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The EU-Russia Gas Relationship: a mutual dependency[1]

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Abstract

Current debate on the energy security in the EU often stresses the EU dependency on gas imports from Russia. However, Russia is no less dependent on the EU – more than half of its gas exports goes to Europe. The purpose of this paper is to characterize this mutual dependency through an index-based approach, and to discuss how the development of gas markets may affect such dependency.
We suggest a unified framework to assess the security of gas supply for the EU and the security of gas demand for Russia, and construct dependency indexes for both parties. Our approach accounts not only for the traditional import/export dependency measures but also for the balance of power between Russia and the EU.
The proposed methodology is then used to address the evolution of the EU-Russia gas relationship in the view of gas market's developments. New gas pipelines projects (e.g., South Stream, Nabucco) and increasing use of liquefied natural gas are all likely to impact both the demand side and the supply side of the EU-Russia gas trade, and affect mutual gas dependency between the EU and Russia.

Key words: Energy Security, European Union, Gas transit risks, Index, Russia

JEL codes: Q4, Q48, C8

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1. Introduction

Over last two decades roughly 20 percent of the EU gas exports has originated from Russia.[4] For several EU Member States this share exceeds 90 percent.[5] Current debate on the energy security in the EU often refers to these figures when stressing the EU dependency on gas imports from Russia. It often proceeds to argue that the expected increase in the EU gas consumption would make the dependency of the Russian gas even more of a concern. However, Russia is no less dependent on the EU – with approximately half of Russian budget revenues coming from energy-related exports[6], and about 55 percent of its gas exports going to Europe,[7] Russia needs the EU gas markets to facilitate development and growth. Some have even argued that Russia's gas dependency on the EU is stronger than the reverse dependency (e.g. Havlik 2010 or Stern 2006).

The above argument clearly suggests that there are gains from trade for the gas relationship between the EU and Russia. However, these economic gains can be affected by geopolitical or economic tensions between Russia, the EU and/or a third party. In particular, the continuity of the gas trade flows may be interrupted, as it was indeed the case during several gas crises between Russia and the transit countries. This implies that for both parties, security is a concern: (i) it is the *security of gas supply* for the EU, who wants to avoid Russian gas supply disruption; (ii) it is the *security of gas demand* for Russia, who would like to secure a stable gas market share in the EU despite the geopolitical tensions. Clearly, these two objectives are closely interrelated and represent the core of the mutual gas dependency between Russia and the EU.

Moreover, the development of the fuel markets is very likely to affect the state of this

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4 BP (2011)
5 Eurostat
6 Economic Expert Group by the Ministry of Finance of Russian Federation
7 BP (2011)

mutual dependency. Dependency would be influenced by the launch of new pipeline projects, such as South Stream and Nabucco, or the expansion of the liquefied natural gas market. It could be affected by the EU energy policies such as increased competitiveness and further integration of internal markets. The uncertainty associated with the discovery and processing of the shale gas, as well as other aspects of technological progress would also contribute to the evolution of the Russia-EU gas relation.

The purpose of this chapter is to suggest a way to quantify mutual gas dependency between the EU and Russia. We propose a unified framework, which allows us to focus on the power and the dependency in this buyer-seller relationship. More specifically, our approach accounts for the economic dependency on gas, the reliability of gas trade routes and the balance of power between Russia and the EU. We construct an index for each gas trading party, the *Supply Dependency Index (SDI)* for the EU, and the *Demand Dependency Index (DDI)* for Russia.

We then demonstrate how the indexes can be used to evaluate future gas market developments from the dependency angle. We consider South Stream and Nabucco in 2020, and, for each of the routes, we study how SDI and DDI vary depending on the volume of gas sent through the route. Unsophisticated reasoning would suggest that SDI should increase for South Stream and decrease for Nabucco. However, we find that for a sizable range of export values, both South Stream and Nabucco decrease the EU dependency on Russian gas, though the effect of Nabucco on SDI is stronger. The surprising result for South Stream comes from the following observation: While an increase in Russian gas imports raises the economic gas dependency of the EU, it is also associated with the EU becoming more important gas customer for Russia. The latter improves the EU bargaining position vis-à-vis Russia. Moreover, a new gas route provides a better possibility to redirect the gas flows if needed, which also lowers SDI. Thereby, the net effect of these three factors results in SDI decrease. In turn, Russia's dependency of the EU increases with Nabucco, but decreases with South Stream. So, based on dependency, South Stream would be preferred by Russia, while Nabucco – by the EU, creating tension in the EU-Russia relationship. We then show that a scenario combining a moderate use of LNG with some imports through South Stream may be preferred by both the EU and Russia. We conclude by discussing some policy implications of our analysis.

The rest of the chapter is organized as follows. Section 2 presents the index methodology and discusses related literature. Section 3 provides the estimates for the SDI and DDI under alternative scenarios and discusses scenarios' benefits and drawbacks for Russia and the EU. Section 4 addresses the limitations of the approach, and section 5 concludes.

2. Measuring the EU-Russia gas dependency

This section describes our methodology to assess the EU-Russia gas dependency. We first outline the key features of this dependency. We then explain how these features are incorporated into two indexes: the *Supply Dependency Index (SDI*) quantifying the EU dependency of Russian gas, and the *Demand Dependency Index (DDI)* describing Russia's dependency on the EU's demand for Russian gas. We conclude this section by discussing related literature.

Our dependency indexes characterize the stability and the importance of the gas relation for the EU and Russia. The EU and Russia's objectives in this relationship do not necessarily coincide – each party can be driven both by economic and by geopolitical considerations. Further, this dependency may well be asymmetric between the two involved parties due to different access to alternative markets, the features of the domestic market, etc. As a result, we assess dependency separately for the EU and Russia. Still, the bilateral nature of the gas trade relation implies that the dependency indexes for the supplier and the consumer are based on a number of common principles. More specifically,

Economic dependency principle: A dependency index should account for gas export/import dependency.

It has been long recognized that the extent of exposure to gas trade is likely to affect country's gas dependency. The dependency is traditionally proxied by import/export dependency measures, such as the share of gas trade in total consumption (for consuming side of the market) or total exports (for supplying part). However, large volumes of gas trade do not *per se* pose a threat to any of the trading parties. The problem comes from the fact that the gas trade may be affected by geopolitical developments, transportation risks, especially so for the pipeline gas with its low fungibility. These concerns should be reflected in the dependency index, leading to our next common principle:

Reliability principle: A dependency index should account for the reliability of gas trade routes between the exporter and importer.

