PROPOSAL FOR

A HELSINKI - TALLINN TUNNEL PROJECT

14.5.2018

HDL Economics

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Main arguments:

- Tunnel creates a globally visible innovation node and facilitates mobility.
- Tunnel enables economic renewal and growth.
- Tunnel stabilizes or even cuts growing seaborne traffic between Helsinki and Tallinn which will have positive environmental impact on Gulf of Finland.
- Tunnel implementation model is new: it fosters private entrepreneurship with facilitation by governments.

1 Executive Summary

Tunnel between Helsinki and Tallinn would be an infrastructure project which had impact over the 21st century or longer. Even the construction phase could increase positive global visibility for Finland and Estonia. Most importantly, the region could become **a globally visible innovation node** that brings stability, wealth and prosperity between Europe and Asia.

Environmentally and from sustainability perspective the tunnel project is feasible. It has risks but overall impact is neutral or even positive as it is energy efficient compared to other transportation modes and decreases emissions and increases environmental safety in the Gulf of Finland. Economically the project is feasible if wider impacts are taken into account.

From European perspective the tunnel can be seen as a gateway that connects Europe from High North to Black Sea and enables a new route to Asia. The railway tunnel combines Finland's and Estonia's transport networks and the local commuting systems. The level of interoperability and multimodality in the system is higher than those without the tunnel. The greatest direct beneficiaries of the tunnel are citizens, workers, students and tourists as passengers. When considering the wider impacts, the railway tunnel would benefit remarkably businesses, trade, investments and culture. The tunnel project follows strategic objectives of EU and transport policy in particular.[1]

Optionally the tunnel can serve also in data, energy and other transfer activities. The tunnel provides a safe location for data cables that can connect Asia and Europe. Moreover, it can assist in connecting planned renewable energy sources between Estonia and Nordic electricity grid.

It is proposed that a private tunnel company will be established to take responsibility of planning, investment, construction, operation and maintanenance of the tunnel on behalf of the states of Finland, Estonia and private shareholders. The Tunnel

[1] EU transportation objectives are defined as follows: "Transport is a strategic sector of the EU economy. Prerequisite for most of the activities in the society, it has a major impact on Europe's social, economic and environmental development. Transport contributes to economic growth and jobs, global competitiveness and trade, enabling people and goods to move across Europe and beyond. Transport is the key enabler of the four freedoms of movement defining the Single Market - people, goods, services and capital. Transport directly affects everyone in Europe. Whatever age we are, and whatever activities we undertake, transport and mobility play a fundamental role in today's world. The Commission's aim is to promote mobility that is efficient, safe, secure and environmentally friendly, serving the needs of citizens and businesses."EU transport policy and investment activities contribute actively in particular to the following 5 Priorities:
Priority 1: "A New Boost for Jobs, Growth and Investment",
Priority 2: "A Connected Digital Single Market",
Priority 3: "A Resilient Energy Union with a Forward-Looking Climate Change Policy", Priority 4: "A Deeper and Fairer Internal Market with a Strengthened Industrial Base", Priority 5: "A Stronger Global Actor".

Company could be financed from multiple sources including equity investors, global infrastructure investors, international financial institutions and private large and small investors. Majority of the finance comes from private sources.

In fact, the private tunnel project would represent a new model for infrastructure implementation where private sector entrepreneurs drive for implementation and the role for the government is to support and facilitate.

Furthermore, It is proposed that governments in Estonia and Finland commit and communicate mutual understanding of the tunnel project benefits but also of its challenges. In order to create the globally visible innovation node long-term facilitation of both governments is needed.

2 Vision

The tunnel could be a catalyst for something far larger: **Globally recognized node for innovation and trade**. The tunnel might serve as a connection for trade flows between EU and Asia. The result can be environmentally, socially and technologically unforeseen urban region that catalyzes Eurasian growth. It would be the way 21st century Nordic society gives back to the world. It could embrace openness, stability, innovation and values the fragile nature.

On Tunnel Island it would be possible to find global innovations to resolve threats of climate change and other wicked problems for the world.

Figure 1 ***6-8 hours flights between Asia and Europe***

According to United Nations globally by 2050, 66 per cent of the world's population is projected to be urban.[2] The tunnel could take the urbanization challenge and provide a sustainable solution based on the model know in Nordic and Baltic countries.

2.1 Global Innovation status[3]

The tunnel could create a region that would have a global status. The tunnel project could connect two regions in a globally unique way. Connecting cities into metropolitan areas might have benefits which can be seen for instance in:

- China: Hong Kong – Shenzhen
- Japan: Kyoto – Osaka

[2] This is due to number of reasons due to various reasons but mainly because populations growth rates are higher in urban than in rural areas.
https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf .
[3] Based on views of author.

- USA: San Jose – San Francisco

The tunnel project could result legitimate addition to the list

- FIN / EST: Helsinki - Tallinn

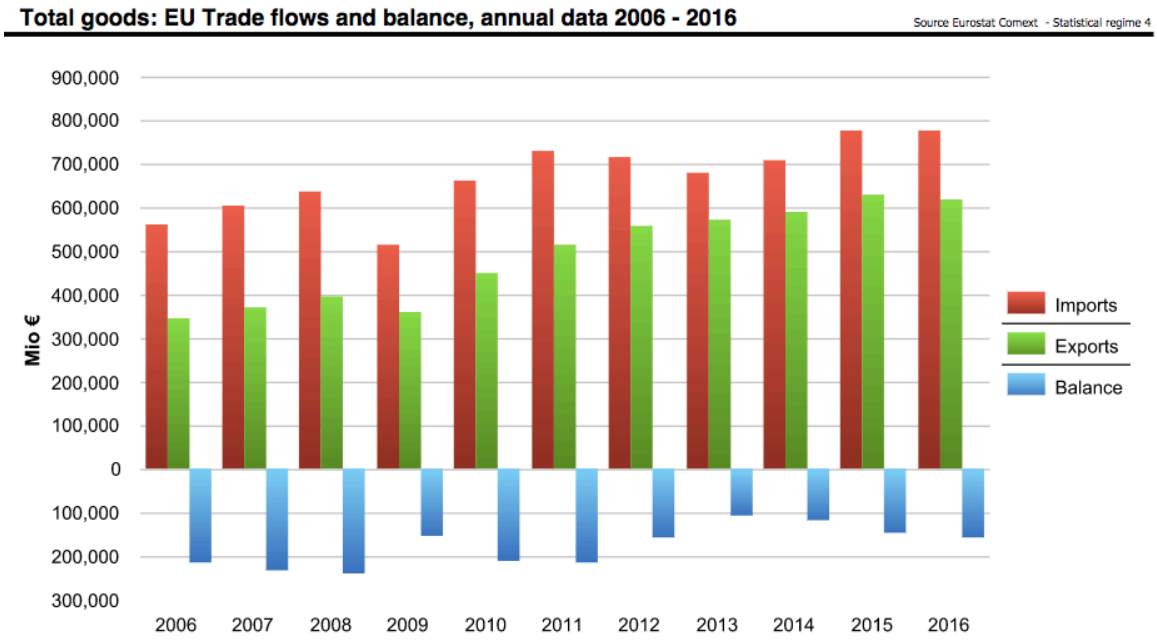
The tunnel might facilitate creation of an innovation intensive metropolitan region with a population of 3 million, several universities and globally significant start-up ecosystem which is based on success stories such as Skype, Transferwise, Pipedrive, Cloutex, Click & Grow, Grabcad, Erply, Fortumo, Lingvist, Rovio, Supercell, MySQL, MariaDB, Jolla, Jaiku etc.

2.2 Tunnel can enable faster trade between EU and Asia

Arctic corridor is arguably 37% faster sea route between Asia and Europe than traditional sea route through Suez Canal[4]. Traffic from Europe to Kirkenes could be organized through Finland and Sweden. Potential rail route using Rail-Baltica and Arctic Railway would require a solution to pass Gulf of Finland. That could be operated by increased rail vessel traffic or by the tunnel. The tunnel would remove the missing link for rolling stock between Europe and Kirkenes.

This connection could allow cargo traffic from Europe to Asia and export transportation from Finland and Northern Norway to both Europe and Asia. The volume of cargo is potentially large.

Figure 2 ***EU trade flows***[5]



[4] Distance from Northern Europe to China and vice versa is approx 40% shorter via Northern route than via the Suez Canal or 60% shorter via the Cape of Good Hope.

[5] Source: http://trade.ec.europa.eu/doclib/docs/2011/january/tradoc_147207.pdf .

According to European Commission Directorate-General for Trade, total value of traded goods between EU and Asia was € 1,393,047 millions. From 2010 to 2016 the value of traded goods has increased 53% (2006: € 907,542 milions). In 2016 total value of goods traded with China was € 514,597 millions making the second largest trading partner with EU. Moreover, trade with Japan was € 124,636 millions making it the sixth largest trading partner with EU. Traded goods between EU and China and between EU and Japan correspond 18% of total value of traded goods between EU and the world.

