RISKS OF THE FINNISH STATE GUARANTEE SYSTEM

Background Report for the Economic Policy Council Report 2019#

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Abstract
In this report, we evaluate the risk exposures of the Finnish state guarantee portfolio in terms of its two main components: the guarantees for export credits and guarantees for the domestic housing market. We find that even though the proportional shares to GDP of both these components in the overall state guarantee portfolio, and especially that of export guarantees, have increased considerably in recent years, the *risks are not completely in line with the actual sizes or GDP shares of the positions* if the real economic and financial market developments (globally and in Finland) follow the current path. The main ingredient of the export guarantee exposure of Finnvera plc is the high concentration of guarantees in certain firms and industries. However, because the system also includes the possibility of issuing guarantees to large international companies for buying the products of Finnish companies, this actually reduces the overall risk position when using the current macro and financial market risk factor values. However, the *international diversification also imposes an additional layer of risks on the export guarantee portfolio if for some reason world economic and financial market developments begin to resemble the situation around the Global Financial Crisis (GFC).* In that case, the effects on expected shortfalls from the export credit guarantee portfolio would be dramatic. As regards the housing market guarantees, we find that the single most important risk factor is the real economic development of the Helsinki area, because the majority of the overall Housing Fund guarantee portfolio is allocated there. It alone is responsible for similar sizes of losses in an extreme situation of slowing GDP growth as the other city areas in the housing market guarantee portfolio in total. In terms of the effects on the expected shortfall from the housing market guarantees, a decline of 1.5% in Helsinki's real growth corresponds to a decline of 10% in all the other cities.

Keywords: State guarantees, exports, housing, credit risk, macroeconomy

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1. Introduction

The state guarantee system serves as a tool to fill gaps in the supply of export finance, to increase the supply of affordable housing, to decrease barriers to education, and to meet socially important goals. This system is internationally accepted and commonly used in many countries. However, despite its indisputable advantages, the system is not without its downsides. *Guarantees are state liabilities and may pose significant risks to public sector (sovereign) budgets.* This is especially important for Finland, where the state guarantee-to-GDP ratio has now exceeded 20%. Even though the academic literature on risk analysis is voluminous and there are a huge number of practical business applications on this subject, *the risks of state guarantees are at least to some extent still uncharted territory*. What makes the risks of state guarantees different from other credit and market risks is that the overall risk of the guarantee portfolio might not be based on well diversified allocations right from the beginning. On the other hand, it is obvious that the government's ability to withstand possible losses from guarantees is linked to taxation. Due to this link, the overall risk position of state guarantees is closely connected to real GDP growth, and also to the market valuation of the guaranteed firms. In the bigger picture, the risks emanating from state guarantees are part of the government risk in general and a prominent subject of GDP-at-risk-type analyses (see e.g. Prasad et al., 2019).

Most OECD countries have scaled down their state guarantee systems in recent years. *Finland is an exception clearly going against this trend*. Finnish governments have recently increased in particular authorizations to grant guarantees for exporters, and to increase the volume of state-guaranteed export credits. The main motivation for this development has been to improve the competitiveness of the exporting sector[1], but naturally it has also induced more state risks. Nevertheless, Finland is an outlier by international comparison. While the average European state guarantee-to-GDP ratio is about 5%, and is heading downwards, in the case of Finland it was already 20%[2] in June 2017, and has even increased since that (see Figure 1 below and Figure 2 in the next section).

[1] Ali-Yrkkö & Kuusi (2018) raise some doubts about this.
[2] Participation in the European Financial Stability Facility is excluded from these numbers.

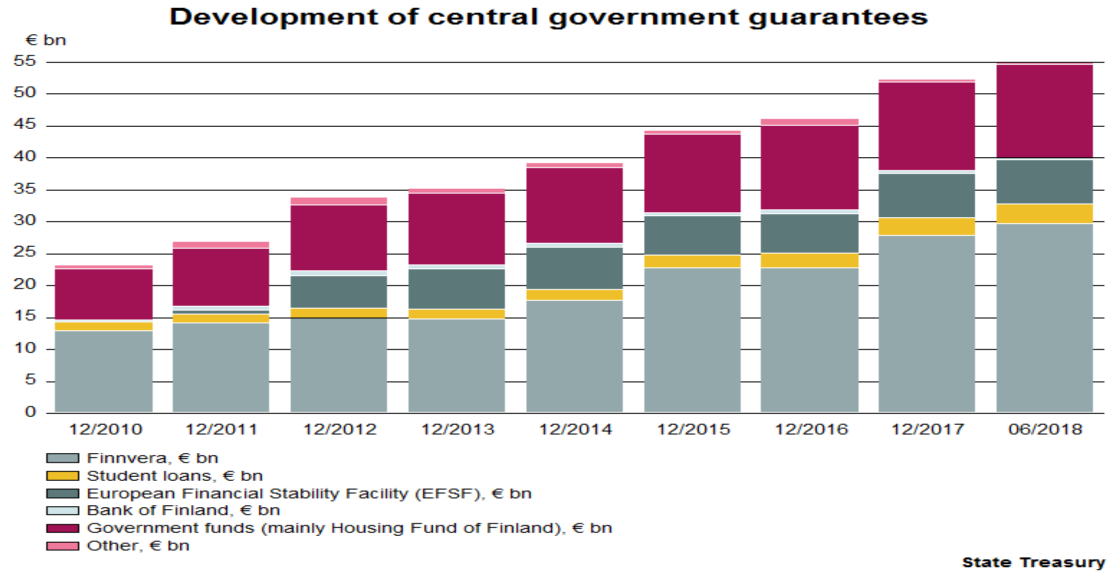

Figure 1. Breakdown and evolution of central government guarantee components in Finland, 2010-2018.

As we see from Figure 1, the major and fastest-growing share of Finnish state guarantees is export guarantees. The export guarantee system is organized via Finnvera plc, a fully government-owned financial institution, and its subsidiary, Finnish Export Credit Ltd. This practice is internationally accepted and conducted within international agreements and rules. In size, the second guarantee category is government guarantees for housing funds, and the third consists of Finnish state guarantees for the European Financial Stability Facility (EFSF). Guarantees for student loans and other purposes are marginal compared to the three guarantee groups above.

The purpose of this report is to analyze the role and quantify the effects of the sources of risks for the two major components in the Finnish state guarantee portfolio. This analysis is based on modeling the effects of macroeconomic risks connected firstly to export guarantees, and secondly to the housing market guarantees provided mainly by the Housing Fund of Finland. The common methodological approach for both of these parts is the Vasicek (2002) model utilized for calculating Value at Risk (VaR) and Conditional Value at Risk (C-VaR) measures for credit portfolios, conditioning developments in them on the main macro risks affecting each of them. Hence, at the end of this report, we get the practical numerical estimates of the size of the risks to the government budget emanating from the state guarantee system. It is worth emphasizing at this stage that our estimates of the risk profiles (based on the 2018 year-end and March 2019 values of the guarantee positions) are fairly moderate in the current more or less stable overall economic situation. However, sudden isolated shocks especially to some of the risk concentrations in the guarantee portfolio, like a strong negative shock in the global economic situation (originating e.g. from the U.S economy) would immediately affect e.g. the risks of the Finnvera position. Analogously, as we shall see from our simulation exercises, for example a strong decline in economic activity in the Helsinki metropolitan area would dramatically affect the risks of the Housing Fund guarantees, so all our overall risk estimates should be viewed especially in view of the risk concentrations stemming from the actual guarantee portfolio allocations.