Gas trade between Russia and the EU takes place through a number of pipeline gas routes, several of which are passing through so-called transit countries, such as Belorussia and Ukraine. Moreover, most of these routes are serving several EU Member states.[8] As a result, shortage of gas supplies from Russia to a single EU Member state is likely to affect other EU Member states served by the same gas route. That is, a substantial part of gas trade uncertainty should be attributed to the reliability of the gas routes (which we would also refer to as "transit risks").

Transit risks associated with a particular route should therefore include the probability of technical failure along the pipeline and the political risk associated with the transit country(ies) located on this specific route. Further, the reliability of trade also depends on the possibility to re-route the gas flows between Russia and the EU in case of a possible route halt, and can be captured, for example, by gas route diversification.

Balance of Power Principle: *A dependency index should reflect the allocation of bargaining power between Russia and the EU Member States served by a particular gas route.*

Assume that the Member States served by some route *i* are predominantly consuming Russian gas. Further, assume that these Member States do not have a solid outside option in case of a Russian gas supply disruption – that is, they are very dependent on gas and do not have an easy access to alternative gas suppliers. Then Russia has a strong bargaining position vis-a-vis these Member States. This position can be used to exercise monopolistic pricing or to have a certain political leverage.

Similarly, the larger is the amount of Russian gas consumed by the Member States served by some route *i,* the stronger is their buyer power vis-a-vis Russia, that is, the possibility to obtain certain concessions from Russia. Indeed, if the considered route consumes a large share of Russian gas exported to Europe, Russia does not have a good outside option, that is, the possibility to reallocate the gas trade to the alternative buyers

[8] See appendix A.1 for the description of the pipeline gas routes from Russia to the EU.

in case of disagreement with the Member States in question. In this case the EU may exercise its buyer power to obtain gas price discounts or exert certain political pressure on Russia, for example, during a transit crisis. Further, the extent of such a buyer power would also depend on the importance of EU gas export revenues for Russian economy.

The above considerations suggest a common framework for the construction of both the *Supply Dependency Index*, and the *Demand Dependency Index*. Below we present the two indexes in more detail.

2.1 EU's dependency toward Russia: Supply Dependency Index

This section introduces the *Supply Dependency Index (SDI)*. It assesses the EU exposure to potential instability of the Russian gas supply, and resulting impact of this instability on the EU economy.

To evaluate the dependency on Russian gas at the EU level, the Supply Dependency Index aggregates the information across the EU Member States. More specifically, it builds upon the individual Member State dependency indexes, so-called Transit Risk Indexes (TRIs), developed in Le Coq and Paltseva (2012). In what follows we first sketch the TRI approach, and then discuss the way to combine the TRIs for the EU Member States into a unified EU dependency measure, the SDI.

Transit Risk Index is a country-level index quantifying the risk of Russian gas import with special emphasis on the transit dimension. It consists of an import dependency component and a transit risk component.

The import dependency component, in line with the *Economic Dependency Principle* outlined above, reflects the importance of the Russian gas imports and, more generally, of natural gas for the considered EU Member State. It is represented by the share of Russian gas imports in the Member State's gas consumption multiplied by the share of natural gas in the total energy bundle of this Member State.

The transit risk component reflects the vulnerability of the gas pipeline transit. According to the *Reliability Principle*, it accounts for the route diversification of Russian gas supply to the considered Member State. It measures diversification by using a Herfindahl-Hirshman-like sum of squared shares of Russian gas imports over all routes serving the considered Member State. Then, for each such route *i* the respective share of Russian gas imports is weighted by the route reliability characteristics, such as political risks along the route, and risks of technical failure. Further, the route weights also include a proxy for the "bargaining power", BP_i, of the group of the EU Member States served by this gas route vis-à-vis Russia, as suggested by the *Balance of Power Principle*. More precisely, for higher values of TRI to be associated with higher transit risks, BP_i is *inversely* related to the buyer power of the EU Member States served by route i, the latter measured as a share of Russian gas to the EU via route i. That is, higher buyer power would imply lower BP_i and less risky gas imports.

Summing up, the TRI for the Member State *c* is defined as follows:[9]

$$TRI_c = Import\ dependency\ component * Transit\ risk\ component\ ,$$

where

$$ImportDependency_c = \frac{RussianGasImport_c}{GasConsumption_c} GasShareInFuels_c$$

$$TransitRisk_c = \sum_{\substack{i \in Transit\ routes \\ serving\ c}} \left(RussianGasImportShare_i^c\right)^2 * PolRisk_i * TechFailure_i * BP_i.$$

Lower gas import dependency of country *c*, better route diversification of Russian gas imports, more reliable transit routes (with lower political risks and/or risks of technical failure), and higher buyer power along the route all lead to lower values of TRI.

We are now ready to present the overall EU's dependency index, SDI, which is

[9] See Le Coq and Paltseva (2011) for more details on the definition of TRI

constructed by aggregating the TRIs across the EU Member States. Specifically, SDI is defined as a weighted sum of the TRIs across all EU-27 Member States consuming Russian gas,[10] with the weight of each TRI being the share of Russian gas imports of the respective Member State in the total EU imports of Russian gas. Further, as argued by *Balance of Power Principle*, the stability of a gas trade is related to value of this trade for the trade partners. The value for the EU Member States is already taken into account in each TRI through the share of Russian gas in their gas consumption. Thereby, SDI is left to account for the importance of this trade for Russia. To do so, it controls for the share of Russian gas exports to the EU in the budget revenue of Russia: The lower is the budget share of EU-Russia gas trade, the less important is this market for Russia, and the less would Russia be interested in ensuring the stability of supply to this market.

Following this logic, the *Supply Dependency Index* is given by the following expression:

$$SDI_{EU} = \left[\sum_{c \in \text{EU Member States}} TRI_c * \frac{RussianGasImport_c}{RussianGasImport_{EU}} \right] \left(1 - \frac{RussianGasExportValue_{EU}}{BudgetRevenues_{RU}} \right)$$

Higher values of SDI correspond to higher EU's dependency on Russian gas imports.