Respectively, according to Statics Finland, total value of traded goods between Finland and Asia was € 8,100 millions in 2016 which accounts 0,6% of value of traded good between EU and Asia. Market potential in transportation could be significant.

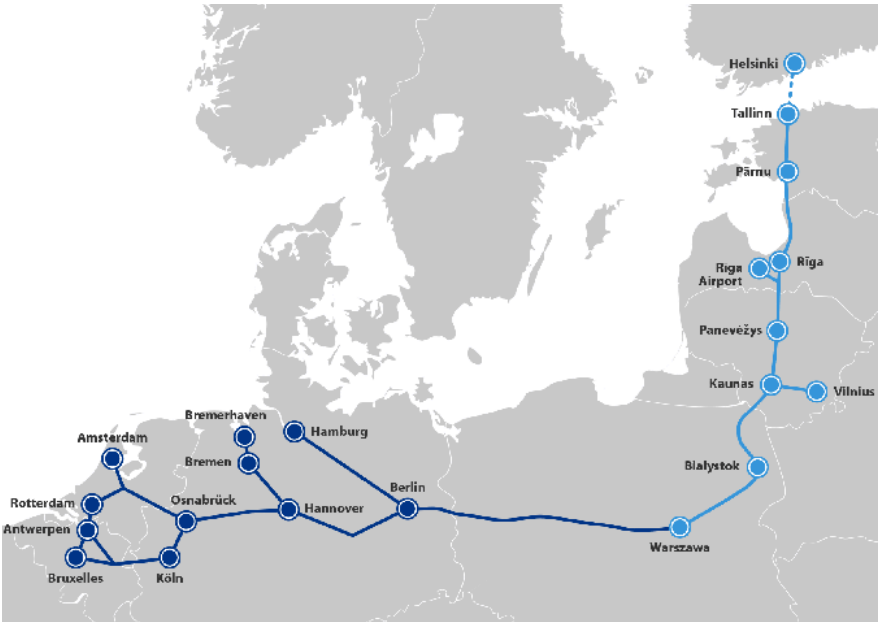
Figure 3 ***Arctic corridor***[6]

Rail-Baltica could open railway route on the eastern side of the Baltic sea and connects Baltic countries and Finland to Europe.

As a vision opening Arctic corridor and North-East Passage for Europe could bring new passanger and freight demand for the tunnel even though a recent report does no give support for the vision[7].

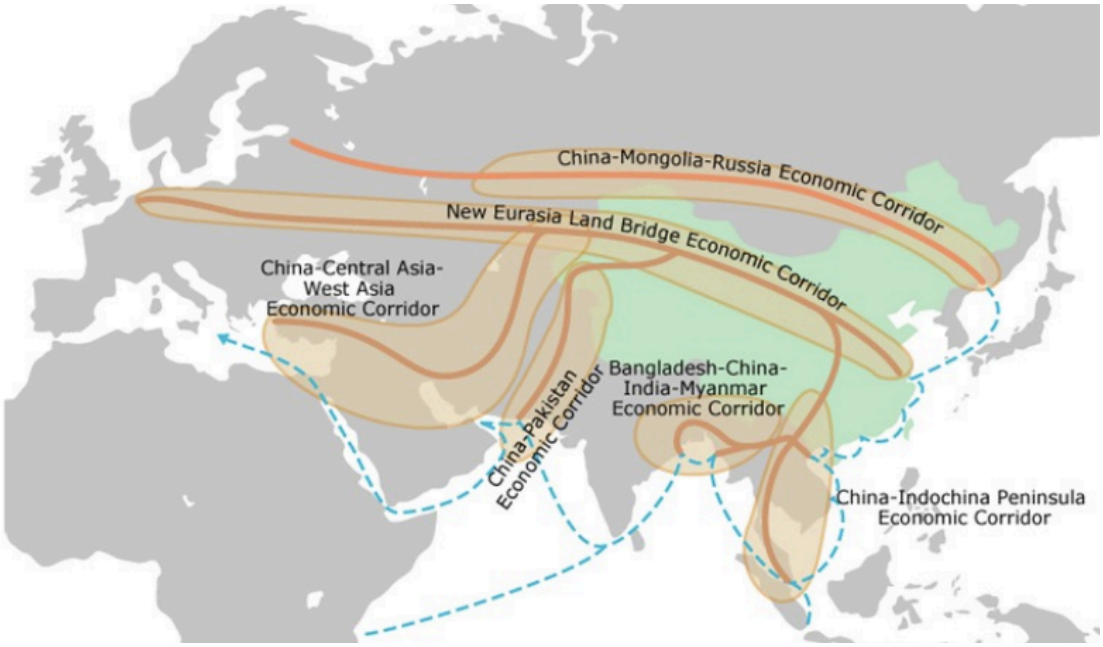
[6] Source: http://arcticcorridor.fi/ .
[7] https://julkaisut.liikennevirasto.fi/pdf8/ramboll_jaameren_ratayhteyden_web.pdf .

Figure 4 ***Rail-Baltica connection from Europe***[8]



The tunnel might have further linkage to Belt and Road Initiative proposed by China in 2015. In Belt and Road Initiative China-Mongolia-Russia Economic Coorridor and related railway provides additional connection for flow of goods between Nordic countries and Asia. The tunnel could serve as an access to Belt and Road connection. Moreover, Belt and Road provides additional connection point for the tunnel related innovation node.

Figure 5 ***Belt and Road Initiatiave***[9]



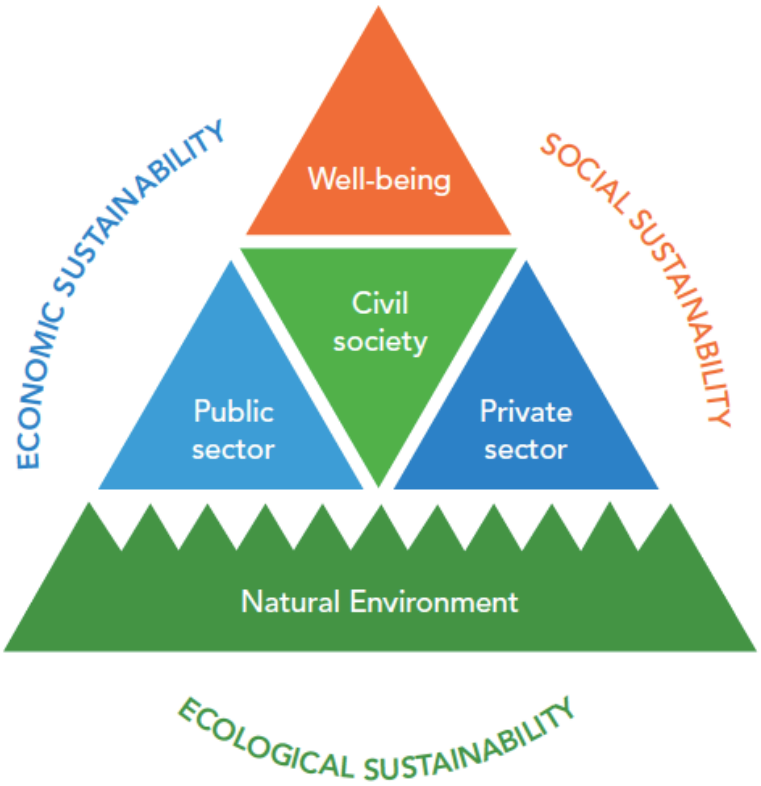
[8] Source: http://www.railbaltica.org/ .
[9] Source: HKTDC Research: http://china-trade-research.hktdc.com/business-news/article/The-Belt-and-Road-Initiative/The-Belt-and-Road-Initiative/obor/en/1/1X000000/1X0A36B7.htm.

2.3 Smart City

The tunnel could have four stations which might become new urban living environments. Station areas could be built on the basis of smart city opportunities. Smart city-based urban planning will balance between ecological, social and economic sustainability. In new urban living environments Finnish and Estonian societal structures could be applied. This would include public sector services, civil society, private sector operation and natural environment that all aim to Nordic well-being.

New urban living environments could connect vibrant start-up ecosystems from Tallinn and Helsinki creating a unique open innovation environment that can produce totally new concepts and solutions for societal challenges.