Based on the positions at the end of 2018 for the housing guarantees, and on the situation at the end of March 2019 for the export credit guarantees, combined with the most recent development in the relevant macro factors both for the export guarantees and housing market guarantees, we obtain the following results for the risk profiles. First, for the Finnvera part of the guarantee portfolio, even though the exposure is highly concentrated in certain firms and industries, the sizes of the risks are not completely in line with the amounts of the individual guarantees and the size of the overall position. At first, when analyzing the risks based on the *current global economic and financial market situation,* the overall export guarantee risk position is significantly reduced due to the fact that the guarantee system essentially also includes the possibility of issuing guarantees to large international companies for buying the products of Finnish companies. This reduces the overall risk position significantly because this part of the guarantee system actually introduces an *international risk diversification dimension* to the Finnish export guarantee portfolio. However, in our further scenario analyses, i.e. when using macro and financial market data reflecting the situation around the years of 2007-2009 Global Financial Crisis (GFC), we get more dramatic results. If the current situation in the global macro economy and financial markets suddenly evolved into a systemic crisis analogous to the situation around the GFC, the expected losses, especially from the internationally diversified export credit guarantee portfolio, would be enormous. Due to the obvious contagion effects, *the expected loss would be over 4 billion euros, and at each level of tail loss probability* (5%, 1%, and 0.5%)*, the expected shortfall would be around 4.5 billion euros*.[3] In comparison to the projected government budget deficit for the year 2020, this scenario would triple it[4]. However, we would strongly emphasize here that the world economic and financial market outlook at the moment does not indicate such scenarios in the near future, even though the risks related e.g. to Brexit and the China-US trade war have recently increased considerably.

As regards the housing market guarantees, we find that the single most important risk factor is the real economic development of the Helsinki area, because the majority (over 50%) of the overall Housing Fund guarantee portfolio is allocated there. Based on our results, when using the current values

[3] This is analogous to findings by Acemoglu et al. (2015) regarding stability of financial networks. Acemoglu et al. find out that the same factors that contribute to resilience of the system under good economic conditions may be the key risk factors under bad economic conditions.
[4] This is assuming that in the current Ministry of Finance deficit projection there have been no risks attached to the state guarantees.

of the macro factors, the risks related to the housing market guarantees are fairly moderate. However, if the real GDP of all the cities guaranteed (other than Helsinki) falls by 10%, the risk measures increase dramatically, but the effects of the decline in the Helsinki area alone are of almost a similar size. Even a moderate 1.5% decrease in the real growth rate of Helsinki results in fairly high risk estimates. For the ultimate 0.5% probability of default, the expected shortfall is over 1 billion euros for a 1.5% decline in the real economic growth of Helsinki. Hence, based on our results, strong real economic development of the Helsinki metropolitan area is centrally important for the risks emanating from the Housing Fund guarantees in the Finnish state guarantee system. If real growth in Helsinki declines by 1.5% compared to the current situation, this would have an effect of 1.06 billion euros on public finances, corresponding to an additional burden of about 46% on the projected deficit of the government budget in 2020.

The structure of this report is the following. In Section 2 we discuss some international evolutions in state guarantees, so as to place the Finnish situation in a somewhat broader perspective. In Section 3 we describe the Finnish system in more detail, and in Section 4 we describe our methods for evaluating the risk positions of the Finnish State guarantee system, as regards its two main components. Section 5 reports our empirical results for the estimated risk contributions, and Section 6 gives a brief conclusion of this report.

2. International Comparison of the Recent Evolution in State Guarantees

The large size and high growth rate of the Finnish government guarantee system has raised attention and concern, both nationally and internationally (see for example Ministry of Finance, 2018, 2019, Ministry of Economic Affairs and Employment, 2017, and Eurostat, 2019). This raises the difficult question of whether the risks are in line with the benefits of the system, and if the overall risk is at a level that central government can tolerate. The ultimate, and perhaps most important, question is how these risks should be managed as part of the central government risk position. The importance of all these questions is highlighted by the fact that while the international policy trend seems to have been to scale down guarantee positions, Finland has gone very much against this trend for over a decade now.

On an international comparison, the Finnish government guarantee exposure is the largest relative to the size of the economy in the European Union. Based on the 2018 situation, the central government exposure as a percentage of GDP in Finland was about 22%, and the second-highest ratio, in Lithuania and Austria, was about 12%. In comparable small Nordic countries, Denmark and Sweden, the ratios stood roughly at the level of 5%. When looking at a wider sample of countries, the total Finnish general government guarantee-to-GDP ratio was 32% at the end of 2017, while the second-highest ratio was 16% (in Austria), and the average ratio of the EU countries was about 6%. As can be seen from Figure 3, at the local government level, high exposure is typical of the Nordic countries, and in fact in Sweden and Denmark the local government exposure exceeds the size of the central government exposure. However, Finland is an outlier here too. The Finnish guarantee system differs from the average European systems not only in the size of the exposure, but in the direction of change. In several countries, exposures increased after the subprime crisis, but after that exposures have decreased both in monetary terms and in relation to GDP.

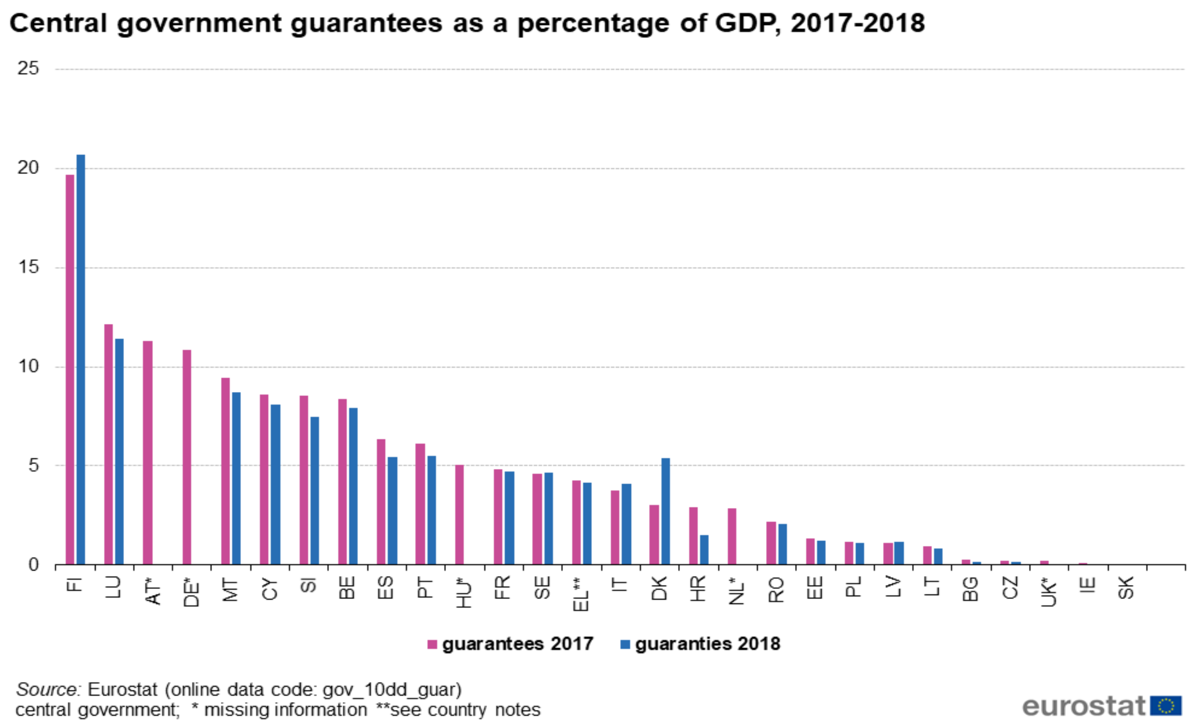

Figure 2. Central government guarantees as a percentage of GDP, 2017-2018. Source: Eurostat