2.2 Russia's dependency toward EU: Demand Dependency Index

This section addresses the *Demand Dependency Index (DDI)* that characterizes Russia's gas sales dependency from the EU. The DDI intends to capture potential instability of the demand for Russian gas in the EU and the resulting impact on the Russian economy. Similarly to above, the index is constructed based on the three main principles outlined in the beginning of this section. However, unlike SDI, DDI is not

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[10] Note that for the EU Members not buying gas from Russia TRI=0, so including them into the sum does not change SDI.

build by aggregation over the sub-indexes characterizing bilateral relations between Russia and individual EU Member States. Indeed, as mentioned above, a gas supply shortage is likely to involve a group of the EU Member States served by the same transit route, rather than a single Member State. Thereby, we argue that a measure of gas demand vulnerability for the gas supplier, Russia, should be based on transit route-level relations rather than country-level ones.

DDI can be roughly subdivided into an export dependency component and a demand risk component. The export dependency reflects the economic importance of the gas demand instability for the Russian economy, in line with the *Economic Dependency Principle*. Two factors need to be taken into account here. Consider a decrease in gas exports from Russia to the EU due, for example, an introduction of a new pipeline to an alternative supplier. On one hand, such a decrease would lower the dependence of Russia on the EU gas sales.[11] On the other hand, due to low fungibility of pipeline gas trade, it might be difficult for Russia to find an alternative market for the freed-up gas volume, at least in a short-to-medium run. As a result, the decrease in exports would imply a loss in profits and/or budget revenues, resulting in negative impact on Russian economy. Thereby, the export dependency component consists of two parts: the term given by the ratio of the EU gas export value to the Russian budget, to capture the degree of importance of the Russia-EU gas trade for Russian economy; and the term inversely related to the change in the budget revenues from the EU gas exports resulting from a change in market conditions, to capture the loss (or gain) in gas trade profits.

The demand risk component evaluates the reliability of the gas relationship between Russia and the EU. To start with, it incorporates the diversification of gas

[11] For example, in the limit, with no sales to the EU Russia will have zero dependency.

demand for Russia measured as a sum of squared shares of gas exports over different transit routes between Russia and the EU, $GasExpShare_i$. Notice that this measure would also account for the possibility of re-routing gas supplies (in case of a political conflict or a physical rupture), in line with the *Reliability Principle*. The export shares in the above sum are weighted by a number of features of each route, such as political instability along the route, and risk of pipeline rupture.

Further, as suggested by the *Balance of Power Principle*, the route weights also account for the allocation of bargaining power between Russia and the EU. First, larger Russia's market power along these routes and the overall importance of gas for the EU Member States served by this route would lower Russia's gas dependency. For each route, we aggregate these measures across the Member States served by this route into a measure of a route's dependency on Russian gas, $RouteDep_i$. Higher values of $RouteDep_i$ correspond to routes serving countries relatively independent on Russian gas, and, consequently, to Russia having relatively little bargaining power along this route. Further, the buyer power of the countries served by route *i* vis-a-vis Russia would improve their bargaining position and limit the possibility of Russia to use gas trade for geopolitical objectives, thus, increasing Russia's dependency on the EU. In DDI we proxy this buyer power by $(1\text{-}BP_i)$.[12]

Summing up, the *Demand Dependency Index* (DDI) for a gas-selling country (Russia, in our case) supplying gas to the EU is given by the following equation:

$$DDI_{RU} = \textit{Demand risk component} * \textit{Export dependency component},$$

where

[12] Recall that BP_i is inversely related to the respective buyer power.

$$ExportDependency = \frac{RussianGasExportValue_{EU}}{BudgetRevenue_{RU}}\left(1 - \frac{\Delta RussianGasExportValue_{EU}^{new\ routes}}{BudgetRevenue_{RU}}\right)$$

$$DemandRisk = \sum_{\substack{i \in Transit\ routes \\ to\ EU}} \left(GasExpShare_i\right)^2 * PolRisk_i * TechFailure_i * RouteDep_i * (1 - BP_i)$$

Higher values of DDI correspond to higher Russia's dependency on its gas exports to the EU. More detailed description of DDI components can be found in Appendix A. 2.

2.3 Related literature

By focusing on the mutual dependency between Russia and EU, this paper relates to the large literature on energy security. The energy supply security from the buyer's perspective has been heavily discussed, with several papers looking specifically into the EU's energy security. It is also quite common to assess the energy security quantitatively, by the means of an index. The methodology may however differ among studies, depending on the countries involved in the energy trade, the time frame, the energy commodity considered, etc. (an overview of approaches is offered in e.g. Le Coq and Paltseva (2009), Sovacool and Mukherjee (2011), or Cherp and Jewell (2011)).

Given the focus of our paper, the mutual gas dependency between Russia and EU, energy supply security and demand security are central in our quantitative analysis. Le Coq and Paltseva (2012), focusing on EU's gas supply security, provide a Transit Risk Index (TRI) designed to quantify the risks associated with pipeline gas imports. We extend their methodology to quantitatively assess the risks associated with imports but also, exports of pipeline gas. By doing so, we acknowledge that Russia is also gas-dependent on the EU, the energy exports being determinant for a sustainable economic growth in Russia. This solo fact has been stressed in many papers (see e.g. Havlik (2010)). More importantly the literature has also recognized that the EU's gas security is the outcome of the balance of power between EU and Russia (see e.g. Stern (2006) or Finon and Locatelli (2008)). However, while addressing the mutual dependency between EU and Russia, the literature does not usually provide a unified framework to characterize and quantify such mutual dependency, which is one of the key points of our analysis.

Another key point of our approach is that in evaluating dependency we explicitly account for the bargaining power of each of the gas trade parties. Hubert and Ikonnikova (2011) and Hubert and Suleymanova (2008) also use the notion of bargaining power when formalizing the EU-Russia gas trade. Their focus is however the investment in pipelines and not the characterization of the mutual dependency and they use cooperative game theory. Further the informal concept of the EU "buyer power" used in our approach is motivated by the theoretical arguments in e.g. Inderst and Shaffer (2008) and Inderst and Wey (2007), though they do not apply their analysis to the energy markets.

Finally, our approach allows conducting a prospective analysis, looking at different scenarios of gas market development. We therefore are able to discuss alternatives available to the EU as well as Russia. In particular we contribute to discussion on the possibilities and the difficulties of creating a common energy policy (e.g. Findlater and Noel (2009)).