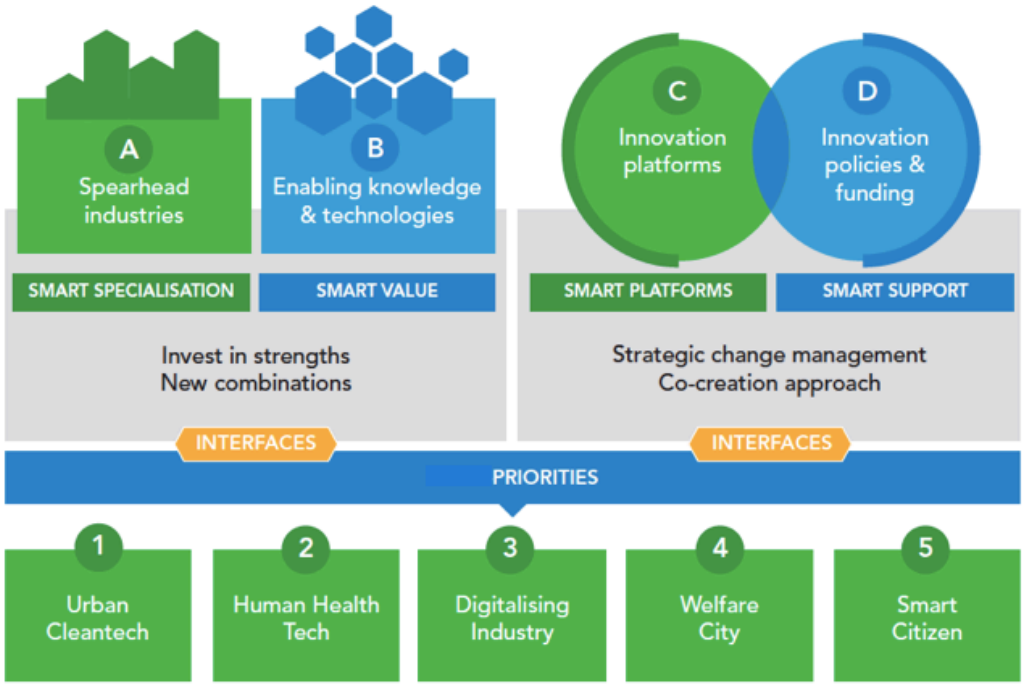
Figure 6 ***Foundations of new urban living environments***[10]



Strategic focus of this platform could be in urban cleantech, human health tech, digitalizing industry, welfare city and smart citizen.

[10] Source: Orchestrating Regional Innovation Ecosystems 2015.

Figure 7 ***Structure of regional innovation platforms***[11]



2.4 New business areas[12]

The tunnel could create a unique opportunity to achieve structural industrial renewal not only related to new technologies and governance structures but also based on more efficient transportation connections to Europe and Asia. So far nine new business areas with extensive impact have been identified. Further analysis is needed to identify the scale and scope of these potential new business areas.

Table 1 ***New business areas enabled by the tunnel***

Business	Description
Sharing economy	Tunnel allows sharing of both private and public services on all levels. For instance, special equipment in surgeries and healthcare can be shared between Estonian and Finnish institutions. The same applies to universities, educational and sports facilities.
Mobility-as-a-Service	Technological development allows major changes in urban mobility. Mobility will be provided as a service. The tunnel project and related new urban living environments will provide technology-based mobility services that will include all traditional mobility services (bicycle, car and bus), train and even flights for islands residents.
Tourism	New innovation node, events and architecture create globally visible tourism attraction.

[11] Source: Orchestrating Regional Innovation Ecosystems 2015.
[12] Views by author.

Fish transportation to Asia and Europe	Norway is one of the largest salmon producers in the world. Increasing salmon production requires more transportation capacity in the future. Salmon trains to Europe and salmon ships to Asia create new business to Northern part of Nordic countries.
Pre-fabricated and other wood artifacts to Europe	Finland provides wood as a raw-material for construction and other food artifact developers in Europe. The tunnel decreases costs for transporting these artifacts to European markets
Raw material development industries	Finland provides metals and other minerals for basic and technology industries. The tunnel facilitates e.g. battery, car parts and other development in Finland for German car industry.
Bio-based materials and products to Europe	The tunnel potentially decreases costs for transporting these products to European markets.
Berries, mushrooms and other natural nutrition products to Europe and Asia	Traditionally both Finalnd and Estonia have been producers of berries, mushrooms and other special nutrition products. The tunnel facilitates faster transportation of fres and organic food to bot European and Asian markets.
Fish, clam and aquatic vegetation farming	New artificial islands provide platform for business development in fish, clam and aquatic vegetation farming

2.5 Network infrastructure services: data, electricity and water

The tunnel does not only serve passenger and freight traffic. It can also be used for data cables, electricity cables and water pipelines. If needed other pipelines such as natural gas and oil can be considered.

Each of these cases could save compared to costs of traditional network infrastructure investments € 100 – 400 million, summing investment cost savings up to approximately € 1 billion altogether[13]. Moreover, operational and maintenance can be organized in association to normal tunnel operation with lower expected costs compared to alternatives. The table below illustrates potential cases. Detailed case studies are needed to investigate viability of thses additional network services.

Table 2 ***Tunnel use options for network services***

Case	Description
Data	Tunnel allows more secure data cables which are easier to maintain.
Electricity	The tunnel provides a cost-efficient solution for electricity cable between Finland and Estonia[14].
Water	Water delivery through the tunnel could support the supply of drinking water in Estonia.

[13] Estimates by author.

[14] https://news.err.ee/691373/polish-baltic-leaders-meet-with-juncker-discuss-baltic-desynchronization .

Natural gas	LNG grid is under construction in the Gulf of Finland region. Planned connection between Estonia and Finland will be based on "Baltic connector"[15][16]. If needed the tunnel can be used for gas transportation.
Oil	Not relevant.

3 Justification

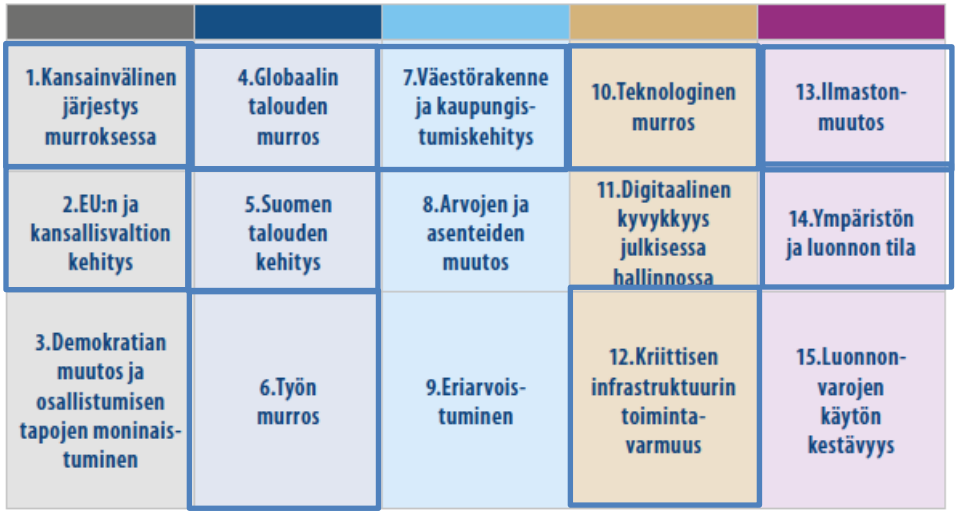
Both Finland and Estonia are small countries with ageing populations. Moreover, countries are far at the North-East side of Europe. Both countries face challeges related to industrial structure. Estonia is a small economy with no major natural resources. Finland is an economy that is based on telecommunications and pulp and paper industries. Both of these industries have been in steady decline.

Innovation and economic renewal require actions that foster growth, openness, trade and mobility. Building the tunnel between Helsinki and Tallinn is justified in order to increase mobility between these states but also because of structural change that embraces free flow of ideas and people, globally.

3.1 Macroeconomic imperatives

Finland and Estonia face severe internal challenges in the near future. Moreover, international phenomena will have major impact to both nations. These challenges have been organized in 15 categories by Prime Minister's Office in Finland.

Figure 8 ***List of major changes (in Finnish)***[17]



The tunnel project addresses at least of 10 of the identified 15 categories as illustrated in the figure above. Most importantly the tunnel project could connect Finland and

[15] Source: Ministry of Economic Affairs and Employment: Energy and Climate Policy 2030, 4/2017.
[16] Source: https://ec.europa.eu/eipp/desktop/fi/projects/project-98.html .
[17] Source: http://vnk.fi/tulevaisuuskatsaukset .

Estonia to changing global economic system and provides platform for new jobs, innovation and growth. More detailed analysis is needed to quantify potential impacts.

Table 3 ***Projections of GDP growth in Finland (in Finnish)***

Taulukko 1. BKT:n kasvu sekä julkisen talouden keskeisiä ennustelukuja*, % suhteessa BKT:hen

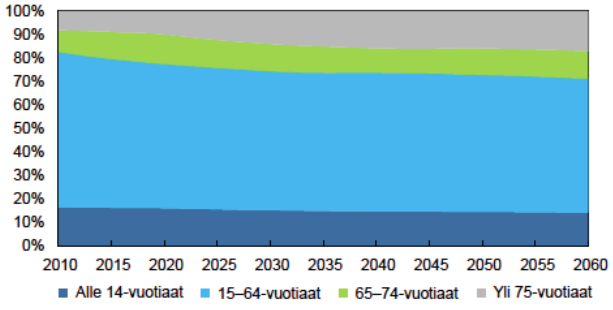
	2015*	2016**	2017**	2018**	2019**	2020**
BKT markkinahintaan, määrän muutos, %	0,2	1,6	0,9	1,0	1,2	1,2
Julkisen talouden alijäämä	-2,8	-2,2	-2,5	-2,0	-1,5	-1,2
Valtionhallinto	-3,0	-2,6	-2,6	-2,1	-1,7	-1,3
Paikallishallinto	-0,6	-0,5	-0,5	-0,5	-0,5	-0,5
Sosiaaliturvarahastot	0,9	0,9	0,7	0,6	0,7	0,7
Julkisyhteisöjen velka	63,6	63,7	65,3	66,1	66,0	65,4
Valtionvelka	47,7	47,7	49,2	50,2	50,4	50,0

*Ennusteluvut perustuvat joulukuun 2016 kokonaistaloudellisen ennusteen perusuraan vuosille 2016–2018 ja sen päälle laskettuun karkeasti arvioituun tekniseen keskipitkän aikavälin uraan vuosille 2019–2020. Kyseessä ei ole uusi ennuste. Uusi ennuste laaditaan hallituksen puolivälintarkastelua varten ja se julkaistaan huhtikuussa 2017.