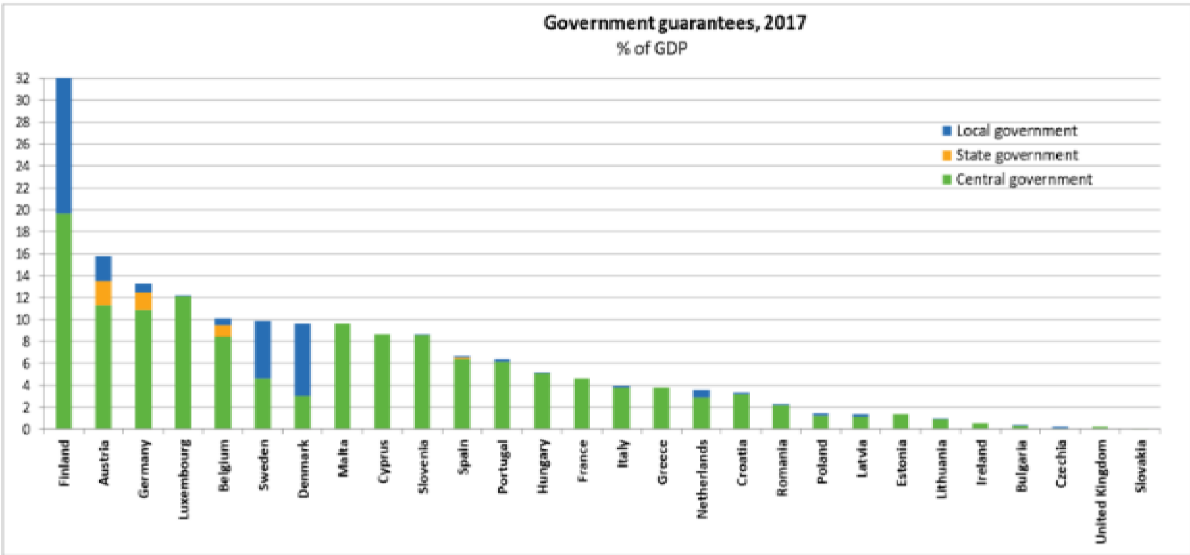

Figure 3. General government guarantees as a percentage of GDP, 2017. Source: Eurostat.

Figures 4 and 5 reveal the recent international trend of scaling down both central and general government guarantee positions and the strong growth rate in the Finnish guarantee positions. They also show that in recent history some other countries have had ratios as high, or even higher, than Finland has now. The reasons for the high ratios of e.g. Austria and Spain in 2011 -2012 were the problems in their domestic banking systems caused by the European sovereign debt crisis in 2011-2014.

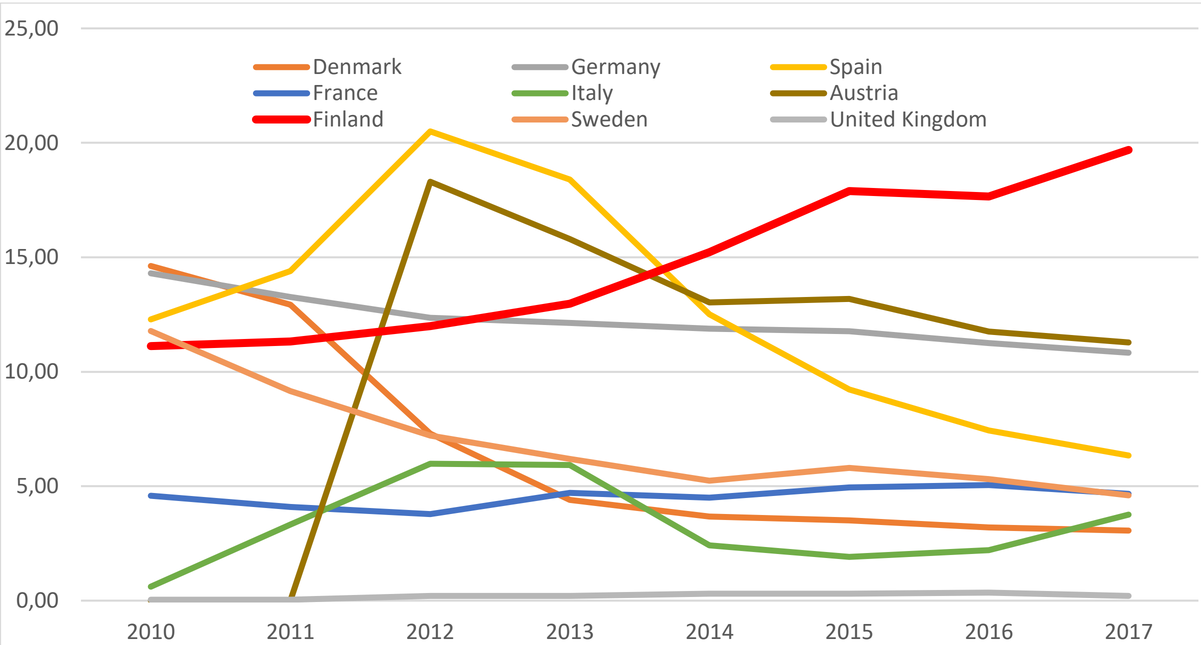

Figure 4. Central government guarantees as a percentage of GDP in selected EU countries, 2010-2017. Source: Eurostat.

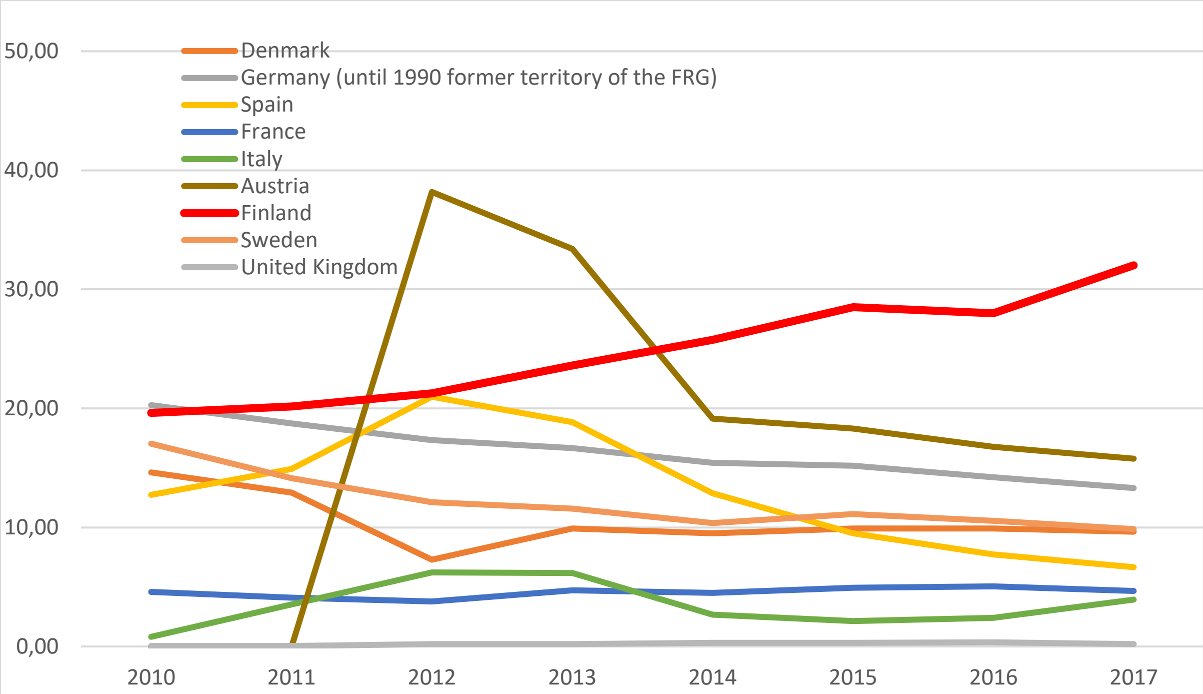

Figure 5. General government guarantees as a percentage of GDP in selected EU countries, 2010 – 2017. Source: Eurostat.