3. The EU-Russia dependency estimation

In this section we show how the above framework can be used to evaluate future gas market developments through the EU-Russia gas dependency lens. As an example, we consider three alternative scenarios of new gas supply to the EU in 2020: an increase in Russian gas supplied via the South Stream pipeline, an increase in non-Russian gas via the Nabucco pipeline, and a scenario, combining the use of South Stream with an increase in the EU consumption of liquefied natural gas (LNG). For each of the three scenarios, we discuss how DDI and SDI change depending on the volume of gas received by the EU via the respective pipeline. We then compare the dependency indexes under these three scenarios, and discuss scenarios' advantages and disadvantages for Russia and the EU.

3.1 Data

The 2020 forecasts of the EU Member States' gas consumption and total gas imports come from the European Commission publication "EU energy trends to 2030" (2010). We choose year 2020 for our estimates for a number of reasons. On one hand, among the years with the "EU energy trends to 2030" forecast available, 2020 is the earliest year when both South Stream and Nabucco would be completed according to the current planning. On the other hand, Russian gas trade with China is expected to take off after 2020 (see IEA (2011), p. 314), so in our estimates we can ignore the additional uncertainty associated with this new market. The forecasts for the EU imports of Russian gas in 2020 are scenario-specific and will be discussed below (more detailed description is available in Appendix A.3).

The idea behind the political risks of gas transit suggests that these risks should take into account both the political stability in the supplier and transit countries, and the potential conflicts between these countries. However, to our knowledge, no quantitative forecast on the latter component of the political risk is available. Thereby, we base our proxy of political risk of gas transit on the country-level Political Risk Rating (PRR) forecasts suggested by the PRS group in their International Country Risk Guide.[13] In

[13] As the 2020 proxy was not available, we have used the closest available forecast date, 2015.

turn, the risk of technical failure is approximated by the length of the pipeline multiplied by the probability of a rupture per km within a considered period of time (see Le Coq and Paltseva (2012) for more details on both risk indicators).

As a forecast for the 2020's share of the EU-Russia gas trade revenues in Russian budget is, to our knowledge, not available, we approximate it by the following procedure: First, we assume that, in the absence of any new routes (i.e. without South Stream/Nabucco), the ratio of the EU gas export value to Russian budget revenues would stay the same as in 2011. Then we adjust the ratio to the market developments in our scenarios, such as an increase in Russian gas exports to the EU due to the use of South Stream, etc. In turn, the 2011's Russia-to-EU gas exports to budget ratio is calculated based on the data from RossBusinessConsulting (2012), BP Statistical Review (2012) and Russian Federation Federal State Statistics Service (2012).

3.2 South Stream effect on dependency indexes

The South Stream pipeline's project is planned to transport Russian gas via the Black Sea (to minimize the political risks of gas transit) to Bulgaria and further to Greece and Italy via one branch, and Hungary and Austria via the other one. The project is expected to start in December 2012 and to be completed in 2015. The maximum planned capacity is 63 billion cubic meters per year (or $49.3*10^3$ KToe).

We estimate SDI and DDI for different capacity usage of South Stream. The idea is as follows: As was discussed above, an additional consumption of Russian gas would increase the EU import dependency. However, it would also improve the EU bargaining position vis-a-vis Russia due to stronger buyer power of the EU. Further, an introduction of South Stream would facilitate reallocation of gas flows between Russian and the EU in case of a gas crisis, thereby improving the gas route diversification. The first effect raises SDI, while the two latter ones would lower it. Similar conflicting effects can be identified for DDI. We want to see how the relative impact of these effects on dependency changes with the volume of gas sent via South Stream.

In this exercise, we make a conservative assumption that the *total* gas imports of the EU Member States do not change with the introduction of South Stream. However, this implies that the *allocation* of gas imports between Russia and other gas suppliers would be affected by South Stream: Russian gas sent via South Stream would "crowd out" some gas sent through the previously existing transit routes, both Russian and non-Russian ones. Thereby, the non-Russian gas imports will decrease and the Russian gas imports will increase, but not at the rate of South Stream usage. Note that this crowding out will have an effect on the bargaining power of both Russia and the EU, and, in turn, on the dependency indexes.

Figure **1** provides SDI estimates for different capacity usages of the South Stream pipeline. Contrary to the commonly expressed concerns, the EU dependency on Russian gas does not monotonically increase with the usage of South Stream. Instead, SDI graph is given by a convex curve with a minimum reached at around 20% of South Stream's total capacity. This shape of SDI curve illustrates the trade-off discussed above: With low usage of South Stream, the EU buyer power effect combined with an improved gas route diversification outweighs the increase in import dependency, resulting in SDI reduction. When the South Stream capacity usage exceeds 20%, the increase in import dependency becomes relatively more important and SDI starts to increase. Further, at high levels of South Stream usage the affected Member States import too much gas through South Stream, creating imbalance in gas transit diversification and contributing to SDI increase.

