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The effectiveness of policies to transform a gas-exporting country into a gas-transit country: The case of The Netherlands[☆]

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HIGHLIGHTS

- The Netherlands has been a major gas producer and exporter for decades.
- This country implemented a gas hub policy to deal with diminishing resources.
- We study the effects of this policy using hourly data over the period 2006–2013.
- Storage and trading became more important, but transit hardly grew.
- The investments in the gas hub did not have clear effects in the short term.

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ABSTRACT

The Netherlands has been a major European natural gas producer and exporter for many decades, but now faces the challenge to deal with diminishing resources. In response, the Dutch government initiated a gas-hub strategy, which is the policy to transform the gas industry from an export-oriented business into a transit-oriented business. This policy included a number of investments in the gas infrastructure as well as institutional reforms to enhance the liquidity of the gas market. We study the effects of this gas-hub policy. Using hourly data on the Dutch gas balance over the period 2006–2013, we find that gas storage and trading have become more important, but that the level of gas in transit in the Netherlands remained fairly constant. Consequently, the Dutch gas industry is still mainly oriented on domestic production and export of gas, while the Dutch gas hub (TTF) has become a key virtual trading place. The policy lesson from the Dutch experience is that implementing a gas-hub strategy requires significant investments in the gas infrastructure, while their effects do not necessarily become visible in the short run.

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1. Introduction

Energy markets have been in transition for the past decade and will probably be so even more in the immediate future. Many natural resources are depleting and several scholars believe that the world's production of conventional oil will peak in the coming decades (Sorrel et al., 2010). Although gas reserves are estimated to be more lasting than oil, at least some of the gas-producing regions are anticipating the looming depletion of their gas reserves (Paltsev et al., 2011). When a country's production of gas decreases and eventually stops, it will lose both a secure form of energy supply and a source of income (Kruyt et al., 2009). In response, energy-supply security may be restored by

importing gas or by using alternative energy sources, but both options may coincide with considerable costs (Stern, 2004). Probably more complex, however, is the transition to other suitable sources of profits and employment. Such transformations have been subject to debate in several countries. The United States found, through technological development, an alternative in shale gas production, while the United Kingdom has pivoted from being an exporting country into a net importer in 2006, which coincided with several expansions of their import and storage capacity (Stern, 2004; POST, 2004). This country now largely depends on imported gas, but with continuing high risks on shortfalls during cold days (Skea et al., 2012).

Another country that is facing the challenge to transform its energy industry is the Netherlands. This country has been a major European producer of gas for more than half a century, with a yearly

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production of around 80 billion cubic metre (bcm). Roughly 60 bcm is exported yearly, mainly to other European countries (IEA, 2014). The reserves of the country's largest field in the Northern Province Groningen¹ are expected to decrease at such a pace that within the next 10–15 years the Netherlands will be unable to meet national demand with its own gas production and, consequently, it will become a net gas importer (The Brattle Group, 2010; TNO, 2014). Hence, Dutch policy makers face the challenge of transforming the gas industry so that it can withstand the loss of income and the reduced security of gas supply. In an attempt to fulfil their aspirations, the Dutch government introduced a package of policy measures in 2006 that should turn the country into the gas hub of north-western Europe (Brattle Group, 2010). As the region's main transit and trading location, the Netherlands aims to import gas from different places in the world in order to distribute it to neighbouring European countries. Profits of this would come from adding flexibility to the flat flow of imports, i.e. by balancing the near constant flow of supply from imports with the more volatile demand for gas. The goals set in these plans require investments in network capacity, connections with neighbouring countries, storage facilities and trade facilities.

The case of the Netherlands is different from the UK in the sense that it is expected to remain an exporter for at least another decade. Contrary to the UK, where policy changes in the 1980s accelerated gas production at the fastest possible rate, the Netherlands has focused on extending their production into the future (Correljé and Odell, 2000). The Netherlands implemented the so-called small-fields policy which was meant to produce gas from the small gas fields (both onshore and offshore) as much as possible and to conserve the gas in the Groningen field as long as possible. The Groningen field is mainly used for delivering flexibility, both in the short term as seasonal (summer–winter periods). The ability of Groningen to act as a swing supplier, however, is expected to diminish in the near future. In addition, the increasing occurrence of earthquakes caused by the gas depletion in Groningen has triggered social pressure to reduce gas production from this field (Dutch Safety Board, 2015). As a result, the gas security is not immediately at risk in the Netherlands, but for flexibility other sources will increasingly be needed. Moreover, the Dutch government looks for economic benefits from the gas-hub strategy, now the Groningen field can no longer cover all peak production and, hence, will generate fewer revenues.

This paper analyses the development of the Dutch gas hub since its initiation in 2006 by analysing how the Dutch gas balance has changed over time in response to a number of policy measures. The main question addressed in this paper is to what extent the Dutch gas market has changed from a domestic-supply driven market into a transit market. We will first set out the key characteristics of the Dutch gas market, including the most important steps taken and the investments made towards the gas hub over the past eight years (Section 2.1). Next we define the indicators we have developed to measure the development of the hub (Section 2.2). In Section 3, we apply these indicators on hourly data on the Dutch gas balance. In Section 4, we discuss our findings regarding the impact of investments and other policy measures directed at the Dutch gas hub. In Section 5, finally, we elaborate on these conclusions from a policy perspective.