At the European level, Figures 4 and 5 seem to indicate a strong trend to decrease government guarantee positions, especially as a ratio of gross national product. Table 1 shows as an example the evolution of central and general guarantee positions in monetary terms. It reveals that downscaling of positions also holds in monetary terms for example in Denmark, Germany, Spain, and Sweden, but not in Italy, France, and, as already discussed above, Finland. In fact, the Italian central government positions have increased in 7 years from 9.7 billion to 64.9 billion euros. However, due to the larger size of the Italian economy, and due to the stronger growth rates of the economies of some other countries, the ratio of guarantees to GDP has not increased significantly. In fact, it has actually declined in most of the countries.

Table 1. Government guarantees in selected European Union countries, 2010 and 2017.

	Government Guarantees (beur)			
	General Government		Central Government	
Country/Year	2010	2017	2010	2017
Denmark	35,19	27,76	35,19	6,24
Finland	36,72	71,68	20,81	44,07
Italy	13,04	67,92	9,72	64,94
Germany	522,85	436,11	369,04	354,95
France	91,33	106,69	91,33	106,69
Spain	137,71	77,65	132,81	73,92
Sweden	57,00	42,90	39,43	19,99

Source: Eurostat

As already mentioned above, the majority and the fastest growing part of Finland's state guarantees are export guarantees. The export guarantees of Finnvera plc occupy a dominating role in the Finnish central government guarantee position, and, as observed from Figures 1, 2 and 4, export guarantees have clearly been used as an active foreign trade policy tool to support Finland's export competitiveness and economic growth. The export guarantee position began to increase after the subprime crisis, which hit the Finnish economy harder than any other western economy. During the crisis, several other countries also had to use public funding and government guarantees to stabilize the domestic banking sector. Finland did not have any serious problems with the stability of its banking sector, but the strong dependency of the Finnish economy on the export sector had a strong and long-lasting impact on the aggregate economy in the first years of the global crisis.

From the figures above it seems that at least central government export guarantees have been used as a tool to support economic growth in Finland for some time. This raises several questions. The first questions is whether this way of subsidizing exports is economically efficient and whether it produces the most efficient allocation of resources. This has been studied by e.g. Ali-Yrkkö and Kuusi (2018), who were not able to find strong quantitative evidence in favor of the economic efficiency of the guarantee system. This is, of course, to a large extent caused by the complexity of the problem and a lack of sufficient quantitative data to analyze the effects of these subsidies. This leaves the final answer to the problem open, even though the authors conclude that if there had been no government guarantees, for example the shipbuilding industry in Finland would have collapsed. The second problem is the transfer of private business risk to the government, and, ultimately, to taxpayers. On several occasions it has been argued that the Finnish banking sector is unable to offer funding for large export projects without government support (see for example Ministry of Economic Affairs and Employment of Finland, 2017). This may be the case in a small open economy like Finland, with large global exporting firms, but it deserves more analysis. Historically this argument has been used for centuries in lobbying for government guarantees. Given economic developments, this argument has not always been in line with the economic realities (see for example Irwin, 2007, who details some historical cases). However, these problems are outside of the focus of our study.

If a small country applies government guarantees as an active tool to promote export growth, it faces a scale problem. As a practical example, let us assume that the average size of an individual project is 50 million euros, and there are 600 projects to be financed. This implies that the total financing need is 30 billion euros. On the current European scale, this is about 0.9% in relation to Germany's GDP, but 12.7% in relation to Finland's GDP. In a global business environment, large international companies are more or less equal in size (the size category depending obviously on the industrial sector, but not on the size of the home country) and they compete over the same projects. This is also evident when we compare the information in Figures 4 and 5 to the numbers in Table 1. The ratio of German guarantees to GDP is about half of the Finnish ratio, but in monetary terms, the German central government guarantee position is eight times larger than the Finnish position. In the case of Finland, being a small open economy domiciling internationally large exporting companies and large export projects, this implies a need for high guarantee ratios to GDP if the guarantees are used as an active tool in international trade policy. This choice also creates a high risk for a small economy, and, at the end of the day, to its taxpayers. However, *we would like to stress here that normative discussions about whether this tool should be used, or not, are beyond the scope of this study*. De facto, we have observed that e.g. the export guarantee system has been heavily used in Finland's international trade policy, and in our analysis we focus only on *computing the risks of the guarantee positions generated*.

3. Main Components of the State Guarantee System in Finland in More Detail

3.1. Export Credit Guarantees

As already described above, the export guarantee system in Finland is organized via Finnvera plc, a fully government owned financial institution and its subsidiary Finnish Export Credit Ltd. This practice is internationally accepted and conducted within international agreements and rules. The second largest guarantee category in Finland is government guarantees for housing funds, and the third largest consists of Finnish state guarantees for the European Financial Stability Facility (EFSF). Guarantees for student loans and for other purposes are marginal compared to the above three guarantee groups.

In addition to its exceptionally large size compared to the size of the Finnish economy, a striking feature of the export guarantee system is the *high concentration of credit risk in certain companies, industrial sectors and partially also in individual countries*.[5] In March 2019, the share of the largest single credit counterparty was 16%, and the share of the ten largest was about 64%, whereas the share of the twenty largest firms was about 80% of the total credit risk exposure. 84% of the exposure was concentrated in shipbuilding, tele and data communications, and the forest industry (Ministry of Finance, 2018, Ministry of Economic Affairs and Employment of Finland, 2017, OECD, 2017, 2018, and

[5] The exposure includes both guarantees and loans. In addition to the data sources mentioned in the text, as regards exports guarantee exposure evaluations, all the analyses and discussions in this report are based on a strictly confidential dataset obtained from Finnvera plc. These data are not currently available for any other analyses. Furthermore, the reporting of our results is limited due Finnvera's stipulation of that the identity of the individual guaranteed firms should be revealed in our analysis. Hence, we are not allowed to discuss in more detail for example the geographical business areas of the guaranteed firms, or any other firm-specific attributes that might help to identify individual entities in our dataset.

our own calculations based on the confidential Finnvera data set). The business clusters around Nokia plc and Meyer Turku Ltd form the two largest guarantee exposures (Ali-Yrkkö & Kuusi, 2018). Obviously, the full industrial cluster has to be taken into account when evaluating the credit risk. It is also especially important to consistently evaluate the company and macro level risks of the entire shipbuilding cluster, which currently faces fierce competition (OECD, 2017).[6]

The export guarantee system usually works in the following way. Finnish Export Credit Ltd (FEC), a fully owned subsidiary of Finnvera plc, grants credit to a Finnish exporting corporation, and Finnvera plc issues a guarantee to FEC. Especially in case of large projects, like ships, telecommunication networks, or construction of pulp and paper plants, Finnvera plc *also grants a guarantee to the foreign buyer*. This guarantee is offered to a (foreign) bank financing the buyer. When the buyer makes payments to the Finnish exporter, the guarantee exposure to the Finnish exporter declines. Exposure to the foreign buyer goes hand in hand with its use of the loan facilities guaranteed by Finnvera. Among the 20 largest Finnvera guarantee exposures there are several foreign customers buying or planning to buy Finnish products or services. This is a common international practice that is also followed in other countries with export guarantee systems (see for example SEK, 2018, IMC, 2019).