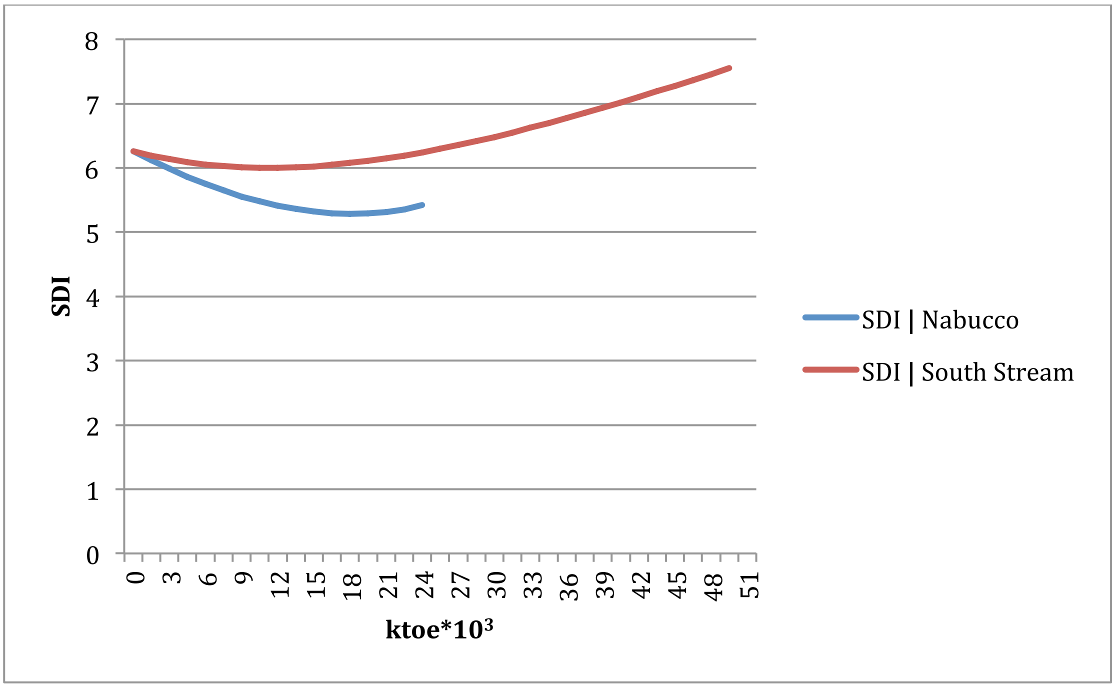

Figure 1. SDI estimates for different usage of South Stream and Nabucco.

Figure 2 presents analogous graph for DDI. Unlike SDI, DDI is constantly decreasing with the South Stream capacity usage: Better gas route diversification and higher market share of Russia on the European gas market both lead to a reduction in DDI. While South Stream increases Russia's budget dependency toward gas exports to Europe, quantitatively this effect is not sufficiently strong to counteract the two above effects and increase DDI.

The above discussion suggests that, based on the dependency, Russia and the EU would prefer different usage of South Stream capacity. However, Figure 1 shows that whenever South Stream load is below app. 50% of its total capacity, SDI does not exceed the level achieved in absence of South Stream (i.e., with zero capacity use). Thereby, the introduction of South Stream may be beneficial for both Russia and the EU if no more than 50% of the capacity is used.

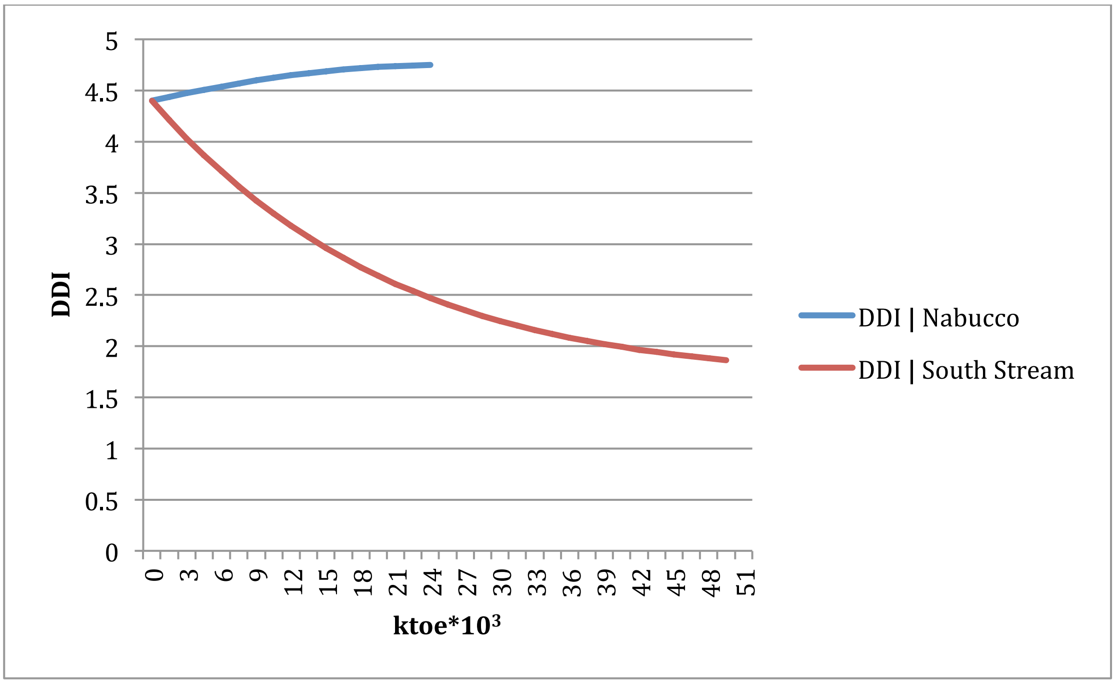

Figure 2. DDI estimates for different usage of South Stream and Nabucco.

3.3 Nabucco effect on dependency indexes

The Nabucco pipeline project is planned to connect Turkey with Bulgaria, Romania, Hungary and Austria. It is meant to diversify the EU gas import portfolio and lessen the EU dependency on Russian gas. The gas would come from Iraq's fields and, to a lesser extend, from Azerbaijan, Turkmenistan, and Egypt. The maximal capacity planned is 31 billion cubic meters per year (or $24*10^3$ KToe). The project is expected to take five years, but the starting date is not yet settled. Nabucco and South Stream projects are often seen as direct competitors.

Similarly to above, we estimate SDI and DDI for different capacity usage of Nabucco. Again, the goal is to look into the interaction of the change in import dependency, diversification and bargaining power, based on the assumption that Nabucco only influences the *allocation* of imports between Russia and the other suppliers but not the *total* imports. Notice that signs of the effects would differ from those in South Stream case. Indeed, Nabucco would provide gas from Iraq, Azerbaijan, etc., leading to a crowding out of Russian gas consumed by the EU. Thereby, an extra gas sent via Nabucco would imply a decrease in the EU gas import dependency on Russia, accompanied by a decrease in the EU buyer power. The former component will reduce SDI, while the latter would raise dependency. Moreover, Nabucco is unlikely to have a sizable effect on the gas route diversification between Russia and the EU. In turn, the effect of Nabucco on DDI would come through the falling EU market share of Russian gas (implying higher DDI), decreasing gas profits (higher DDI) and decreasing export dependency (lower DDI).