In Finland projected GDP growth and related revenues will not cover public sector deficits as shown in the table below[18]. Thus, economic renewal is clearly needed.

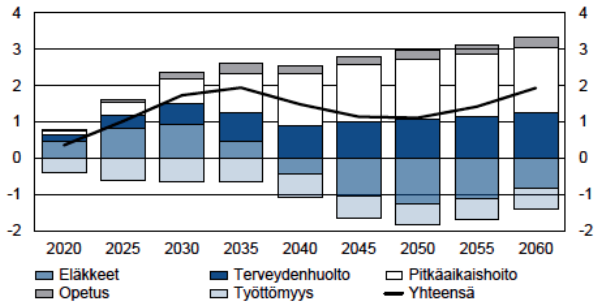
Figure 9 ***Population age structure and costs in Finland (in Finnish)***

Kuvio 5. **Eri ikäryhmien osuus väestöstä**



Lähde: Tilastokeskus

Kuvio 6. **Ikäsidonnaisten menojen muutos**
vuodesta 2015, suhteessa bruttokansantuotteeseen, %



Kuvio on laadittu STM:n kehittämällä SOME-mallilla
Lähde: VM

[18] Source: Ministry of Finance: Public sector projections and challenges.

On the other hand, digitalization has created another kind of a challenge for the society that is related to digital competence and automatization. In the future, needed competencies are remarkably different compared to current professions. According to a research institution Sitra ability to develop competences and acquire new competencies will be needed[19]. The technology sector has identified an immediate need of 25 000 emplyees with new competencies[20].

Moreover, also Aho, Lyly and Mero have brought up a vision of 2030 and 2050 communication and transportation network where digitalization and information play keys roles in their recent report[21]. “The transport and communication system could be used to create favourable conditions for Finland's well-being, competitiveness and economy in 2030 and 2050. The following vision has been defined in the work for 2030 and 2050:

- New revolutionary technological breakthroughs that will transform the current transport and communication systems are about to happen globally.
- Traditional traffic and digital solutions will merge.
- Data will become the primary factor of production and competition.
- Finland's greatest opportunities lie in quickly and comprehensively utilising the technological solutions being created globally.
- These opportunities must be seized, as this would allow Finland's particular challenges in internal and external accessibility to be overcome in a sustainable manner.
- Finland must make radical changes to its existing structures, operating models and decision-making.
- The objective must be to make Finland the global leader of intelligent transport ecosystems.
- This requires investment, readiness for change, risk-taking, new skills and a culture of experimentation.
- Succeeding in this would bring sustainable economic growth, create new business and enable high-quality transport and communications services for citizens.
- This change must be brought about in a way that benefits every Finnish citizen.”

In fact, actions outlined above are addressed in the vision and proposal of the tunnel project implementation. Urban planning related to potential tunnel station areas can be implemented according to principles outlined in smart city context. All urban operation can be based on data connections and smart use of data in e.g. infrastucture maintenance, traffic operation and service provision. Increased mobility

[19] Source: https://www.sitra.fi/artikkelit/osaamisvaje-suurin-haaste-tyon-murroksessa/
[20] http://www.tivia.fi/tiviassa-tapahtuu/tivia-news/ohjelmistosuunnittelijavaje-jo-25000-korkeakoulutettua .
[21] http://urn.fi/URN:ISBN:978-952-243-514-9 .

could be facilitated by the tunnel which could bring innovative ideas, finance and economic activitiy to the region.

3.2 Counterfactual scenarios

Counterfactual scenarios can give understanding what it means if the tunnel will not be made. Scenrios can be divided into several categories such as ”do nothing”, ”do minimum” and ”do something else”. These scenarios are summarized in the table below. Comparing these scenarios with the vision of the Finest Tunnel indicate that some positive wider economic impacts can be gained even without the tunnel. However, in all cases traffic in the Gulf of Finland will increase significantly creating respectively increasing environmental threath.

Table 4 ***Counterfactual scenarios***[22]

Scenario	Description	Implications
“Do nothing”	No tunnel is constructed and urban planning in Tallinn and Helsinki continue as before. No change in harbours or transportation. Urbanization continues to grow. Rail-Baltica ends to Tallinn. Innovations ecosystems continues to grow without supporting connection. No new islands to awake global interest.	Transportation continues to grow through increasingly crowded vessels and facilities even though not as much as in the case the tunnel had been built. Travel and freight costs rise. Environmental risks increase. Lack of real-estate leads to high real-estate prices. No major new international attention to the region. No land connection to Arctic Corridor. No groundbreaking innovation ecosystem. No positive major wider economic impacts.
“Do minimum”	Minimum changes in harbours and sea or flight transportation as mobility increases. Urbanization continues to grow. Innovation ecosystems grow. No new islands to awake global interest.	Increased traffic increases environmental risks. Pressure on real-estate resolved with minimum new construction maintains increasing real-estate prices. High investments need on harbor infrastructure to connect Rail-Baltica to Arctic Corridor. Limited positive wider economic impacts.
“Do something else”	Find new sustainable ways to meet transportation, innovation ecosystem and global visibility challenges. In order to fulfill these objectives radically new CO2-free vessels, related harbor infrastructure and urban space will be constructed.	Sustainable concept with sea as a major transportation channel will awake global interest with its SmartCity and environmentally friendly solutions. Some positive wider economic impacts. Gulf of Finland becomes crowded sea-highway.

[22] Scenarios by author.

4 Environmental impact and sustainability

Environmental concers are of the highest priority in the project. Environmental impact can be shared into two categories: impact of the project phase and impact of the operational phase. It is worth noting that the tunnel will also have a positive impact on environment.

4.1 Environmental concerns

During the project phase using construction equipment and vehicles cause emissions and risks for the environment. Emissions can be mitigated in several ways e.g. by using as much renewable energy as possible. Most importantly, environmental impact will be significant especially in the cases of new islands and re-location of the material from the tunnel drilling.

According to current feasibility study[23] the largest geological risk is related to Estonian ground water resources which can be avoided by circumvention or special constructions. Moreover, groundwater area “Ruskeasanta” close to Helsinki-Vantaa airport needs to be taken into consideration when tunnel ans support function locations are defined.

During operational phase environmental impact will be limited to energy usage of the tunnel. All mobility solutions in the tunnel will be based on electricity which can be produced by using renewable energy sources as much as possible. In fact, tunnel allows stabilization or decline in vessel traffic in Gulf of Finland that leads to mitigated carbon emissions, lower noise pollution and increased environmental safety.

Moreover, building the tunnel and especially artificial islands will cause disturbance to habitats of underwater flora and fauna due to relocation of sediments. Artificial islands can cause changes in sediment flow by altering the course of existing currents causing thus changes in the conditions of sea habitats.

When it comes to environmental aspects of wider economic impacts normal urban and real-estate development related risks are relevant. Environmental issues can be taken into account by applying sustainable urban planning principles and e.g. wood construction. However, social and economic aspects should not be dismissed.

[23] Source: http://www.finestlink.fi/en/2018/02/07/final-report-published/ .

4.2 Environmental opportunities[24]

Respectively, enviromental opportunities can be divided into direct and indirect opportunities.

Direct opportunities are related to potential to decrease traffic by sea vessels. Naturally emissions of sea vessels will decline as engine technologies will develop. However, maritime congestion is clearly a source for increasing challenges for the nature of Gulf of Finland and in particular for Gulf of Tallinn. The tunnel provides alternative mode for sea transportation that will decrease stress for the surrounding nature including seals, fish, aquatic vegetation and coastal erosion.

Sea safety especially in cases of oil disasters and in Estonian coast could clearly benefit sea rescue locations that are closer to areas vulnerable to disasters. Artificial islands can be used as locations for sea rescue and oil spill response units. Moreover, the islands could provide platform for other security activities if found necessary.

Indirectly regional development on railways and concepts such as Mobility-as-a Service will guide traffic volumes towards (electricity-based) public transportation. That will have wider economic impact to climate change as traffic-based energy consumption and emission per user will decline.