Furthermore, when measuring the Finnvera exposure, we have to be extremely careful in defining the exposure in an appropriate way. There are three ways to measure the exposure, i.e. using the *net guarantee exposure in use*, or the *net guarantee exposure including exposure in use and guarantees already accepted by banks but not yet in use*, and the *position including the above items and guarantees offered but not yet accepted by the counterparty's banks*. *We will measure the exposure based on the guarantees in use plus the guarantees accepted by the banks*. The wider concept includes offered guarantees which will never be used, and from which Finnvera may still have the power to withdraw. On the other hand, the first narrow concept excludes guarantees which the client and its bank may use as and when they wish.

Finally, it should also be noted that the Eurostat concept applied in the calculation of the official guarantee statistics also includes guarantees offered to counterparties, but not yet accepted by them. At least in the case of Finland, this causes some bias in the official statistics. The difference between the official statistics and the actual position was on average around 5 billion euros (at the end of 2018). The total size of the actual exposure at the end of March 2019 was 19.3 billion euros.

[6] For example, the German shipbuilding sector has faced more than 10 insolvencies since 2008, and of those only a few during and immediately after the subprime crisis (OECD, 2016).

3.2. State Guarantees for Housing

The other main component of the overall central government guarantee exposure is housing market guarantees, which amounted to 14.7 billion euros at the end of 2018.These guarantees are offered to individuals, to housing co-operatives, and to organizations offering rental housing. Guarantees to private individuals are only partial, because the loans are granted by private banks, and, in the case of a default, the guarantee will be used only if the amount the bank receives when the dwelling or collateral is sold falls short of the size of loan. A major part of the exposure is for rental housing and it is concentrated in a small number of clients – the 20 largest counterparties account for about 45% of the exposure – and the largest cities.

Table 2. Government housing guarantees by municipal areas in March 2019 (biggest cities in Finland and other areas).

City/Area	meur	%
Helsinki	7794.10	52.96
Tampere	1212.42	8.24
Turku	951.69	6.47
Jyväskylä	669.66	4.55
Kuopio	461.56	3.14
Lahti	471.07	3.20
Oulu	630.24	4.28
Other	2525.00	17.16
Total	14715.74	100.00

Source: State Treasury

House prices in Finland diverge greatly between geographical areas and between cities and the areas surrounding the metropolitan growth centers. This is of great concern for general economic wellbeing. There are several areas in which house prices have declined by as much as 20% in the past 18 years. However, regarding the risks of the central government guarantee exposure, its high concentration in geographical areas experiencing moderate or high growth in both housing prices and economic activity is good news (as long as the growth continues). The Helsinki, Tampere, Turku and Oulu regions account for over 70% of the entire exposure.

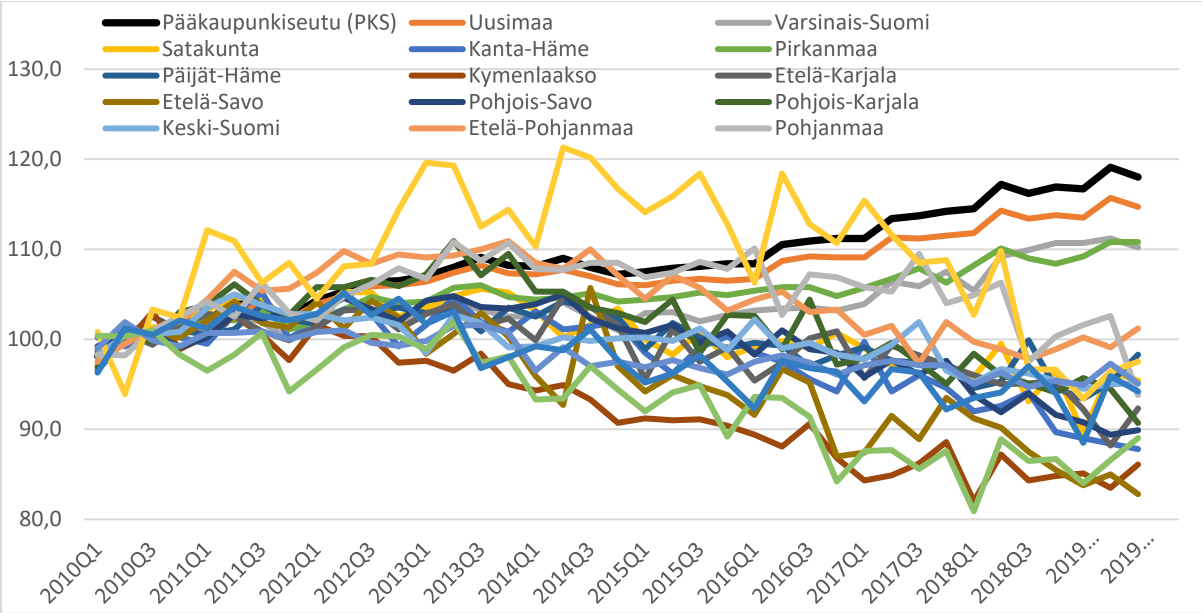

Figure 6. House price development by geographical areas. Source: Statistics Finland

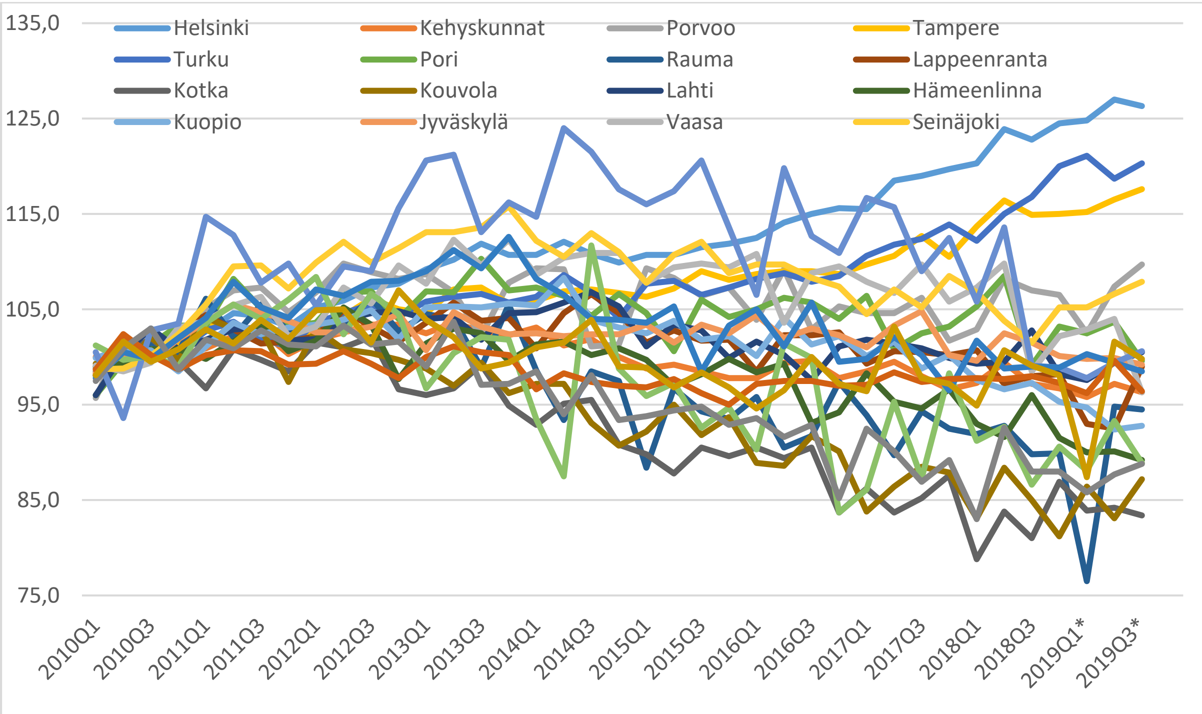

Figure 7. House price development in the largest cities. Source: Statistics Finland

3.3 Other Risk Exposures

Other guarantees consist of guarantees for the European Financial Stability Facility (EFSF), guarantees for student loans, for the Bank of Finland, and some other minor items. Guarantees for the EFSF have been constant since 2013, and they are partially hedged.[7] The state has granted guarantees to the Bank of Finland for its co-operation with the International Monetary Fund. The state also grants guarantees for student loans. In addition to the above guarantees, there are also some other minor items. However, in comparison to the two main components of the total guarantee exposure, all these other items are minor, so in our risk analysis we will focus only on the export and housing guarantee risks.

