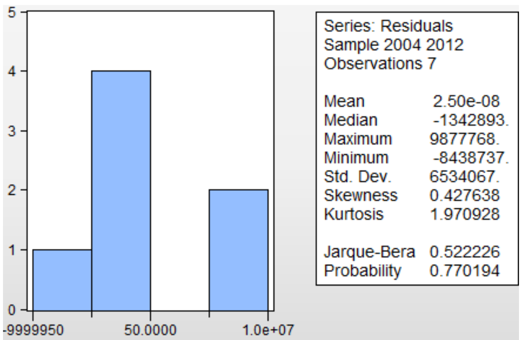


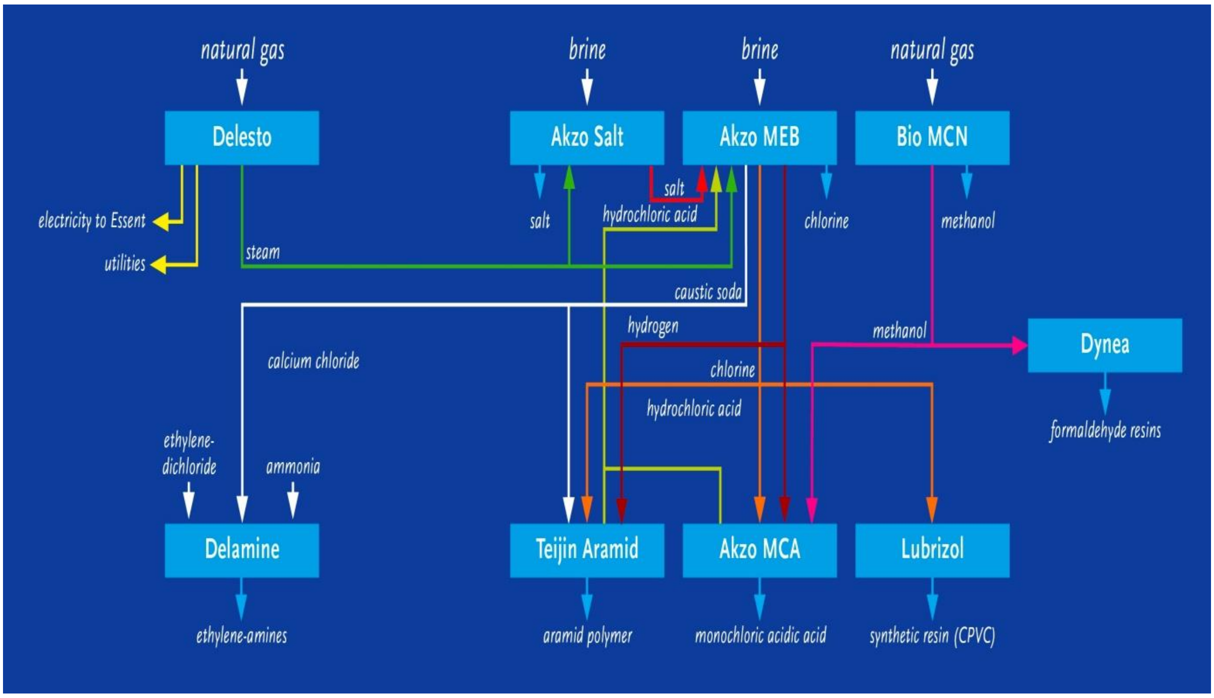
Figure 118

Correlations

		Delfzijl	Amsterdam	Rotterdam
Delfzijl	Pearson Correlation	1	,450	,746**
	Sig. (2-tailed)		,164	,008
	N	11	11	11
Amsterdam	Pearson Correlation	,450	1	,892**
	Sig. (2-tailed)	,164		,000
	N	11	11	11
Rotterdam	Pearson Correlation	,746**	,892**	1
	Sig. (2-tailed)	,008	,000	
	N	11	11	11

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 1.


natural gas
brine
brine
natural gas
Delesto
Akzo Salt
Akzo MEB
Bio MCN
electricity to Essent
utilities
steam
salt
salt
hydrochloric acid
chlorine
methanol
caustic soda
hydrogen
methanol
Dynea
calcium chloride
chlorine
hydrochloric acid
formaldehyde resins
ethylene-
dichloride
ammonia
Delamine
Teijin Aramid
Akzo MCA
Lubrizol
ethylene-amines
aramid polymer
monochloric acidic acid
synthetic resin (CPVC)

Appendix 2.

Company	Economic activity
Delesto	Cogeneration that processes natural gas intro utilities and steam
Akzo Salt	Refining salt from brine
Akzo MEB	Processing brine into chlorine
Bio MCN	Processes natural gas into bio ethanol
Dynea	Using the methanol created by Bio MCN to make formaldehyde resins
Lubrizol	Mixing chloride and PVC-powder intro synthetic resin (CPVC)
Akzo MCA	Producing monochloric acidic acid from chloride gas and acidic acid
Teijin Aramid	Making aramid polymers by using the caustic soda, chlorine and hydrochloric acid from Akzo MEB
Delamine	Producing ethylene-amines from ammonia and ethylene dichloride
Gasunie	Mining and transporting the gas to Delesto and Bio MCN
SGS	Inspecting, verifying and analysing the chemical processes at the park
Stork	Maintenance and installation of the chemical assets
JPB Logistics	Storage and transport of chemical substances
Peroxychem	Hydrogen Peroxiplant

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