2. Methods

2.1 The Dutch gas market

2.1.1 The Dutch gas balance

The role of the Netherlands on the European gas market is about to change, as it has done several times over the past decades. After the

discovery of the massive natural gas reserves in Groningen in 1959, the Dutch quickly became Western Europe's leading gas supplier, with a market share of over 50% in the early 70s (Correljé and Odell, 2000). The role of the Groningen field is extraordinary because of its giant size and geophysical characteristics making it suitable to serve as a swing supplier. The field can provide both long-term and short-term flexibility against relatively low marginal costs. Consequently, it is not only a crucial factor for a secure gas supply, but it also able to generate significant profits by selling gas when the market is tight and, hence, prices are relatively high.

The contribution of the gas production to the Dutch GDP increased to approximately 8% in 1985 and decreased afterwards to the current 3%, which is equal to about 16 billion euro per year (Rossem and van Swertz, 2010). The annual revenues for the Dutch government from the depletion of gas fields are about 10 billion euros, which is about 5% of its total revenues. Over a period of 50 years, the Dutch government earned over €210 billion. The country, however, failed to maintain its leading position on the European gas markets due to policy measures that constrained production in Groningen and gave incentives to competitors to enter energy markets in Europe (Correljé and Odell, 2000). Blurred visions on level of scarcity of gas and political desires to secure domestic demand with national gas reserves led to several economically sub-optimal choices (Correljé, 1998; Mulder and Zwart, 2006). In the 1980s, the expectation was that the gas production in the Netherlands would quickly diminish and policy measures were required as a response (Evans, 1981). Although later attempts to further penetrate the European energy markets and regain the market share of the old days were unsuccessful, the Netherlands remained a dominant player in Western Europe thanks to the Groningen field.

The contribution of Groningen and other sources of gas to the Dutch market are depicted by Fig. 1, which represents the so-called “gas balance”. The bottom of this figure shows the fairly flat imports and production from small gas fields (both onshore and offshore), while the Groningen field as well as the extraction from storages cover the peaks in demand. The seasonality in demand mainly comes from domestic residential consumers as well as export, indicating that the Groningen field is mainly used to supply seasonal flexibility, i.e. to meet both domestic and foreign demand during winters. From Fig. 2, it appears that storages are increasingly used for providing seasonal flexibility as well, besides more short-term flexibility. This figure also shows that linepack is the third source of flexibility, which is the ability of the transport network to deal with short-term imbalances between injection and extraction (Van Dinther and Mulder, 2013). It appears that the magnitude of the source exceeds the contribution of storages a number of years ago, but the latter has increased strongly in the recent past.

Fig. 1. Gas balance of the Netherlands, 2006–2013 (per month). Source: ACM/GTS.

¹ Throughout this article we refer to the Netherlands' largest gas field by “the Groningen field” or simply “Groningen”.

Fig. 2. Three sources of flexibility: linepack, net storages (exit minus entry) and the production by the Groningen gas field, 2006–2013 (per hour). Source: ACM/GTS.

2.2. The gas-hub policy

The Dutch reserves are depleting and, as a result, the Dutch economy is expected to lose the annual billions from mining activities in the near future (IEA, 2012). Because the Groningen field is gradually losing pressure as more gas is being extracted, it is already unable to cover the largest spikes in demand (GTS, 2014). This process will continue, despite the investments made to increase pressure,² which calls for additional supply. With this looming end of gas revenues within the next 10 years, the Dutch government searches for a new role in the liberalised European gas market (Van Witteloostuijn et al., 2007). The motive behind this is two-fold (EZ, 2006). First of all, the Dutch government wants to use the current expertise and infrastructure to create a new source of income. Secondly, as the country greatly depends on gas for its energy demands, it needs to secure supply. The above resulted in the gas-hub policy, which was presented by the Minister of Economic Affairs in the spring of 2006. By serving as north-western Europe's gas hub, or “gas roundabout”, the Netherlands would find themselves with a new profit model. The Brattle Group (2010) estimates the potential contribution to the economy to be €21bn and with 136,000 full time jobs for the total period from 2010 through 2020. These numbers include both direct effects, as indirect and induced effects. In terms of GDP contribution, this is far less than the yearly billions generated from gas production. Furthermore, to erect a gas hub, large investments in infrastructure and storage facility are required.

2.3. Investments in the gas infrastructure

A large amount of the investments in the Dutch gas hub were made

Table 1

Major investments in the Dutch high-pressure gas network, 2008–2013. Source: Gasunie annual reports 2007–2013.

Name	Year and month of finalisation	Amount invested (million EUR)	Invested by Gasunie/EBN (million EUR)
BBL (pipeline)	2008 December	500	300
Zuidwending (storage)	2011 January	600	600
GATE (terminal)	2011 September	800	360
Nordstream (pipeline)	2012 October	7,400	666
NEL (pipeline)	2013 November	1,000	200
Beverwijk–Wijngaarden (pipeline)	2014 October	500	500
Bergermeer (storage)	2015	800	300
Total		11,600	2,926

by Gasunie, the state-owned company responsible for the gas infrastructure in the Netherlands (see Table 1). Other substantial investments were made by EBN, also a state-owned company, which is responsible for exploring and extracting gas. Since 2006, Gasunie and EBN have invested several billions of euros in the gas hub, mostly in transportation and storage capacity (Court of Audit, 2012). The Netherlands has, for example, increased cross-border transport capacities with Germany, Belgium and the United Kingdom. Key investments are the BBL³ pipeline to the UK, the Nordstream line transporting gas from Russia to Europe and the NEL pipeline that is developed to make Russian gas flow to Western Germany and the Netherlands.⁴ The LNG

³ Pipeline from Balgzand (NL) to Bacton (UK).