Figure **1** andFigure **2** present SDI and DDI estimates for different volumes of gas sent via Nabucco. Consider the SDI graph first: Up until app. 75% of Nabucco capacity the falling import dependency effect dominates and SDI decreases. Thereafter, the EU buyer power loss becomes large enough to counteract the import dependency effect and increase SDI. However, SDI never comes back to the original level. In turn, DDI curve increases with the quantity of gas sent via Nabucco, suggesting that the loss in profits and market power is stronger than the decrease in Russia's exports exposure towards Europe. Notice also, that the shape of SDI and DDI curves in case of Nabucco excludes the possibility of a mutually beneficial capacity choice for both Russia and the EU.

Now we are ready to compare the dependency in the South Stream and Nabucco scenarios. Notice that the traditional import dependency argument would suggest that South Stream and Nabucco should have opposite effect on the EU dependency on Russian gas: the dependency should increase in case of South Stream and decrease in case of Nabucco.

However, this logic no longer holds when the changes in transit route diversification and allocation of bargaining power are taken into account. While the direction of the route diversification effect and the bargaining power effects differ for South Stream and Nabucco (see the above discussion), the outcome is surprisingly similar: SDI first decreases and then increases with South Stream/Nabucco usage. Still, the decrease in SDI produced by Nabucco is noticeably steeper, suggesting that for any volume of gas not exceeding Nabucco's full capacity, Nabucco yields less EU dependency on Russian gas than South Stream. This suggests that, were the EU choose the new gas pipeline project based on the gas dependency, it would prefer Nabucco. [14]

In turn, DDI is affected differently by the two projects; it decreases with South Stream usage and increases with Nabucco one, suggesting that Russia would strongly favour South Stream.

We see that the dependency-based project choices of the EU and Russia do not coincide, potentially straining future Russia-EU relationship. A natural question to raise is whether some gas market development, ignored in our analysis so far, can facilitate a compromise between Russia and the EU.

For example, LNG is seen to be an important component of the future gas market in the EU. Consider the following idea: Assume that the EU combines a (moderate) increase in LNG share in the EU gas import portfolio with South Stream use. It is natural to expect that higher share of LNG would decrease the EU dependency on Russian gas. If the combined LNG-South Stream scenario can match the Nabucco SDI performance, the EU could save on the costs of constructing Nabucco while not sacrificing its (in)dependency on Russian gas. However, the LNG-South Stream scenario would lower Russia's budget revenues from EU gas sales, increasing its DDI. Still, if this increase is not too high (as compared to the Nabucco outcome), both Russia and the EU could prefer this scenario as a sensible compromise. In the next section we

[14] It is important to remember that our exercise does not take into account the investment costs of either project: unlike South Stream, Nabucco is expected to be partially backed by the EU (European Parliament and the Council (2009)). These investment costs may ultimately affect the EU choice.

identify the minimum LNG import share that can realize the above scenario.

3.4 Combining LNG consumption and a South Stream

We consider the following scenario: First, we assume a certain share of LNG in the EU gas imports. Given this share, we study the variation in SDI and DDI depending on the usage of South Stream capacity similarly to the exercise in subsection 3.1.

Similarly to above, we assume that the total imports of the EU Member States do not change. This has two implications: First, the presence of LNG implies less pipeline gas imports, both from Russia and other sources. Second, combined with the assumption of a fixed LNG import share, this implies that the South Stream crowds out only the pipeline gas imports, both from Russia and other providers, but has no impact on LNG imports.

Figure 3 presents the outcome of the above exercise for the case when LNG constitutes 15 percent of the EU gas imports. The upper panel of Figure 3 shows that SDI graph for the combined LNG-South Stream scenario lies consistently below the graph for the South Stream scenario. Indeed, a decrease in Russian gas imports due to substitution by LNG means that the EU lowers its economic dependency of Russian gas. Notice, that it also decreases the EU buyer power vis-a-vis Russia. However, for sufficiently low levels of LNG imports the first effect dominates, implying a fall in SDI for any volume of gas sent via South Stream.

More importantly, with 15 percent of LNG imports, the EU is at least as well off under the combined LNG-South Stream scenario as under Nabucco (and often better off, depending on the capacity usage): the SDI graph under the combined scenario lies below the one for Nabucco. This result implies that the EU could avoid building Nabucco if it consumes at least 15 percent of LNG gas while still using South Stream.