The tunnel can serve as a medium for transportation for all kinds of resources data, electricity, water, gas or other transported items. One tunnel for transportation could have indirect impact for all the other future transportation-related projects between Europe and Arctic Ocean and in particular projects over Gulf of Finland. Potentially, there will be no need to build another pipeline, set-up another sub-sea cable or increase the size of harbours as would be the case without the tunnel. Wider environmental impact for the Baltic Sea could be profound. As reference according to a recent study[25] the Channel Tunnel between the UK and France has widely positive economic footprint.

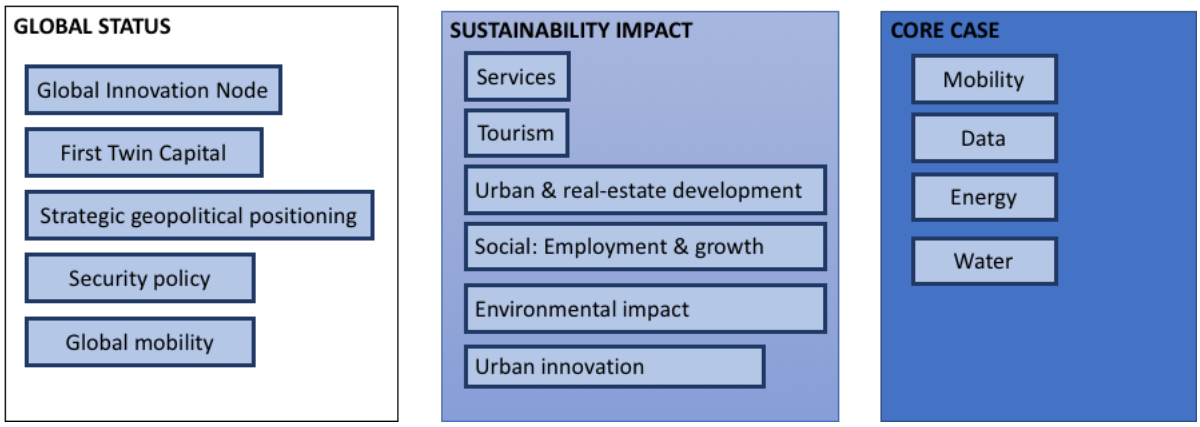
[24] Views by author.

[25] http://www.ey.com/Publication/vwLUAssets/Economic_footprint_of_the_Channel_Tunnel_fixed_link/$File/Channel%20Tunnel%20EN%20light.pdf " The opening of the Tunnel has had far reaching economic consequences, enabling the development of new and varied business models. It has enabled the development of integrated cross-border supply chains in sectors such as manufacturing and retail, driving gains in productivity, and delivering clear and direct benefits to the UK economy. It has also helped to facilitate online purchasing, as express delivery companies ship goods to UK consumers via European hubs."

5 Tunnel impact structure: global status, economic impact, core benefits

The tunnel project is of the size that will have global impact without mentioning wider regional and direct impacts to all relevant stakeholders.

Figure 10 ***Tunnel impact structure***[26]



5.1 Global status

As decribed in Section 2.1. the tunnel could have impact on global status of the region. That impact can be categorized into the following main elements:

- Global innovation node
- First Twin Capital
- Strategic Geopolotical positioning
- Global mobility

In previous feasibility studies these elements have been analyzed in a lesser degree.

Qualitiatively taken innovation hubs have proven to catalyze further growth especially if surrounding infrastructure allows development of new services and trades. This will be the case in the tunnel region as it is technologically advancced in international comparison as Finalnd ranks number 2. In EU DESI ranking[27].

Never before two nations have had so close connections between their capital cities. Together Tallinn and Helsinki will form the first comnination of nation capitals. It is a benchmark case of urbanization and how the rol of cities is increasing in the world. It fosters the role of free movement of city dwellers over the boundaries of nations and cultures.

[26] Structure by author.
[27] Source: https://ec.europa.eu/digital-single-market/en/news/digital-economy-and-society-index-desi-2017

The tunnel has also an undeniable geopolitical security policy impact as it connects Estonia and Finland together in terms of mobility. It will be part of a larger transportation and data network that connects Arctic regions, Asia and Europe together. The tunnel will potentially connect:

- Arctic corridor and Rail Baltica
- Northeast Passage telecommunications cable to Estonia and Europe
- Estonian renewable energy to Nordic grid

The tunnel would change the strategic geopolitical role of Helsinki and Tallinn.

5.2 Wider sustainability impact

Sustainability impact includes environmental, social and wider economic impacts. Environmental concers are of the highest priority in the project. However, environmental risks are not found to be abnormal. The largest geological risk is related to Estonian ground water resources which can be avoided by circumvention or special constructions. Environmental impact will be significant especially in the cases of new islands and re-location of the material from the tunnel drilling. In fact, tunnel allows stabilization or decline in vessel traffic in Gulf of Finland that leads to mitigated carbon emissions and increased environmental safety.

In the feasibility study wider economic impact is estimated to be € 7,0 billion excluding tourism. [28]

Economic growth includes estimated 200 000 inhabitants in four tunnel station areas including two built islands. One of the Islands is planned to be of a size of 50 000 inhabitants, that is the size of city of Vaasa. Inhabitants need real-estate, infrastructure and services respectively. That leads significant positive economic impact.[29]

New urban and real-estate development allows application of smart-city technologies and urban innovation. New urban services like mobility-as-a-service (MaaS) can be applied in large scale.
Globally visible innovation node will increase tourism in the region. High quality Nordic destination is especially in demand in Asia[30] but also in the US and other parts of Europe.

5.3 Core benefits[31]

Core benefits include direct mobility related impacts according to contemporary cost/benefit analysis methodology.

[28] http://www.finestlink.fi/en/2018/02/07/final-report-published/ .
[29] Estimates by Finest Bay Area Project.
[30] It is worth noting that in average a Chinese tourist spends € 1 200 on one holidays trip, estimate by Finest Bay Area Project.
[31] http://www.finestlink.fi/en/2018/02/07/final-report-published/ .

In current scenarios the demand in passenger transport in different scenarios is assumed to increase from 9 million (in 2017) to 23 million (in 2050 scenario with tunnel) of which 12,5 million passengers travel in the tunnel. Maritime transport and daily commuting between Helsinki and Tallinn are assumed to continue to grow also if the rail tunnel service will be built. The demand in freight transport in different scenarios is as 3,8 million tons (in 2017) 8 million (in 2050 scenario with tunnel) of which 4 million tons in tunnel and 4 million on ferries; freight in the tunnel represents value/ton above the average.

All direct construction costs are allocated into project costs including terminals (€ 2 billion), tunnels and equipment (€ 12 billion) and management / owner costs (€ 2 billion). Baseline cost/benefit analysis[32] results total economic costs € 11,2 billion and total economic benefits € 5,0 billion. Thus, direct net benefits are € - 6,20 billion. Respectively, B/C ratio is 0,45, that is below threshold level 1,0. Thus the direct costs outweight benefits. However, including wider economic impact increases the value to € 0,8 billion net positive. Moreover, potential additional direct impact from services such as data cables, energy cable and water services are excluded from the analysis. These services optionally include Northeast Passage telecommunications cable to Estonia and Europe and Estonian renewable energy cable to Nordic grid. Potential economic value of these services is € 1 billion[33].

6 Proposed structures and aspects for finance and risks[34]

Project risks are normal and can be mitigated by appropriate expertise even though the size of the project is expectionally lage in the Nordic context.
Moreover, the size of the project that has a time span over a decade impose risks related to expertise, organization continuity and even geopolitical circumstances. These risks need to be assessed apprioriately. External quality assurance of all activities is proposed to be applied.

6.1 Proposed diversified finance model

Alternative structures for project finance have been developed in earlier feasibility studies[35]. The tunnel project is of such a scale that it requires some degree of public involvement whatsoever. Therefore, finance model will be based on common PPP approaches. Proposed model will largely follow widely know DBFO (design-build-finance-operate) model. Additionally, the private entity will take responsibility of design of the total outcome. Other alternative PPP models are presented in the table of Types

[32] 3,5% discount rate applied.
[33] Estimate by author.
[34] Views by author.
[35] http://www.finestlink.fi/en/2018/02/07/final-report-published/ .

of PPP models. DBFO-model gives a clear mandate for the tunnel company to accomplish the construction phase and find the most efficient solutions for operation.

Each of station projects can be implemented as separate and independent real-estate infrstrucure cases which follow normal urban construction procedures except the tunnel aspect is taken into planning.

As the whole initiative consists of number of separated but interlinked elements the finance and, therefore, the whole initiative, can be divided into phases. Separate phases consist of at least 6 phases.

Table 5 ***Phased project portfolio***

Phase	Description
Phase 0	Phase portfolio
Phase 1	Station 1: Airport: transportation hub for cargo and passengers and new living environment
Phase 2	Station 2, Finland: new urban living environment and station
Phase 3	Station 3: Island 1 (FIN): New living environment for 50 000 inhabitants
Phase 4	Station 4: Ülemiste transport hub for cargo and passengers and new living environment
Phase 5	Tunnel 1: Airport to Island 1(FIN): rail connection to Island 1
Phase 6	Tunnel 2: Island 1(FIN) to Ülemiste transport hub
Phase 7	(option) Island 2 (EST): New living environment or nature reserve
Phase 8	(option) Tunnel 3: Data cable
Phase 9	(option) Tunnel 4: Electricity cable
Phase 10	(option) Tunnel 5: LNG pipeline

If the project is considered as a portfolio phased projects risks are diversified and the whole project becomes more agile. It must be noted that responsibility of financial, legal and risk aspects on international and government level will be carried out as one by the entitiy that governes the project.