⁴ Gasunie participates in the Nordstream project and holds a 9% share. Other participants are the Russian gas giant Gazprom (51%), Wintershall AG and E.ON AG (both 20%). The NEL project is a joint-venture between Gasunie, Gazprom, E.ON and

² In 2006 the first compressor was installed to increase the pressure of the gas field.

terminal GATE in the port of Rotterdam makes it possible to import LNG delivered over sea and to distribute it into north-western Europe. At the same time investments were made in the domestic transport network. The new pipeline Beverwijk–Wijngaarden in the western part of the country was made operational in 2014 in order to remove the barrier in the north–south connection which forced significant amount of gas flows to transit through the eastern part of the Netherlands.

In addition to the investments in the transportation infrastructure, more capacity for gas storage has been developed to balance flat import flows and volatile export flows. Those storages are generally constructed in depleted gas fields or salt domes. Since 2006, two storage locations have been developed of which one is already operating (Zuidwending) and another will be so in 2015 (Bergermeer). An overview of the current Dutch gas network is shown in Fig. 3. The highly developed infrastructure stands out, especially in the north-east of the country where Groningen is located. Note the separate network for Groningen gas (dark grey lines) and the one for high caloric gas (lighter lines).

2.4. Institutional measures regarding the gas market

Next to the investments in the physical infrastructure, institutional measures have been taken to facilitate trade in gas. In 2002, Gasunie created a virtual trading place within the high-pressure network: *Title Transfer Facility* (TTF). Gas that enters the Dutch network from a border or a domestic entry point can be traded with market participants on the TTF before leaving the network on an exit point. Such a trading place is seen as a necessary condition for developing a gas hub. The creation of TTF was part of the implementation of the European regulation for gas markets (Mulder and Zwart, 2006). Activities on the TTF have grown rapidly over the past years. The facility now serves as a European benchmark for gas prices and is the largest continental trading place (Heather, 2012).

Several institutional changes may have triggered the development of the gas trading place in the Netherlands (Table 2). The Dutch TSO, Gas Transport Service (GTS), removed the obligation for market parties to book quality-conversion capacity in July 2009, which made it possible for shippers to simply trade energy, regardless of the caloric quality of the gas. In April 2011, a new market-based balancing regime was established (Van Dinther and Mulder, 2013). Previously, traders who were not in balance just had to pay a fine independent of the market value of that imbalance. In the new system, the price for imbalance is determined by bid and supply curves. This balancing regime proved to be successful, attracting several new (financial) market players to the trading platform. Nevertheless, recently GTS has changed its balancing method by directly operating on the intraday market on TTF, which is seen as a further improvement of the liquidity of this market place. Moreover, in May 2012, GTS launched Europe's first cross-border “market coupling” scheme between the Netherlands and Germany. This meant that gas could be transported through the area of Gasunie⁵ under one transport agreement, traded on a single electronic platform.

2.2 Indicators and models

To analyse the development of the gas roundabout in the Netherlands, we use high frequency (hourly) data of the gas market over the years 2006 through 2013.⁶ This dataset includes, amongst others, hourly data on all injections into the gas network and all extractions

from the network. These data, which describe the hourly gas balance on the Dutch gas network (see Fig. 1), enable us to calculate the amount of gas that uses the network just for transit purposes as well as the relative importance of storage and TTF. In this section, we first describe how this calculation is done. Then we present the regression models used to estimate the effect of the policy measures and investments in the gas infrastructure on transit, storage and TTF.

2.5. Definition of indicators based on the gas balance

The definition equation of the gas balance between injection and extraction is given by Eq. (1) below.

$$P + M + S_{en} \equiv C + E + S_{ex} + L \quad (1)$$

where P =domestic production of gas, M =imports of gas, S_{en} =entry of gas into network from storage, C =domestic consumption of gas, E =exports of gas, S_{ex} =exit of gas from network to storage, and L =linepack.

All variables in this equation consist of flows except linepack, which is just the (hourly) imbalance between total injection ($P + M + S_{en}$) and total extraction ($C + E + S_{ex}$). We define linepack as

$$L = (P + M + S_{en}) - (C + E + S_{ex}) \quad (2)$$

implying that a positive value of L means that more gas is ‘stored’ within the network, while a negative value means that gas is extracted from the network. Using definition (1), we are able to define the transit of gas, which is gas that is both produced and consumed abroad. This gas enters the network as import and leaves it, at a later moment in time, as export. We can define this from both the import and the export perspective. From the import perspective, the amount of imported gas that is meant to be re-exported is equal to the imports minus what is consumed or stored domestically (in storages or as linepack). Likewise from the export perspective, the amount of exported gas that comes from import is equal to the exports minus the gas that comes from domestic production, storages or linepack. By definition, both should be equal resulting in the next definition equation:

$$E - P - S_{en} \equiv M - C - S_{ex} - L \quad (3)$$

This definition can be transformed into ratios measuring the part of exports and imports, respectively, which is used for transit:

$$T_e = (E - P - S_{en} + L) / E \quad (4)$$

$$T_i = (M - C - S_{ex} - L) / M \quad (5)$$

The export-transit ratio (T_e) measures the share of export that does not come from domestic production, storages or linepack, but from import. The import-transit ratio (T_i) represents the imports which are not meant for domestic consumption or injection into storages or linepack.⁷ Basically the two ratios measure the same thing and, hence, their pattern should be equal. Their main difference lies in the numerators, which mainly show different seasonal effects. If the Netherlands is becoming a transit country and transit volumes are increasing, the export- and import-transit ratios are expected to rise over time. More specifically this means that the ratios can never exceed their theoretical maximum value of 1. If for example all domestic production stops and no gas enters from storage or linepack, the export-transit ratio will be 1. In this case all exports will come from imports. If a country would have no consumption at all, the result would be a pure transit country for gas. In the case of the Netherlands, the opposite is currently true. Note that a net producing country exhibits negative export-transit ratios, implying that the production level exceeds the exports, while a net consuming country exhibits negative import-

(footnote continued)

Fluxys.