4. Methodology

The main focus of our research is in estimating the risk profiles of the major components of the state guarantee system. An essential element of the two largest components in the overall guarantee portfolio risk is the high concentration in both the credit risks of the export guarantee portfolio and in the housing market portfolio. In addition to the credit risk, we will analyze the foreign currency and interest rate risks in connection to the overall macro risks. The first step in the analysis is to choose the appropriate risk metrics. Finnvera plc applies a value-at-risk (VaR) framework (Ministry of Economic Affairs and Employment of Finland, 2017). As a measure of risk VaR metrics have some disadvantages (Artzner et al, 1997, 1999, Delbaen, 1998), and a better and more coherent measure – conditional value-at-risk (C-VaR)[8] – has recently gained popularity. C-VaR is defined as the expected loss conditional that the loss exceeds the VaR estimate. We will calculate both the VaR and C-VaR measures in our analyses. However, calculation of both of them is based on the macro-risk sensitivities that we obtain based on our theoretical models, i.e. application of the Vasicek (2002) factor model, and standard arbitrage pricing theory (Ross, 1976). We use these for modeling the role of international macro risks in determining the guarantee portfolio risk exposures through their effects on the market valuation of the guaranteed firms in the case of Finnvera position, and on the (regional) market prices of housing when it comes to the Housing Fund position.

[7] 40% of the exposure to the second Greek loan program is hedged by guarantees given by the Greek government.

[8] C-VaR is also called expected shortfall (ES).

4.1. Numerical Method for Evaluating State Guarantee Risks in Practice

Our main target in the risk evaluation is to use the available data as efficiently as possible. One empirical limitation of the data is the (fortunately) small number of defaults of the guaranteed firms. We would also like to highlight that the risk measures are linked to observable macroeconomic variables (instead of using latent variables also, as for example in Rosen & Saunders, 2010). Because of this, we chose the single-factor and multifactor versions of the Vasicek (2002) model as our main risk simulation tools. Following Vasicek (2002) and Merton (1974), we assume that the market value of the obligor (i.e. the guaranteed export-related firm or the housing asset in our case) follows a geometric Brownian motion. Furthermore, if the market value of the company falls below the value of its debt, it defaults. For the practical procedure, let $X_{i,t}$ be the stochastic return based on the change in the market value of the obligor, so, in accordance with our assumptions, the data-generating process of it follows

$$X_{i,t} = S_t\sqrt{\rho} + Z_{i,t}\sqrt{1-\rho},$$

where S_t is a common N(0,1) distributed risk factor, observed at time t, and $Z_{i,t}$ (i=1,…L) are the obligor-specific N(0,1) distributed risk factors. All the risk factors are mutually independent, and as Vasicek (2002) has shown, ρ is the (average) asset correlation coefficient between all obligors. The obligor-specific risk factors Z_i are independent of the $S_{k,t}$ factors. An obligor *i* defaults if

$$X_{i,t} < c_i,$$

in which c_i is the obligor *i* default trigger. If we have a long-term default probability p_i^* estimated for example by ratings agencies, we can approximate the default trigger by

$$c_i = N^{-1}(p_i^*),$$

where $N^{-1}()$, is the inverse of the cumulative normal distribution. It can be shown that in this case the obligor *i* default probability (conditional on the systematic risk factor S_t) at time t is

$$P\left(\frac{c_i - S_t\sqrt{\rho}}{\sqrt{1-\rho}}\right).$$

In the Vasicek model, the long-term default probability is called the through-the-cycle (TTP) probability and the above conditional probability is called the point-in-time probability.

According to the Bank for International Settlements (BIS) rule book (the Basel rules), banks should estimate the asset correlations for individual obligors based on

$$\rho_i = 0.12\frac{1-e^{-50P_i}}{1-e^{-50}} + 0.24\left[1-\frac{1-e^{-50P_i}}{1-e^{-50}}\right],$$

where P_i is the obligor *i* TTP probability.

A multifactor version of the model is given in Hull & White (2004) as

$$X_{i,t} = \sum_{k=1}^{K}\lambda_{i,k}S_{k,t} + \sqrt{1-\sum_{k=1}^{K}{\lambda_{i,k}}^2}\,Z_{i,t}\ ,$$

where $S_{k,t}$ (k=1,…,K) are the common systematic risk factors, following again an $N(0,\Sigma)$ distribution, whereas $\lambda_{i,k}$ (i=,1,…,L, k=1,…,K) are the factor loadings, and Z_i are the individual mutually independent specific risk factors following an N(0,1) distribution. The obligor-specific risk factors Z_i are independent of the $S_{k,t}$ factors. We will analyze the credit risks of the Finnvera guarantee position and the housing market guarantee position by using both the above single-factor model with BIS correlations, and the multifactor model based on estimated factor loadings. Instead of closed analytical solutions for the loss distribution (based on estimated macro factor loadings), we apply Monte Carlo simulation (with 1 million draws), which is a very common practice in portfolio credit risk analysis.

We measure the risk of the position first by the value-at-risk approach, i.e. by estimating risk from the negative tail of the predicted portfolio profit/loss distribution only. In our analysis, the length of the prediction horizon is one year. The Value-at-risk (VaR) is a cut-off level of the distribution where the probability of a loss equal or larger than VaR is equal to the chosen probability. As a graphical example, in Figure 8 the chosen loss probability is 5% and the VaR is 2 million euros. The probability of a loss equal to or larger than 2 million euros is 5%. In our analysis we have chosen to analyze the loss levels at probabilities of 5%, 1%, and 0.5%. Furthermore, in addition to Value-at-risk analysis, we also estimate the Conditional Value-at-risk (C-VaR) measures, which by definition are the expected shortfalls conditional on the chosen VaR level being exceeded, so they refer to the expected values of the tail risk at the chosen probability levels. In Figure 8, these are the conditional expectations of the red areas for the chosen probability levels. Figure 8 presents as an example a typical stock and bond portfolio distribution, which is more or less symmetric. We focus on the credit risk of the guarantee position, and, compared to Figure 8, the typical credit risk distributions are highly asymmetric and fat-tailed.