Table 6 *Types of PPP models*[36]

Type of PPP	Contractual Description	Main Fields of Application
O&M (operations and maintenance)	The public body (*contractor*), usually a municipality or a local public contractor, negotiates with a private partner (*operator,* one single firm or a consortium) the management and maintenance of a public infrastructure.	Local public services: water and sewerage services, waste management, green parks maintenance, road maintenance, parking lots management
DB (design-build)	The public body negotiates with private partners the design and construction of a facility that must be compliant with minimum performance standards set by the public party. Once the construction is completed, the public body retains the ownership of the facility and manages it.	Public infrastructure: roads, toll roads and highways, water and sewerage, leisure facilities (sport centers), and public utility works
TK (turnkey)	The public sector provides funding for the project but involves private counterparties for the design, construction, and management of the facility for a predefined period of time (usually long term). The public entity requires the private partner to be compliant with minimum performance standards and is the owner of the facility.	Public infrastructure where the government has the interest to maintain ownership but also wants to get private involvement for the construction and management services (water and sewerage, public buildings, sport facilities and stadiums)
Wraparound addition	A private partner builds and finance an add-on facility to an existing one and manages the new facility for a predefined period.	Similar to the TK scheme, but in this case the public entity does not provide funding, which is in charge to the private sector.
Lease-purchase	The private sector provides funding and builds a new facility that is then leased to the public entity. The public party makes periodic leasing payments to the private party and has the right to acquire the facility at the end of the leasing contract.	Public buildings, water and sewerage, waste management, IT, and hardware
Temporary privatization	Similar to the wraparound addition. However, in this case the ownership of a public facility is transferred to a private partner in order to be restructured or expanded. The facility is managed by the private party until the public sector has completely repaid the investment.	Public infrastructure: roads, water and sewerage, parking lots, public buildings, sport facilities, airports
DBO (design-build-operate)	The private partner stipulates with the public body a single contract whereby it provides design, construction, and management of a public facility.The public sector retains the facility ownership.	Similar to temporary privatization
BDO/LDO (buy/lease-develop-operate)	The private party leases or buys a facility from the public sector in order to modernize or expand it. Then, it manages the facility for a period of time that is sufficient to repay the investment and get a sufficient rate of return.	Similar to temporary privatization
BOT (build-operate-transfer)	The private partner builds a facility compliant with the standards agreed with the public entity. Then it manages it for a given period of time and transfers the facility at the end of the concession period. The project should repay the investment made by the private sector during the concession period. In BOT the ownership of the facility remains to the public body.	Similar to temporary privatization
BOOT (build-own-operate-transfer) or DBFO (design-build-finance-operate; the term used in the U.S. to identify BOOT schemes)	The private sector stipulates a concession agreement with the public body and obtains the ownership of the facility. It is entitled to design, build, operate/maintain the facility. Funding is provided by the private partner, who has the right to retain the revenues coming from the management of the facility during the concession period. The concession period must be sufficiently long so to enable private partners to pay back the investment and get an adequate return on investment. At the end of the concession, the facility ownership is returned to the public sector.	This is the most-used form of private finance initiative (PFI) in the UK; it involves a wide range of public infrastructure: water and sewerage, sport and leisure facilities, airports, public buildings, parking lots, waste management.
BOO/LOO (build-own-operate)	The public sector transfers to the private sector ownership and management of an existing facility or negotiates with the private partner the construction and management of a new facility that will not be transferred by the private sector (as it happens under a BOOT scheme). The provision of funding is in charge to the private sector.	Similar to the BOOT scheme, although this contractual arrangement looks more like a privatization

[36] Gatti: Project Finance in Theory and Practice, 2013.

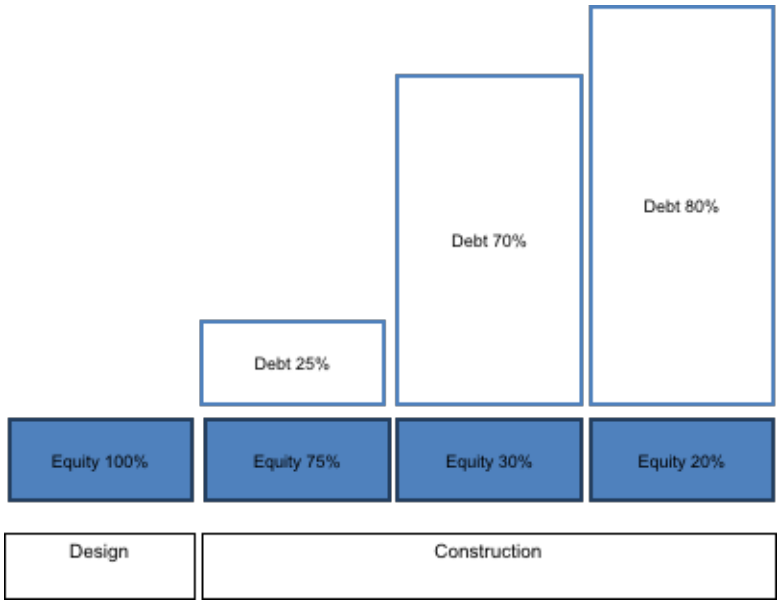
6.2 Sources of finance[37]

The tunnel investment cost is estimated to be € 16 billion[38]. Depending on assumptions investment is expected to vary between € 12 – 20 billion. This proposal is based on assumption that no public funding or grants will be available from Finland, Estonia and EU whatsoever.

It is proposed that the tunnel construction project will be fully financed privately by using proven project finance instruments such as equity instruments, bonds, long-term and syndicate loans and other typical project finance contracts. Moreover, the structure of finance follows terms of western financial contracts. The structure of the finance case depends on the risk-profile of the project. Typically, higher risk leads to higher role of equity finance.

Large infrastructure projects are actively financed over the course of the project and operation. In the beginning of the project the role of sufficient equity finance and guarantees are of the highest importance before entering into debt finance contracts. During construction phase the role of agreements with contractors can have impact on the project finance case.

Figure 11 ***Proposed core structure for financing project stages***

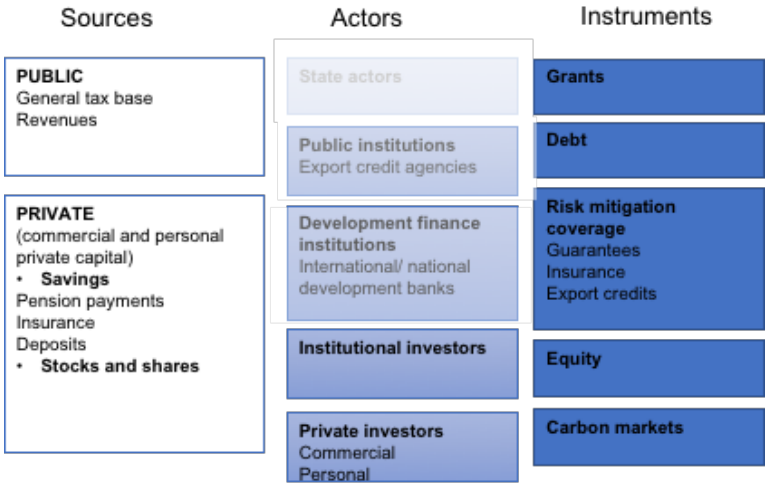


As a reference, a typical project finance structure is illustrated below. However, in the case of a lack of public funding from Finland, Estonia and EU and due to high risk profile of the role of public funding will be small.
In order to build an acceptable finance case for equity and debt investors the net value of the investment should be positive including risk reserves. Alternatively, guarantees

[37] Views by author.
[38] http://www.finestlink.fi/en/2018/02/07/final-report-published/ .

or compensation arrangements by public sector entities should be provided. As a compensation mechanism a positive tax based on future transportation volume can be considered.