⁵ The two Gasunie TSOs are the Dutch Gas Transport Services (GTS), which is the operator of the high-pressure Dutch gas infrastructure, and German Gasunie Deutschland (GUD), which is the operator of the northern German network.

⁶ Sources: Authority for Consumers and Markets (ACM) and Gas Transport Services (GTS).

⁷ Note that linepack and storage are only relevant in the short run, as in the long run its net position regarding the network is zero.

Fig. 3. The Dutch high-pressure gas network, showing pipelines, entry/exit points, storage facilities and other attributes of the network.
Source: GTS.

transit ratios, implying that the consumption level exceeds imports.

A second pillar of the gas-hub strategy is storage. As mentioned, gas storage is essential for both earnings and security of supply. In the past, the gas supply was commonly secured by using Groningen as swing producer, but it is expected that this field will soon be less able to conduct this function. As a consequence, storage will become more important to meet flexible demand. We analyse the total amount of gas stored over time and the role of storages versus the Groningen field during periods of high demand (i.e. winter periods). To study the relative importance of storage for gas demand against the role of the Groningen field, we use a measure that is similar in its nature to the transit ratios. The storage ratio (S) measures the contribution of entry from storages to meet the total extraction from the network, while the Groningen ratio (G) measures the contribution of supply from the Groningen field:

$$S = S_{en}/(C + E + S_{ex} + L) \quad (6)$$

$$G = P_{gron}/(C + E + S_{ex} + L) \quad (7)$$

If storages in the Netherlands become a more important supply source over time, while the production of Groningen (P_{gron}) decreases, ratio (6) will show an upward trend while ratio (7) moves in the opposite direction.

The third subject of measurement concerns the TTF market for gas trading. The focus here lies on market share of TTF, while trading volumes, number of market participants and the churn ratio are also examined. TTF market share is measured as a ratio between the amount of gas delivered on TTF (Q) and the total injection into the Dutch network:

$$MS_{TTF} = Q/(P + M + S_{en} + L). \quad (8)$$

2.6. Regression models

Besides monitoring how the relative importance of transit, storage and TTF has emerged over time, we want to understand which factors have contributed to that development. Therefore, we use regression analysis in which the above ratios (R) are the dependent variables and a number of external drivers as

Table 2

Main policies concerning TTF development, 2008–2013.
Source: Oxford Institute for Energy Studies, 2012.

Name	Year and month of implementation
Abolishment of the obligation to book quality-conversion capacity	2009 July
Introduction of a market-based balancing regime	2011 April
Introduction of market coupling	2012 May

Table 3

Correlation matrix of the independent variables of the regressions.

	Dummy BBL	Dummy Nordstream	Dummy NEL	Dummy GATE
Dummy Nordstream	0.3251			
Dummy NEL	0.1367	0.4205		
Dummy GATE	0.4474	0.7268	0.3056	
Dummy Zuidwending	0.5816	0.559	0.2351	0.7692

independent variables. Table 3 shows the correlation coefficients between the dummies for the investment measures.

Both the transit ratios and the storage ratio are modelled under OLS assumptions using dummies for the dates the investments (I) listed in Table 1 became operational as independent variables. Most of these investments became effective gradually over time. A trend variable is added to capture all additional, smaller, investments made by Gasunie that are not mentioned in Table 1. We correct for monthly (D_m), daily (D_d) and hourly (D_h) effects using dummy variables. The monthly dummies capture the seasonal volatility, while the hourly dummy variables correct for differences during the day (e.g. day and night). We add the heating-degree days (HDD) to capture the influence of the outside temperature.⁸ The resulting regression formula is as follows:

$$R_{i,t} = \alpha + \sum_j \beta(I_j)_t + \gamma(\text{HDD}) + \delta(\text{Trend}) + \sum_{m=2}^{12} \theta(D_m)_t + \sum_{d=2}^7 \rho(D_d)_t + \sum_{h=2}^{24} \omega(D_h)_t + \varepsilon_t \quad (9)$$

where i refers to the different ratios, being the export-transit ratio, the import-transit ratio, the storage ratio and the TTF market share. Note that, because TTF data is on a daily basis, the hourly dummies (D_h) are dropped in that case.

3. Results

The transit ratios are depicted in Fig. 4. It appears that both the import- and export-transit ratios follow a fairly similar pattern,⁹ with high seasonal volatility that reduces over the years, especially for exports. The export-transit ratio moves within a range of approximately –1 to 0, while the import-transit ratio moves within the range of –4 and 0. We thus observe more negative and volatile outcomes for the import-transit ratio, which is related to the lower import volumes.¹⁰

⁸ The heating-degree days are measured by subtracting the average daily temperature from the base temperature of 18 for observations on which the daily temperature was below this base temperature. In all other situations the heating degree day gets a value of zero (see CIBSE (2006)).