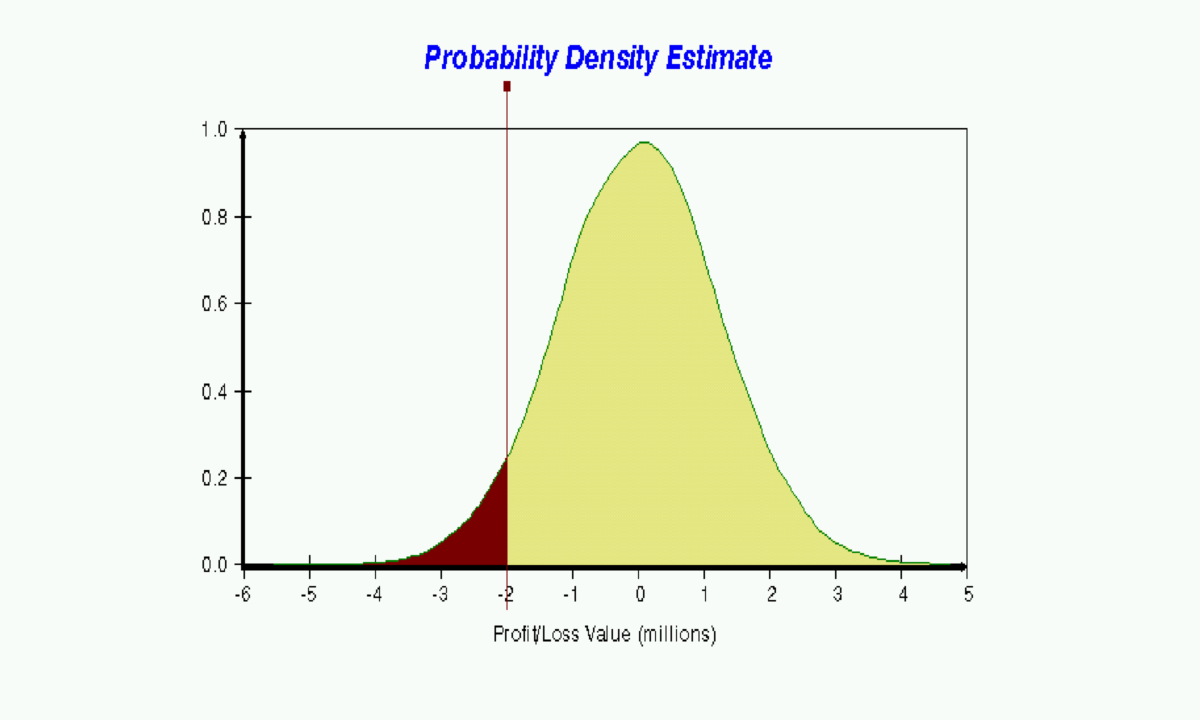

Figure 8. Value-at-risk analysis

4.2. Theoretical Background for Modeling the Macro Risks: the Arbitrage Pricing Theory

For the purposes of deriving the macro risk factors and their loadings for calculating the risks of the Finnvera guarantee portfolio based on a pricing model for the value of guaranteed firms, we rely on the standard arbitrage pricing theory (APT) originally formulated by Ross (1976). The main part of the following description of the application of APT is based on Junttila, Perttunen & Larkomaa (1997), who give a description of research focusing especially on Finnish markets. More recent examples of empirical applications of APT theory can be found for example in Lee, Wei & Chen (2014) and Kou, Peng & Zhong (2018).

According to modern financial theory, the value of a financial asset is equal to the sum of its discounted expected future cash flows. Thus, any macroeconomic variable that systematically influences either the discount rate or the expected cash flows will have an effect on the observed returns. The APT theory is partly based on an intertemporal (I-CAPM) version of Sharpe's (1964) capital asset pricing model (CAPM) introduced by Merton (1973 and 1994). According to the I-CAPM, macroeconomic variables may represent state variables that have an effect on the investor's preferences over time, and consequently influence the expected rate of return. The APT model assumes that the factors determining asset prices might be identified as macroeconomic variables. Most empirical studies in the APT framework have utilized U.S. data and a major part of the evidence denotes the importance of macroeconomic variables as determinants of stock returns (see, for example, Chen, Roll and Ross 1986, Kim and Wu 1987, and Chen and Jordan,1993, for early contributions).

The APT theory suggests the stochastic return generating process to be a *k* factor model of the form

$$R_{it} = E(R_i) + \beta_{i1}\delta_{1t} + \beta_{i2}\delta_{2t} + \cdots + \beta_{ik}\delta_{kt} + \varepsilon_{it},$$

where R_{it}, i = 1,...,n, is the random return of asset *i* in time *t* and $E(R_i)$ is the expected return on asset *i*. The term δ_{kt} denotes the k^{th} mean zero common factor and β_{ik} is the sensitivity of returns on asset *i* to movements in common factor δ_{kt}, also denoted as factor beta. This equation states that the return of an individual asset depends on the expected value of the asset and its sensitiveness to movements in common factors. If the prices and hence returns of assets conform to the condition of no arbitrage above the expected return vector, the expected return on a risky asset *i* is linear in the factor sensitivities of the asset, i.e.

$$E(R_i) = \lambda_0 + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \cdots + \lambda_k b_{ik},$$

where λ_0 is the constant risk-free rate of return and λ_1 (j = 1,...,k) represents the risk premium for the j^{th} factor in the market equilibrium. The usual interpretation of the common factors is that these represent unanticipated changes in fundamental economy-wide macroeconomic variables.

Early empirical tests of this pricing model have relied on principal component analysis to estimate the factor betas and the associated risk premiums. Generally, the results of these studies have indicated that the APT model performs rather well. There are, however, essential drawbacks associated with interpretation of the results of factor analysis. An often-mentioned drawback is that factor analysis makes it difficult to interpret statistical results, because there is an almost complete lack of economic meaning attached to the factors. Due to the lack of usefulness of APT factors in real financial predictions, some heavily quoted early empirical studies on APT have concentrated in pre-specifying macrovariables which would compensate for the factor scores. In particular, the evidence of studies where innovations in a group of selected macroeconomic time series have been used to estimate factor betas and the associated risk premiums has been encouraging (see for example Chen, Roll and Ross 1986, and Chen and Jordan 1993). In their seminal paper, Chen, Roll and Ross (CRR) tested a prespecified set of macro variables, which could be interpreted as representing the risks that are rewarded in the stock market. In general, according to at least CRR and Chen and Jordan, the variables which systematically affect stock returns in the U.S. market are short- and long-term interest rates, inflation expectations, inflation, industrial production and risk premiums. Intuitively, these variables represent the essential factors affecting either the discount rate or firms' future cash flows.

According to CRR, the theoretical interpretation of individual macro effects could be the following. The term structure of interest rates is an essential factor affecting the discount rate of future cash flows. On the other hand, changes in the expected rate of inflation are linked to nominal expected cash flows and the nominal rate of interest, whereas unanticipated inflation will have a systematic effect on asset valuation. Changes in the expected level of real production would influence the current real value of cash flows. Thus, unanticipated changes in the production level should be rewarded in the stock market. Unanticipated changes in risk premia reflect changes in the indirect marginal utility of real wealth and might also capture the uncertainty in industrial production.

We will use the APT approach as the main tool in our analysis to extract the effects of macro risks on the valuation of firms that have obtained guarantees from Finnvera plc. Due to the extremely diverse distribution of the countries of origin and main businesses of the firms in the guarantee portfolio, one of the problems in this application is that the set of country-specific relevant macro factors varies greatly between the guaranteed firms. Hence, regarding the data on macro risk factors, we initially used the quarterly observations of a single global variable in all cases, i.e. world real GDP growth, to represent the single macro risk factor. As we shall see, this results in high risk position values at the final stage of our analyses. The second set of macro risk estimates is based on modeling the market valuation of each individual guaranteed firm (the 20 largest in the entire Finnvera portfolio) using as the risk sources the country-specific and geographical area real GDP growth rates, country-specific inflation, nominal exchange rates (against the U.S. dollar), short- and long-term interest rates (and the difference between them, i.e. the yield spread in some cases), aggregate stock market indices, changes in the oil price, and some financial market indicators, like the VIX index and the TED spread. As we will see below, the results for the risk exposure values obtained vary greatly between the case of carefully chosen country-level vs. global single macro risk factors[9].

[9] Note that in order to take carefully into account the role of all the possible spillover and contagion effects from other countries and markets on each country, and hence on the valuation of the firms in question, using for example the GVAR models of Pesaran et al. (2006) to evaluate credit risks is one possibility. For the sake of the robustness of our results, we will apply these in our data at a later stage too.