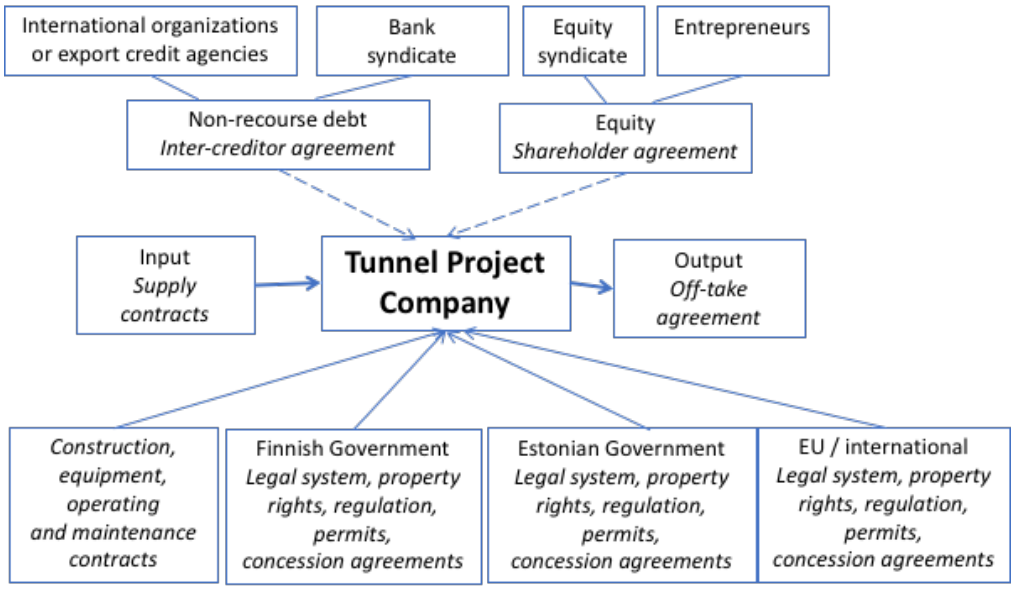
Figure 12 ***Reference model for infrastructure project finance***[39]



6.3 Proposed structure for contracts and finance in design stage

The tunnel project requires appropriate legal and organizational arrangements for each stage of its life-cycle. In the project initiation and design phase, roles of stakeholders, finance and potential contractors are proposed to be taken into account by establishing a tunnel project company. A private company model has been found to be successful governance model in recent large infrastructure cases such as Olkiluoto 4 or Äänekoski bioproduct mill.

Figure 13 ***Proposed structure for contracts and finance in design stage***



[39] CPI and CICERO 2015 modified by author.

6.4 Proposed key finance risk areas

In previous feasibility study[40] a list of risk factors is provided in discussion of operational models and risk allocation. We are extending the discussion towards risks relevant to finance and including most common mitigation approaches into the discussion. It is proposed that finance and risk management will be based on these dimensions in order to provide basis for finance analysis (ie. bankability of the project).

Table 7 ***Risk dimensions***

Risk	Mitigation
Macro/political/regulatory	Use of political risk insurers Reduction of country risk Involvement of local shareholders Strong regulatory framework
Legal risk	Strong legal framework Complementary shareholder group
Environmental risk	Environmental audit Mitigation technology
Natural disasters and operational accidents	Insurance
Conflicts of interest	"Arms length" contracts Complementary shareholding group
Project sponsors/suppliers/ contractors/contracted purchases	Long-term supply contracts Minimized mismatch between supply and purchase contracts either by contract or by hedging
Financial exposure – currency, interest rate, commodity prices	Hendging, pass through in contracts, matching revenues and costs
Market risk	Capital structure Long-term contracts Control over disbursements based on achieved / contracted revenue
Technical and technology	Proven technology Strong operators Manufacturers' warrants
Operating	Operator experience
Cost overruns	Strong construction contracts Sponsor guarantees Standby credit facilities
Capital structure	Tools, resources and financial instruments for capital restructuring, equity investor commitments
Management	Management commitment scheme

[40] http://www.finestlink.fi/wp-content/uploads/2018/02/FinEst-link-REPORT-FINAL-7.2.2018.pdf p.86.

For the successful project finance, appropriate risk mitigation is fundamental. Before any financial contracts can be signed also the following aspects need to be considered:

- Legal regime and context
- Grantor identity
- Negotiation and economic powers
- Political context

Key finance risk elements do not cover construction or operational phase in particular. In construction phase, risks related to site accidents, delays and planning errors are of high importance. On the other hand, in operational phase safety of passengers, cargo and environment are the highest priorities. These aspects are left to be considered in future planning.

It is emphasized that risk analysis and mitigation strategies are by no means one-time activities but should conducted on practical level and on continuous basis over the whole life-cycle of the project and also in operational stage.

6.5 Proposed legal aspects and taxation

Legal aspects include number of complex structures such as:

- Shareholder agreements
- Building permits
- Land use and ownership in Finland and Estonia
- Land use and ownership in international waters
- International law on operation under international waters
- Financial contracts
- Insurance contracts
- Construction contracts
- Operational contracts
- EU regulation on environment, water (Water framework Directive) and transportation

In particular, the case for international law that concerns use of land under international waters will require special expertise. There is a clear reference case for this kind of a legal arrangements: The Channel Tunnel. It was legally established in legislation of France and the United Kingdom[41]. Similar actions may be required for the part of tunnel that undercuts international waters.

A tax solution can have a major impact on financials in the project. On the other hand, taxation is of high interest for both governments in Finland and Estonia. VAT (Value-

[41] http://www.legislation.gov.uk/uksi/1993/1813/made .

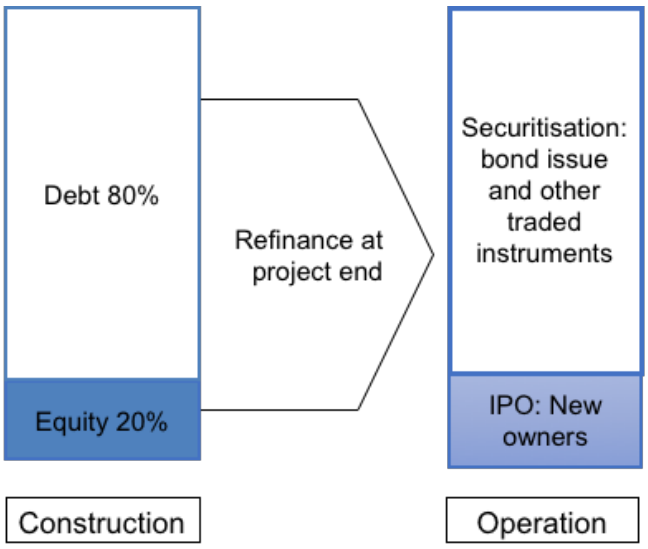
Added-Tax) management of the construction project must also be organized between both countires and the project. VAT taxation of operational phase must considered separately in the future.

It is proposed that legal and taxation aspects are carefully investigated and managed throughout all project stages.

6.6 Proposed finance of the operational mode

It is proposed that when the tunnel will be opened for use, the company will be restructured into operational ecosystem mode. Alternatively, the project stage company can transfer activities to the tunnel ecosystem operation company.

Figure 14 ***Finance in the operational mode***



Respectively, its financial structure and financial management instruments will be restructured. It is proposed that the company will be publicly listed in order to ensure full scrutiny of environmental, social and governance responsibilities. Moreover, its project stage debt instruments will be transformed into normal corporate bonds that are openly traded.

7 Proposed governance of the project, operation and other activities for design stage

The tunnel is an extensive construction project. Moreover, its operation requires special expertise and service capabilities. In order to implement the tunnel and take responsibility of its operation, safety and maintenance, a tunnel ecosystem company is proposed to be established.

The purpose of the tunnel company is to:

- Organize detailed planning of the project, ecosystem and operation
- Prepare decision and permission materials for the tunnel
- Acquire finance
- Take construction project responsibility
- Operate the tunnel ecosystem and its services
- Take care of tunnel maintenance investments
- Own and govern the tunnel, its ecosystem and related material and immaterial properties
- Take responsibility of stakeholder management and communications

The tunnel company could represent start-up spirit and agility in its operation. It could take a form of a limited company and it can seek external shareholders such as global infrastructure investors, International financial institutions, public entities (states, cities), institutional investors and small investors. Moreover, alliance partner structure will be established in order to align interests of all major stakeholders such as cities, construction and project companies and other infrastructure providers.

Permissions and authorization of operation requires co-operation with large number stakeholders including authorities, citizens, real-estate and infrastructure companies, service providers, firms, cities, regional councils, public entities, associtions, environmentalists, international bodies, and states. Therefore, representation of stakeholders and co-operation in stakeholder board or even specifird taskforces will be required.

7.1 New facilitating role for governments

Even though the project is driven by the private sector, the role of public sector is fundamental over the project life-cycle. Traditionally large infrastructure construction processes have been led by ministries or government bodies and all the necessary committees and steering groups have supervised the implementation of the project. However, this incurs extensive costs due to normal operational costs in often lengthy projects where public procurement processes are in central role (direct costs) and, also, due to demanding committee and supervision work by number of public bodies (indirect costs).