⁹ The degree to which the two indicators are related is expressed in a correlation coefficient of 0.69.

¹⁰ As import volumes are generally around 25 GW/h and exports are on average 67 GW/h over the sample period, the volatility of the import-transit ratio is

Fig. 4. Export-transit ratio and import-transit ratio, 2006–2013 (per day).

Source: ACM/GTS.

Table 4

Transit ratios: annual average and differences w.r.t. previous years.

Year	Export-transit ratio		Import-transit ratio	
	Value	Difference w.r.t previous year	Value difference w.r.t previous	Difference w.r.t previous year
2006	−0.313		−0.949	
2007	−0.304	0.009	−0.884	0.066
2008	−0.468	−0.164	−1.315	−0.432
2009	−0.353	0.115	−1.104	0.211
2010	−0.524	−0.171	−1.394	−0.29
2011	−0.42	0.103	−1.124	0.27
2012	−0.406	0.015	−1.015	0.109
2013	−0.317	0.089	−0.842	0.172
	Mean difference	T-value	Mean difference	T-value
2006–2013	−0.00061	−0.0134	0.01529	0.1508
2010–2013	0.06894*	2.5227	0.18387**	3.9314

* Significantly larger than zero at the 10% significance level.

** Significantly larger than zero at the 5% significance level.

We test whether the transit has increased over time by applying a year-to-year mean comparison test. This t-test compares the differences between yearly averages with its preceding year and analyses whether they are different from zero (see Table 4). We see that the differences in means are very close to zero for the full sample period. Consequently, the null hypothesis that the annual values are equal to each other cannot be rejected. If we test the previously made observation that there is a small increase in the transit ratios since 2010, we see that the increases are significantly larger than zero on the 10% level and 5% level for export- and import-ratios, respectively. Hence, we find a small increase in

(footnote continued)

understandable. With low volumes, the volatility of the ratio is very high, but this volatility quickly decreases if volume goes up.

Table 5

Results for the regression model on hourly transit ratios, 2006–2013 (nObs=69,014).

Independent variable	Export-transit ratio		Import-transit ratio	
	Coefficient	Std. error	Coefficient	Std. error
Constant	−0.11***	0.022	−0.826***	0.091
Dummy BBL	0.011	0.032	−0.188*	0.097
Dummy Nordstream	0.161***	0.02	0.434***	0.143
Dummy NEL	−0.033	0.033	0.071	0.062
Dummy GATE	0.036	0.023	−0.038	0.066
Dummy Zuidwending	0.086***	0.02	0.341***	0.088
Heating degree days	−0.005***	0.001	−0.02***	0.003
Trend	−0.00000488***	0.000001	−0.0000066*	0.000004
Adj. R ²	0.92		0.97	
Log likelihood	110,819.5		51,237.42	

** Significant at 5%.

*** Significant at 1%.

* Significant at 10%.

the relative importance of transit year by year since 2010.

Next we analyse to what extent the policy measures have contributed to the development of the transit ratios. In particular, we test whether the investments in the Dutch gas infrastructure have contributed to the value of the transit ratios. We expect that these investments contribute to the creation of the gas hub and, hence, have a positive effect on the transit ratios. With a few exceptions, all of the control variables prove to be significant in both models (see Table A1).¹¹ We find a negative effect of the heating-degree days on transit: the lower the outside temperature, the

¹¹ The models are tested for stationarity using an Augmented Dickey–Fuller test. Furthermore the results are made robust for autocorrelation and heteroskedasticity using a Newey–West estimator and the autoregressive nature of the model is corrected by adding AR terms to the regression. Significant AR effects have been found, even after correcting for autocorrelation and heteroskedasticity. Because we use hourly data for our analysis an AR(1) and an AR(24) term are added to the regression, removing most of the AR effects and greatly enhancing the results.

Fig. 5. Contribution of storages and the Groningen field relative to total extraction from the network, 2006–2013 (per day).
Source: ACM/GTS.

lower the relative share of transit gas. Apparently, during cold winter days gas is to a large extent used for domestic consumption and less for transit purposes. Moreover, we find a negative trend during the sample period.

Regarding the effect of the policy measures, it appears that the initiation of the Nordstream pipeline and the Zuidwending storage facility enhanced the Netherlands as a physical transit place for gas, both measured by the import and the export transit ratio (Table 5). For the BBL connection to the United Kingdom the effects are less clear. We note that the effects of our variables are, with the exception of the BBL dummy, are consistent over both transit ratios.¹²

The storage and Groningen ratios are presented in Fig. 5. We see that the storage ratio reached higher levels in more recent years, indicating a more important role. The Groningen field shows less flexibility over time, as can be seen from the smaller fluctuations within the Groningen ratio. The daily supply from Groningen is restricted by a technical cap. Fig. 6 shows that the Groningen field is at its maximum capacity during cold winter days and, as a result, it cannot meet the high demand at those moments. This figure clearly shows that the capacity restriction is more pronounced in the recent years, where total gas demand strongly exceeds the production by Groningen. Because imports and production from small fields are fairly flat (see Fig. 1), swing production has increasingly to come from storages if Groningen cannot supply.

Following the methodology applied to transit ratios in the previous paragraph, we use regression analysis to examine the effect of specific investments on the increased role of storages. The results show that the only significant variable is the GATE terminal in the port of Rotterdam (Table 6). This LNG terminal is directly linked to the LNG “peak shaver”¹³ and, hence, feeds in this storage facility.