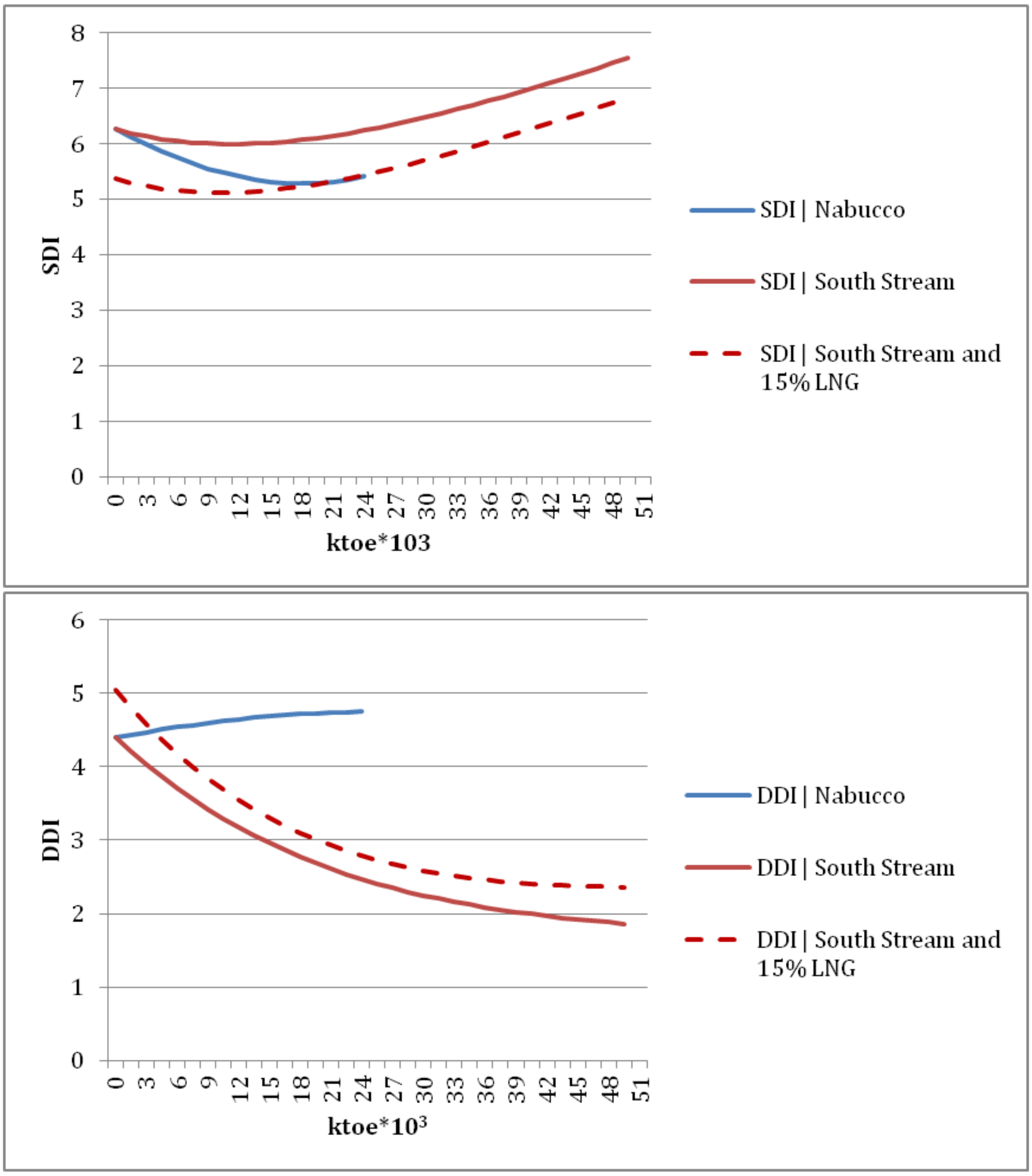

Figure 3. SDI and DDI under all three scenarios

Now turn to the DDI indexes under these different scenarios, presented in the lower panel of Figure 3. As mentioned above, LNG is likely to increase DDI due to the loss in gas export revenues. Indeed, this effect can be seen by comparing the DDI graphs under South Stream and the LNG-South Stream scenarios. Moreover, for very low levels of South Stream usage DDI graph under the combined scenario lies above both other graphs. However, with higher South stream usage, the loss in gas sale revenues due to

LNG is offset by the revenue gain due South Stream imports. As a result, the combined LNG-South Stream scenario outperforms Nabucco in terms of Russia's dependency, as long as the EU gas imports through South Stream are not too low.

Note that the Nabucco project could be realized without Russia's consent, while the South Stream needs an approval of both Russia and the EU. That is, in case of a disagreement about new pipelines between the EU and Russia Nabucco is a likely outcome. Thereby a compromise agreement between Russia and the EU should yield each party at least its outside option – the Nabucco SDI/DDI, – and maybe more, depending on the relative bargaining position. This means that a scenario combining 15 % of LNG gas imports with the South Stream use would represent a reasonable compromise for Russia and the EU. It may seem that under this scenario Russia gains much more than the EU as compared to the outside option of Nabucco. However, our dependency indexes do not account for the investment costs that, in the case of South Stream are largely born by Russia.

4. Limitations of the Approach

Our approach has a number of limitations. First of all, we assume only limited gas route interconnection within Europe. While this assumption is reasonably realistic for the current situation at the EU gas market, characterized by relatively low possibility for reverse flow, it is perhaps less realistic when used in our 2020 SDI and DDI estimation. However, it is currently unclear which reverse flow projects will be operational by 2020. Once this information becomes available, the indexes can be extended to incorporate it. Second, in studying new gas projects our analysis does not account for the associated investment costs. Note that our indexes provide a non-monetary measure of gas dependency. Probably a better approach to the analysis of new gas routes would be to combine the investment costs with the monetary costs of gas supply disruption. However, the latter is difficult to assess. Thereby we chose to base out discussion on the non-monetary dependency measure, addressing the investment costs only in informal arguments. Further, our analysis overlooks the possibility of supply shortage due to insufficient extraction capacity. Again, this is obviously a concern, especially in creation of new gas routes. However, the existing information on the capacity of the fields that may affect our estimation is rather unclear. Once this uncertainty is realized, the extraction capacity constraints can be taken into account.

5. Conclusion

This chapter proposes a unified framework to characterize the mutual gas dependency between the EU and Russia, with a special emphasis on the interaction between the economic dependency and the allocation of bargaining power. It presents the Supply Dependency Index (SDI) which evaluates the EU dependency on Russian gas exports, and the Demand Dependency Index (DDI) which assesses Russia's gas dependency on the EU.

The indexes are then used to illustrate the impact of planned gas market developments, such as an introduction of South Stream and Nabucco gas routes, on the evolution of the EU-Russia dependency. Several messages are to be taken from this analysis. First, contrary to a common perception, an increase in Russian gas consumption via South Stream leads to a decline in the EU dependency on Russian gas, at least for moderate usage of South Stream capacity. This effect is borne by the improvement in the EU buyer power towards Russia. Second, a decrease in the EU exposure to Russian gas due to Nabucco also weakens the EU buyer power vis-à-vis Russia. Thus, while the presence of Nabucco reduces the EU dependency on Russian gas, the effect is non-monotonic in Nabucco use. Third, the EU and Russia's dependency-based preferences over the choice between South Stream and Nabucco, as well as the extent of their usage do not coincide. Not surprisingly, the EU prefers Nabucco, while Russia favors South Stream. However, a moderate use of LNG combined with South Stream may provide Russia and the EU with a sensible compromise, and allow the EU to save on Nabucco investment costs.

These results suggest some implications for the energy policy in the EU and Russia. First of all, in considering new energy options - new routes, alternative fuels, such as shale gas or LNG, etc. – the EU policymakers would need to take into account not only investment costs and change in the energy portfolio diversification, but also associated change in the relative bargaining position of the affected parties. For example, the same decrease in the EU gas dependency towards Russia (or any other partner) could in some situations be achieved by creating a new gas route from an alternative gas supplier, and by mobilizing the coordination between the EU Member States to improve their buyer power vis-à-vis Russia. This argument is in line with the recently revived idea of a "one-voice" EU energy policy, aimed at exercising "the combined weight of the EU in external energy relations" (European Commission (2011)).

Similarly, Russia would need to consider an analogous trade-off in making the decision about securing its energy demand. Partial re-direction of gas export flows to the new markets to achieve better demand diversification, – e.g. to South-East Asia, - could be associated with a loss of the market power in each of the previously served markets.