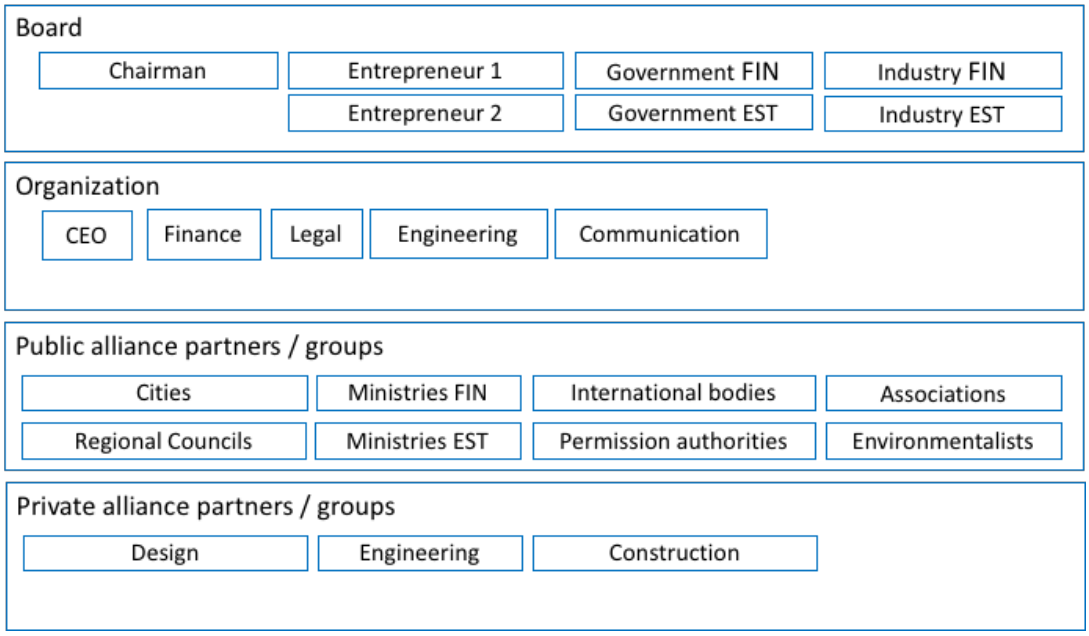
It is proposed that governments are represented in the board of the tunnel organization. However, motivation of board participation will be based on governments' (commercial) interests in the tunnel. In practice, board members could represent government ownership, portfolio management or development organizations.

In order to minimize governments' direct and indirect costs related to the project the alliance approach could used. Typically, in alliance model a cross-organizational communication and decision-making model is applied in order to ensure commitment of all the relevant organizations as well as to minimize communication and other administrative costs. In the tunnel case alliance model would be even cross-cultural

as member of moth countries, Estonia and Finland, should be involved. In addition, participants from cities, international bodies and other relevant institutions should be included.

Role for the governments is to support, give commitment, facilitate, monitor, authorize and accept. The role for the governments and other public organizations will not be operational. It is proposed that public sector entities and representatives would not be planning or procuring materials and services. This also includes financial commitments. All the operational activities would be run by the privately financed tunnel company.

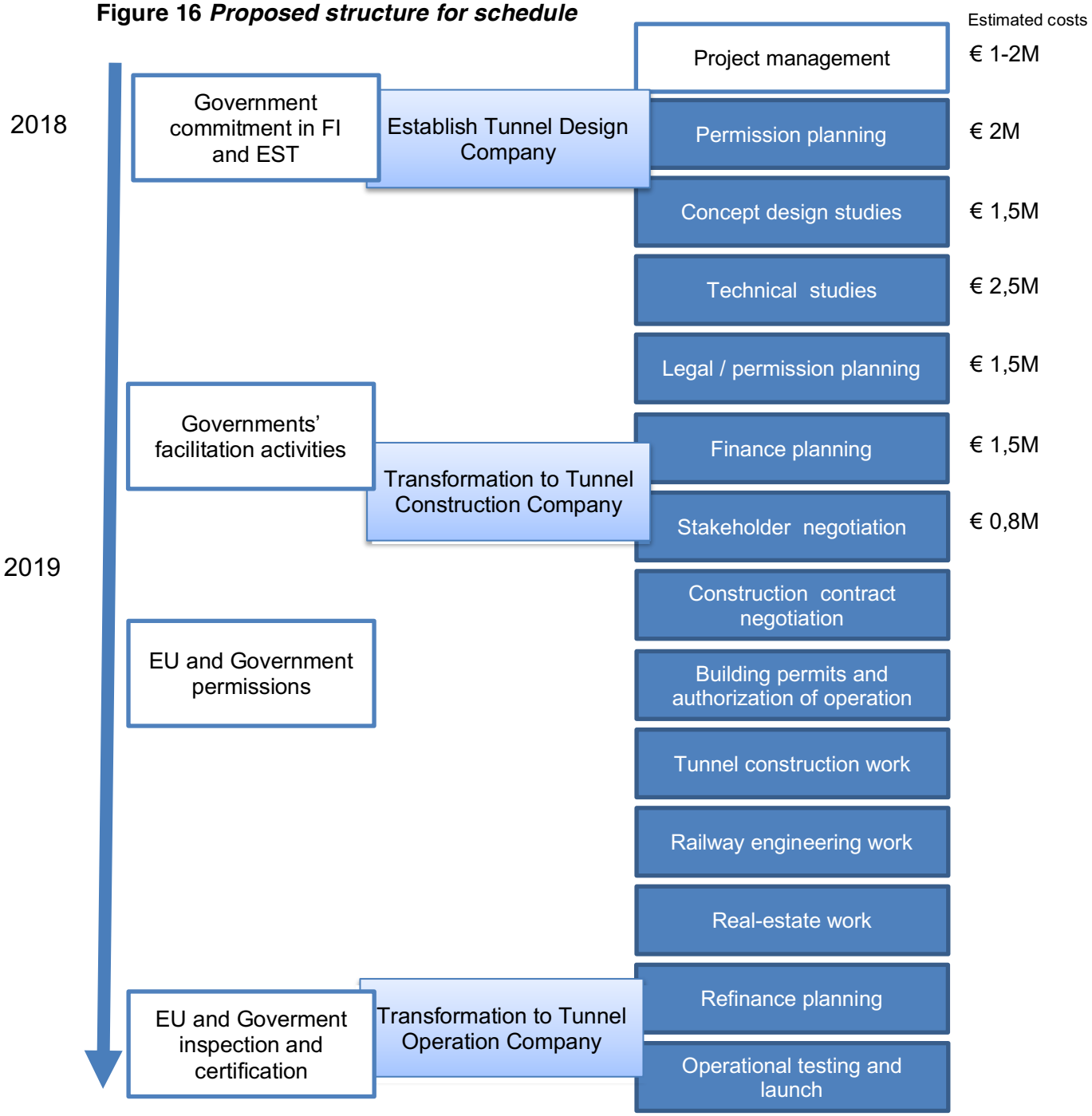
Figure 15 ***Proposed structure for an organization in design stage***



8 Proposed structure for schedule and implementation plan

The tunnel project requires extensive assessments, decisions and permissions before construction can proceed. Estimated time needed for these processes is 10-13 years if normal administrative schedule will be followed. Construction phase is estimated to take 5 - 15 years depending of assumptions. If applicable, exeptions could be considered. In construction phase the newest proven tunnel construction technology will be utilized in order to shorthen the construction phase.

Figure 16 ***Proposed structure for schedule***



Costs of the Design stage are estimated to be € 10 – 14 million.

9 Concluding remarks and next steps

Even the construction phase of the tunnel project would increase positive global visibility for Finland and Estonia. Most importantly, the region would become a globally visible innovation node that brings stability, wealth and prosperity between Europe and Asia.
Environmentally and from sustainability perspective the tunnel project is feasible. It has risks but overall impact is neutral or even positive as it is energy efficient compared to other transportation modes and decreases emissions and increases environmental safety in the Gulf of Finland.

From European perspective the tunnel can be seen as a gateway that connects Europe from High North to Black Sea and enables a new route to Asia. The railway tunnel combines Finland's and Estonia's transport networks and the local commuting systems. The level of interoperability and multimodality in the system is higher than those without the tunnel. The greatest direct beneficiaries of the tunnel are citizens, workers, students and tourists as passengers. When considering the wider impacts, the railway tunnel would benefit remarkably businesses, trade, investments and culture.
Optionally the tunnel can serve also in data, energy and other transfer activities. The tunnel provides a safe location for data cables that can connect Asia and Europe. Moreover, it can assist in connecting planned renewable energy sources between Estonia and Nordic electricity grid.

The vision of the future encompasses the Helsinki-Tallinn region of 3 million inhabitants in a society of intensive cross-border cooperation, education and business life. The society is built on high level of digitalisation, which enables fast growth rates in productivity and international competitiveness.

It is proposed that a private tunnel company will be established to take responsibility of planning, investment, construction, operation and maintanenance of the tunnel on behalf of the states of Finland, Estonia and private shareholders. The Tunnel Company could be financed from multiple sources including equity investors, global infrastructure investors, international financial institutions and private large and small investors. Majority of the finance comes from private sources.

Futhermore, it is proposed that governments in Estonia and Finland commit and communicate mutual understanding of the tunnel project benefits but also of its challenges. In order to create the globally visible innovation node long-term facilitation by both governments is needed.

Most important next steps:

- Communication for political decision-making in Finland, Estonia and EU.
- High-level commitment between governments.
- Establishment of an organization for the project.
- Finding environmentally, technically and financially feasible solution for the implementation.
- Turning the tunnel project into the operational planning mode.