¹² The reason the coefficients in the two models differ in magnitude lies in the fact that the import volumes are on average lower than export volumes in the Netherlands. The nature of the transit ratios causes large volatilities in the ratios when volumes are low, while ratios stabilise around zero for larger volumes. The lower constant in panel B confirms this observation.

¹³ The peak shaver storage facility for LNG is owned by Gasunie and has been operational since 1977. Since 2010 the stored gas has been used on a regular basis to meet peak demand in gas (GTS, 2014).

Hence, the creation of this terminal has enabled the storages to become a more important supplier of flexibility in the Dutch market. None of the other explanatory variables show significant effects on the usage of storage, including the investment in the storage facility Zuidwending. As expected, the storage ratio is strongly related to the average daily temperature: the lower the outside temperature, the more important storages become for gas supply.

Finally, we assess the evolution of the TTF. In order to assess its liquidity, we observe some of the most commonly used liquidity indicators, being (1) market share, (2) traded volume, (3) number of active traders and (4) churn-rate (see Figs. 7 and 8). All four measures clearly increased over the sample period, from which we can roughly conclude that both TTF activity and liquidity increased, as was also found by Heather (2012). The most constant growth can be seen in the number of traders active on TTF. Nowadays more than 100 traders are active on the trading platform, which means an increase of a factor 10 over the sample period. The traded volumes on TTF rose sharply and much quicker than volumes physically delivered, especially after 2008. Consequently, the churn rate increased and peaked around 10 times over the past years. This means that an average unit of gas was traded 10 times before it was delivered at an exit point, which is an indicator of a highly liquid market. The market share of TTF shows a high volatility over time, but on average, the market share of TTF increased from just below 5% in 2006 up to 40% in 2013 (Fig. 8).¹⁴ The most important driver behind the market share growth appears to be the trend variable (see Table 7).

4. Discussion

The transit ratios indicate that the Netherlands has slightly become more oriented on physical transit of gas since 2010. Over the period 2006–2013, however, the annual average values of the transit ratios have not changed significantly. In addition, the import and the export-transit ratio have negative values most of the

¹⁴ Note that Fig. 7 includes monthly moving averages and is thus already smoothed.

Fig. 6. Maximum daily production by the Groningen gas field and maximum daily demand for gas, both against the daily average temperature, 2006–2013 (per day). Source: ACM/GTS/KNMI.

Table 6

Results for the regression model on storage ratios, 2006–2013 (Obs=69,014).

Independent variable	Coefficient	Standard error
Constant	0.018**	0.008
Dummy BBL	0.008	0.006
Dummy Nordstream	0.006	0.007
Dummy NEL	−0.002	0.006
Dummy GATE	0.022***	0.005
Dummy Zuidwending	0.0004	0.005
Heating degree days	0.001***	0.0001
Trend	−0.0000003	0.0000002
Adj. R ²	0.96	
Log likelihood	222,923.9	

*** Significant at 1%.

** Significant at 5%.

* Significant at 10%

Fig. 7. Traded and delivered volumes on TTF together with the Churn rate. All three increase over time, indicating an intensified use of TTF. Source: ACM/GTS.

time, which implies that the Netherlands is still a large producer and consumer of gas. The negative value of the export-transit ratio implies that the domestic supply of gas (coming from production or storages) is more than sufficient to meet export demand. Likewise, the negative value of the import-transit ratio implies that the level of imports is insufficient to meet the domestically needed gas for consumption and to fill the storages.

We find mixed evidence on the effects of investments in the gas infrastructure and the relative importance of transit. The regression results show that the Nordstream pipeline contributed to the level of transit of gas through the Netherlands. This multi-billion project is indeed one of the most important recent European network expansions; its connection to Dutch pipeline became possible a year after its commissioning with the opening of the NEL pipe. We do not find

a significant effect of the NEL pipeline on the transit ratios though. This holds also for the GATE terminal. The Zuidwending storage, however, had a positive effect on both transit ratios. The BBL pipeline has an insignificant effect on the export-transit ratio and a negative effect on the import-transit ratio. Although the results are consistent for the two measures of transit, they give ambiguous support to the hypothesis that the investments in the gas infrastructure enhanced the Dutch gas hub. Overall, there is insufficient evidence to conclude that these investments have strongly enhanced the role of the Netherlands as a gas-transit country.

Fig. 8. TTF market share and the number of shippers trading on TTF.
Source: ACM/GTS.

Table 7

Results for the regression model on TTF market share, 2006–2013 (Obs=2908).

Independent variable	Coefficient	Standard error
C	6.251**	2.89
Dummy quality conversion	−0.232***	0.048
Dummy balancing regime	0.015	0.032
Dummy market coupling	0.025	0.042
Heating degree days	0.001	0.001
Trend	0.013***	0.002
Adj. R ²	0.99	
Log likelihood	3092.094	

*** Significant at 1%.

** Significant at 5%.

* Significant at 10%.

Regarding the Groningen field, we find that the production levels did not decrease, but even increased, in particular during summers, which also implies a reduced supply of seasonal flexibility by this field. In spite of the expectations a number of years ago, this gas field has increased its annual level of production until recently. The actual flexibility of Groningen, however, has reduced, while the flexibility of storages has increased. The maximum daily production by the Groningen field is (technically) capped, which hinders this field to offer increased flexibility to the market during cold winter days. If the daily average temperature falls below the freezing point, this field produces at its maximum level. No matter how far temperature declines, the Groningen field appears not to be able to produce more. This fuels the belief that storage in the Netherlands is increasingly used supplementary to the production fields. The role of storages as a source of flexibility in the Dutch market is increased by the investment in the LNG terminal GATE.