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Appendix A.1. Gas transit routes between Russia and the EU

Route	Transit country	Entry node at the EU border	Countries served by the route
1	Ukraine	Velke Kapušany	Slovakia, Czech Republic, Austria, Germany, Slovenia, Hungary, France, Belgium, Netherlands, Italy
2	Ukraine	Beregovo	Hungary
3	Ukraine	Tekovo	Romania
4	Ukraine	Isaccea	Moldova, Romania, Bulgaria, Greece
5	Belarus	Kondratki	Poland, Germany, Belgium, Netherlands
6	Belarus	Kotlovka	Lithuania, Latvia
7	-	Korneti	Latvia, Lithuania
8	-	Imatra	Finland
9	-	Värska	Estonia
10 (Nord Stream)	-	Greifswald	Germany, Belgium, France, Netherlands, Czech Republic
11 (South Stream)	-	Varna	Bulgaria, Greece, Italy, Hungary, Austria, Slovenia

Table A.1

Appendix A.2. Components of Demand Dependency Index

- $Transit\ Routes$ is the set of transit routes from Russia to its gas trade partners in the EU, with $i \in Routes$ indexing individual routes in this set,
- $GasExpShare_i = Exp_i / Exp$, where Exp_i is the export of gas from Russia to the EU through route i, and Exp is the total amount of Russian gas exports to the EU,
- $PolRisk_i$ is a measure of political instability along the transit route. We assume

here that the political risk associated with the recipient EU countries is negligible, so $PolRisk_i$ simply captures instability in the transit country (ies);

- $TechFailure_i$ is given by the length of the pipeline multiplied by the probability of a rupture per km within a considered period of time.

- $RouteDep_i = \sum_{c \in i} \left[\frac{Exp_i^c}{Exp_i} * \left(1 - \frac{Exp_i^c}{Cons^c} SGas^c \right) \right]$ is given by the weighted sum of proxies for (the inverse of) Russian gas market power in country c served by route i, calculated as one less the share of Russian gas in total gas consumption of country c multiplied by the share of gas in the energy bundle of country c. The weights are given by the share of Russian gas exports to country c through route i in total Russian gas exports through route i. Countries with low market power of Russia along the considered route increase its $RouteDep_i$.

- $BP_i = 1/2 - MS_i/2$, where MS_i is the share of Russian gas exports through route i in total Russian gas exports to the EU. In a hypothetical situation of a single seller (Russia) and a single perfectly coordinated buyer (the EU) the bargaining power would likely be split evenly. Our measure considers the deviation of the bargaining power of countries served by route i vs. Russia from this hypothetical threshold. Higher values of BP_i imply lower bargaining power of the EU (and higher bargaining power of Russia) along a route and, as a result less dependency of Russia on the EU.

- $\Delta RussianGasExportValue_{EU}^{new\ routes} = ExpValue_{EU}^{new\ route} - ExpValue_{EU}^{no\ new\ routes}$ represents the change in the value of Russian gas exports to the EU from the introduction of a new route. For example, a decrease in exports in absence of any price change results in negative $\Delta RussianGasExportValue_{EU}^{new\ routes}$.

Appendix A.3. Scenario assumptions

In this appendix we provide a short summary of the assumptions used in the scenario analysis to predict the volumes of Russian and non-Russian gas imports in 2020.

1. The total amount of 2020 gas imports by Member State *i* is given by the projection of European Commission (2010) and does not change across scenarios or with new route capacity usage.
2. In addition to the above, "South Stream" and "Nabucco" scenarios use the following common set of assumptions:
   a. The share of Russian gas in total imports of Member State *i in absence of any new route/new source of gas* (that is, with zero capacity usage of either South Stream or Nabucco) is the same as in the most recent available data year, 2010. This assumption allows to project the volume of Russian gas imports in 2020 for each EU Member State.
   b. As the total gas imports of Member State *i* are assumed to be constant, a gas inflow through a new route (i.e., South Stream or Nabucco) should crowd out the same volume of gas from other sources. We assume that Russian/non-Russian gas imports are crowded out proportionally to their import shares.

> For example, assume that in absence of any new routes the gas import portfolio of Member State i consists of 80 percent of Russian gas and 20 percent of gas from other suppliers. Then ten extra units of Russian gas received through South Stream would imply an eight unit decrease in Russian gas imports through other pipelines, and a two unit decrease in non-Russian gas imports. Thereby, the net effect of this extra gas via South Stream on Member State i will be an increase in Russian gas imports by 10-8=2 unit met by same size decrease of gas imports from non-Russian sources.
> Similarly, ten units of *non-Russian* gas received through Nabucco will imply a decrease in Russian gas imports by eight units, and a net increase in non-Russian gas imports by 10-2=8 units.

c. The volume of gas sent via a new route (under different capacity levels) is allocated between the recipient Member States proportionally to their total gas imports.

3. The assumptions for the "South Stream + LNG" scenario are similar to the ones for the previous two scenarios, but require an additional step. Recall that this scenario studies the change of dependency indexes with the capacity of South Stream assuming a certain share x of LNG in the total gas imports. This is taken into account through the following set of assumptions

a. The gas import portfolio in 2020 *with zero South Stream use* is calculated as follows: Total gas imports are given, as above, by the projection of European Commission (2010). Share x of them is assumed to be the (new) LNG imports. The remaining (1-x) import share is divided between the gas imports from Russia and other sources proportionally to their shares in the original (i.e., 2010) import portfolio.

b. In turn, additional gas imports through South Stream crowd out other pipeline gas imports (in exactly same way as described above in 2b); however, they do not affect LNG imports, so that LNG import share stays equal to x.

> The evaluation procedure, thereby, becomes two-stage: First, identify the volumes of Russian and non-Russian pipeline gas imports assuming that LNG constitutes share x of total imports and South Stream does not operate. Then vary the capacity use of South Stream, and calculate new import shares taking into account the crowding out effect South Stream imports have on the other pipeline imports.

c. As above, the volume of gas sent via South Stream is allocated between the recipient Member States proportionally to their gas imports.

d. Finally, the list of Member States assumed to receive part of their gas imports as LNG excludes Romania and Bulgaria. This assumption is based on ENTSOG

Ten-Year Network Development Plan (2011), which indicated that only for these two Member States no investment decision on the LNG terminals has been made.