Regarding the TTF, we find that its importance has grown significantly over the past years. This appears to be a rather autonomous growth which cannot be explained by the institutional measures we have analysed. We find that the introduction of the market-coupling policy and the change in the balancing regime had no significant effect on the market share of the TTF, while the measure regarding the obligations of market parties to book quality conversion has a negative sign. The results thus give insufficient evidence of a positive effect of these policy measures on the enhancement of the market share of the TTF. Apparently, the significant growth in the role of the TTF since 2006 has resulted from autonomous market developments. It does, however, show that the Netherlands has become a more important virtual trading place for gas, despite the unchanged physical volumes of transit.

5. Conclusions and policy implications

The Netherlands has implemented a number of measures to reform its gas market from a domestic-production driven market into a transit country for gas. These efforts were nurtured by the aspirations set out by the Dutch government in 2006 to transform the country into north-western Europe's gas hub. This change in the gas policy was triggered by the expectations that the Dutch gas reserves would be depleted in the near future. The objective of the gas-hub policy was to find an alternative source of income for the gas industry by developing the Dutch gas system into a hub for Northwest Europe. A successful creation of a gas hub would result in more gas transit, a higher level of gas storage and more gas trade on virtual trading platforms. This paper tests if these three components increased over the period 2006 to 2013 and assesses the impact of the major policy measures, i.e. the investments in the gas infrastructure and a number of institutional changes.

Based on our analysis of hourly and daily data on the flows in the Dutch high-pressure gas network, we conclude that the Netherlands has made some progress in becoming a gas hub for the north-western region of Europe. We observe increased usage of storage facilities as well as a growth in TTF trading. The TTF has developed into a highly liquid trading place. Transit volumes, however, hardly increased, while domestic production remained high. The modest changes in the Dutch gas balance imply that the investments in the gas hub did not contribute much to the transformation of the Dutch gas industry. Compared to the United Kingdom, the Netherlands has remained a net exporting country that largely depends on domestic gas production. While in the UK the investments in import capacity and storage made a rapid shift from production to import possible (Stern, 2004), these effects have not become visible in the Netherlands until now.

We note that the investments in the gas infrastructure have a long-term perspective and, hence, they may have an effect in the future. We also acknowledge the fact that some of the institutional changes may have other positive effects on the market (Dinther and Mulder, 2013). These effects include, for example, the improved TTF liquidity and the increased storage capacity, which potentially enhance the security of gas supply (Westphal, 2014). Considering the counterfactual of the current situation, we can only conjecture what would be the level of transit gas if no investments were made. The overall trend of our ratios for transit and storage are negative, which fuels the suspicion that the country could have been less suitable as a transit location without the investments. In other words, without the investments in the gas hub, the decreasing ability of Groningen to meet peak demand could lead to a situation in which imports increase and exports decrease, with consequently declining ratios as well. At least the ratios remained stable over time, with a decreasing peak production.

Furthermore, it appears that the magnitude of the Dutch remaining gas reserves is declining less than expected, because of the ongoing exploration activities and technological developments (TNO, 2014). As an illustration for this, the current level of the cumulative production since the offtake of Dutch gas production is much higher than the expected reserves in the past (TNO, 2014). Hence, energy security risks are far less acute than was assumed when the gas hub policy was implemented. Looking into the future, Dutch gas production will undeniably come to an end. The current expectations are that the country will become a net importer around 2025. Because of continuing technological improvements, domestic production, however, might remain even after 2025 (Kong et al., 2009).¹⁵ This suggests that the Netherlands may be able to extend its production into the future even further. Although the recent downscaling of the yearly production of Groningen, because

¹⁵ An example of such technological improvement is the recently discovered technique to extract the full 100% of a gas field using chemicals, while depletion was traditionally limited to around 85%. The status of the Netherlands as exporting country could be extended by 5 years because of this (TNO, 2014).

of several incidents involving earthquakes, may reduce the supply from this field, energy security is likely not an immediate problem, like it was in the UK. Groningen will, however, probably lose its role as the main supplier of flexibility. The policy lesson from the Dutch experience is that implementing a gas-hub strategy requires significant investments in the gas infrastructure, while their effects do

not necessarily become visible in the short run.

Appendix A. Results of the regression models with time dummies

See [Tables A1](#) and [A2](#).

Table A1

Results for the regression model on hourly transit and storage ratios, 2006–2013 (nObs=69,014).

Independent variable	Export – transit ratio		Import-transit ratio		Storage ratio	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Constant	−0.11***	0.022	−0.826***	0.091	0.018**	0.008
Dummy BBL	0.011	0.032	−0.188*	0.097	0.008	0.006
Dummy Nordstream	0.161***	0.02	0.434***	0.143	0.006	0.007
Dummy NEL	−0.033	0.033	0.071	0.062	−0.002	0.006
Dummy GATE	0.036	0.023	−0.038	0.066	0.022***	0.005
Dummy Zuidwending	0.086***	0.02	0.341***	0.088	0.0004	0.005
Heating degree days	−0.005***	0.001	−0.02***	0.003	0.001***	0.0001
Trend	−0.00000488***	0.000001	−0.0000066*	0.000004	−0.0000003	0.0000002
HDUM2	0.011***	0.001	0.042***	0.003	−0.002***	0.0002
HDUM3	0.006***	0.001	0.082***	0.003	−0.003***	0.0002
HDUM4	−0.004***	0.001	0.104***	0.004	−0.004***	0.0003
HDUM5	−0.022***	0.001	0.109***	0.004	−0.004***	0.0003
HDUM6	−0.061***	0.002	0.098***	0.005	−0.004***	0.0003
HDUM7	−0.133***	0.002	0.069***	0.005	−0.003***	0.0004
HDUM8	−0.21***	0.003	−0.003	0.005	−0.0001	0.0004
HDUM9	−0.247***	0.002	−0.071***	0.006	0.004***	0.0005
HDUM10	−0.237***	0.002	−0.117***	0.006	0.01***	0.0005
HDUM11	−0.212***	0.002	−0.155***	0.006	0.013***	0.0006
HDUM12	−0.188***	0.002	−0.157***	0.006	0.014***	0.0006
HDUM13	−0.171***	0.002	−0.146***	0.006	0.012***	0.0006
HDUM14	−0.155***	0.002	−0.135***	0.006	0.011***	0.0005
HDUM15	−0.146***	0.002	−0.135***	0.006	0.009***	0.0005
HDUM16	−0.145***	0.002	−0.132***	0.006	0.008***	0.0005
HDUM17	−0.16***	0.002	−0.127***	0.006	0.008***	0.0005
HDUM18	−0.184***	0.002	−0.127***	0.006	0.008***	0.0005
HDUM19	−0.197***	0.002	−0.136***	0.005	0.008***	0.0005
HDUM20	−0.188***	0.002	−0.142***	0.005	0.009***	0.0005
HDUM21	−0.161***	0.002	−0.136***	0.005	0.008***	0.0004
HDUM22	−0.129***	0.002	−0.113***	0.004	0.007***	0.0004
HDUM23	−0.093***	0.001	−0.082***	0.003	0.004***	0.0003
HDUM24	−0.043***	0.001	−0.043***	0.003	0.002***	0.0002
DDUM2	−0.029***	0.002	−0.033***	0.006	0.005***	0.0006
DDUM3	−0.02***	0.003	−0.033***	0.009	0.006***	0.0009
DDUM4	−0.017***	0.003	−0.032***	0.009	0.005***	0.001
DDUM5	−0.014***	0.003	−0.029***	0.009	0.005***	0.001
DDUM6	−0.01***	0.003	−0.022***	0.008	0.004***	0.0008
DDUM7	0.007***	0.002	0.009	0.006	0.00001	0.0005
MDUM2	−0.0001	0.012	−0.036	0.047	0.006	0.0072
MDUM3	0.012	0.015	0.145*	0.081	−0.007	0.0095
MDUM4	0.038*	0.02	0.341***	0.092	−0.008	0.0091
MDUM5	0.025	0.023	0.353***	0.087	−0.009	0.0091
MDUM6	0.036	0.023	0.395***	0.086	−0.006	0.0094
MDUM7	0.009	0.024	0.38***	0.087	−0.006	0.0101
MDUM8	0.002	0.023	0.298***	0.088	−0.002	0.0112
MDUM9	0.014	0.022	0.242***	0.087	−0.001	0.0112
MDUM10	0.034*	0.02	0.157*	0.089	0.004	0.0118
MDUM11	0.006	0.016	0.015	0.066	−0.002	0.0107
MDUM12	0.015	0.013	−0.04	0.047	−0.002	0.0044
AR(1)	0.871***	0.003	0.878***	0.005	0.916***	0.0035
AR(2)	0.11***	0.003	0.104***	0.005	0.072***	0.0036
AR(3)	−0.11***	0.022	−0.826***	0.091	0.018***	0.008
AR(24)	0.011	0.032	−0.188*	0.097	0.008	0.006
Adj. R ²	0.96		0.97		0.96	
Log likelihood	129.224		46,986.57		222,923.9	

*** Significant at 1%.

** Significant at 5%.

* Significant at 10%.

Table A2

Results for the regression model on daily TTF market share, 2006–2013 (nObs = 2908).

Independent variable	Coefficient	Std. error
C	6.251**	2.89
Dummy quality conversion	−0.232***	0.048
Dummy balancing regime	0.015	0.032
Dummy market coupling	0.025	0.042
Heating degree days	0.001	0.001
Trend	0.013***	0.002
MDUM2	−0.005	0.021
MDUM3	−0.02	0.027
MDUM4	−0.02	0.041
MDUM5	−0.033	0.051
MDUM6	−0.005	0.054
MDUM7	0.003	0.058
MDUM8	−0.051	0.061
MDUM9	−0.056	0.062
MDUM10	−0.007	0.048
MDUM11	0.0025	0.036
MDUM12	−0.015	0.025
DDUM2	−0.027***	0.004
DDUM3	−0.04***	0.006
DDUM4	−0.026***	0.006
DDUM5	−0.024***	0.006
DDUM6	−0.023***	0.006
DDUM7	−0.009***	0.003
AR(1)	1.717***	0.031
AR(2)	−0.593***	0.058
AR(3)	−0.126***	0.029
Adj. R ²	0.999	
Log likelihood	3092.094	

*** Significant at 1%.

** Significant at 5%.

* Significant at 10%.

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