5. Results

5.1. Results for the Finnvera Guarantee Portfolio

We analyzed Finnvera's guarantee exposure based on the end of March 2019 position of guarantees and using the latest available observations for the macro factor values in the APT model in the first stage. We also executed some further scenario analyses, specifically by assuming that, for some reason or other, the global economy is suddenly hit by a systemic crisis on a similar scale as the 2008 global financial crisis (GFC). We will see that the modeling of all the individual country macro risks in the multi-factor specification will be essential in recovering the actual risk position.

As mentioned above, in our analysis we applied the conventional Vasicek single-factor and multifactor models. We calibrated through-the-cycle (TTC) default probabilities and loss-given-default measures to point-in-time probabilities by factor analysis. Risk analysis was conducted based on a Monte Carlo simulation (with 1 million simulation rounds). For the 20 largest (by exposure) firms we applied the Finnvera TTC probabilities, except for one case, in which we applied the marginally higher probability estimated by Standard & Poor's, which was also in line with the Finnvera evaluation for all the other firms. We conducted the factor analysis in two different ways. In the first approach, we estimated individual default correlations applying the Basel approach in the calculation of the capital requirement by banks, and the single systematic (macro-level) risk factor is the growth of world (US) real GDP. The second set of risk estimates is based on modeling the market valuation of each individual guaranteed firm (the 20 largest in the entire Finnvera portfolio) using factor analysis along the lines of the standard APT model described in the previous section. Here the macroeconomic risk sources are the country-specific and geographical area real GDP growth, inflation, nominal exchange rates (against the U.S. dollar), short- and long-term interest rates (and thee difference between them, i.e. the yield spread in some models), country-specific aggregate stock market indices, changes in the oil price, and several other financial market indicators.

As can be seen from Table 3 below, the risk measures based on the Basel approach and world GDP as the single risk factor are somewhat high, but not intolerable, compared to the size of the exposure. *They are in fact higher than similar estimates given by Finnvera*. According to the Basel approach, at 1% VaR probability the expected shortfall (CVaR) would be around 870 million euros. However, our second approach, based on using an APT model for the analysis of country-specific macro risk factors for the valuation of each guaranteed individual firm, is able to capture the impact of *risk concentration or diversification* on the risk profile of the guarantee exposure. When the 20 largest clients form about

80% of the exposure, and 55% of the exposure consists of guarantees to ship building, 19% of guarantees to telecommunications and 10% to the paper and pulp industry cluster, we should expect high risk concentration numbers a priori. However, our results reveal the opposite: *the risk estimates are significantly lower than in the Basel approach with a single global macro risk factor, and probably much lower than even Finnvera's own estimates*. Based on the multi-factor model the expected loss is around 30 million euros, and the expected shortfall conditional that the 1 % cut-off level is exceeded (CVaR) is around 246 million euros.

At first sight, the result obtained may be surprising, but the main reason for it is obvious from a portfolio theory point of view. Instead of granting guarantees only to Finnish exporters operating in a limited number of markets (e.g. only in the U.S. in the extreme example case), a *large part of Finnvera's guarantee exposure consists of guarantees to foreign buyers of Finnish products and services*. This obviously *diversifies the credit risk* of an individual guaranteed firm to different geographical areas (including Europe, Asia, Latin America, the United States, Middle East countries and Russia), and results in very low default correlations. As an example, focusing on the APT loadings (available upon request from the authors), country-specific stock market factors constitute the majority of the risk for some of the firms, whereas geographical area GDP growth, and other macro factors, like changes in the oil price, are the main constituents of some other individual firm risks. This actually also creates an *efficient international risk diversification strategy for the guarantee portfolio*. It explains the empirical fact that even though the absolute amounts of guarantees (in relation to GDP) in Finland have recently amounted to really big numbers by international comparison, we have not seen any major collapses or actual realizations of the export credit guarantee losses. According to our results, the simple reason is that at the individual firm level, part of the guarantee exposure is actually internationally well diversified, and the part of the exposure which is not well diversified is concentrated in markets which are now in very good shape (especially the U.S. market).

Table 3. Risk measures based on single-factor and multifactor macro-risk models (in millions of euros), as of latest available macro factor values on 30th Nov 2019

	Country-specific multifactor model		Basel approach and the world real GDP growth as the only factor	
Probability	VaR	CVaR	VaR	CVaR
0.05	98.89	141.21	128.48	309.47
0.01	146.61	246.71	324.23	872.93
0.005	202.06	323.11	903.83	1103.20

As a background for the risk profile measures reported in Table 3, for the multifactor model we see (by taking a closer look at the confidential firm level Finnvera data) that especially the telecommunications sector guarantees have been well diversified globally and at the firm level. In addition, the effects of the concentration of the shipbuilding industry position with U.S.-based firms is also clearly seen in the numbers, because the single-factor model produces clearly higher risk positions based on the fact that the development of the U.S. economy dominates the global development in our macro factor data set.

In Table 4 we report the risk profiles based on an assumption that all the countries involved in our analysis experience a similar crash as they did between December 2007 – March 2009 around the GFC, based on the actual numbers for these countries regarding the macro factors used in our analysis for this period of time. In these values, when taking a closer look at the loadings of the estimated macro risk factors in our APT analyses, the strong decline in both the stock market prices and the price of crude oil seem to have a specific role.

Table 4. Risk measures based on single-factor and multifactor macro-risk models (in millions of euros) mirroring a similar crash in real economies as was experienced in the global financial crisis (GFC) of 2008-2009.

	Country-specific multifactor model (as of macro factor values during 2008-2009 crash)		Basel approach and the world real GDP growth as the only factor (as of global real GDP during 2008-2009 crash)	
Probability	VaR	CVaR	VaR	CVaR
0.05	4569.13	4586.76	1241.97	1589.25
0.01	4593.07	4629.35	1773.13	2046.05
0.005	4618.74	4653.34	1955.03	2239.29

As we see from the loss estimate values reported in Table 4, in the GFC scenario the VaR and C-VaR estimates are very close to each other at each default probability level. This is understandable in the case of a systemic crisis that changes the loss distribution such that the point estimate (VaR) values are almost the same as the expected values for the tail risk (C-VaR) values. Furthermore, as we see, in such a dramatic global collapse in all economies, which also affects the value of the Finnvera-guaranteed firms, the size of the losses at the default probability of 1% are very close to the sizes corresponding to the 0.5% probability of default. Furthermore, *in this situation the country-specific factor model results in losses more than 2.5 times as high as in the case of the single individual global macro factor model, and this reflects very well the nature and effects of contagion through financial markets and the macro economy in a systemic crisis situation as extreme as the one experienced in the darkest years of the GFC.* Without modeling the effects of country-specific macro and financial market factors, it would not have been possible to reveal these effects. *At the extreme case of 0.5% probability, the expected shortfall would be as high as 4.6 billion euros, and the losses at the 5% and 1% probability levels are actually of a similar magnitude. They are huge in comparison to the projected government budget deficit of 2.3 billion euros in the Ministry of Finance budget for 2020*. If for some reason the global economy started to collapse as it did at the time of the GFC, based on our results the partial effect of export guarantee risks on the public finance situation would be enormous. However, we currently see no signs of this, even though many macro-level risks are increasing, e.g. emanating from Brexit and the trade war between the U.S. and China. Hopefully, these will not culminate in a systemic crisis as the subprime crisis did. In Figure 9 we plot the loss distribution reflecting the GFC crash scenario, which reflects a very high probability of very large losses. This is because there is risk concentration especially in the U.S. market (especially indirectly via contagion effects). This is in fact analogous to the results of Acemoglu et al. (2015), who find that the same risk factors that contribute to the stability of financial networks under favorable economic conditions may serve as the main contaminating factors under other, significantly worse conditions.

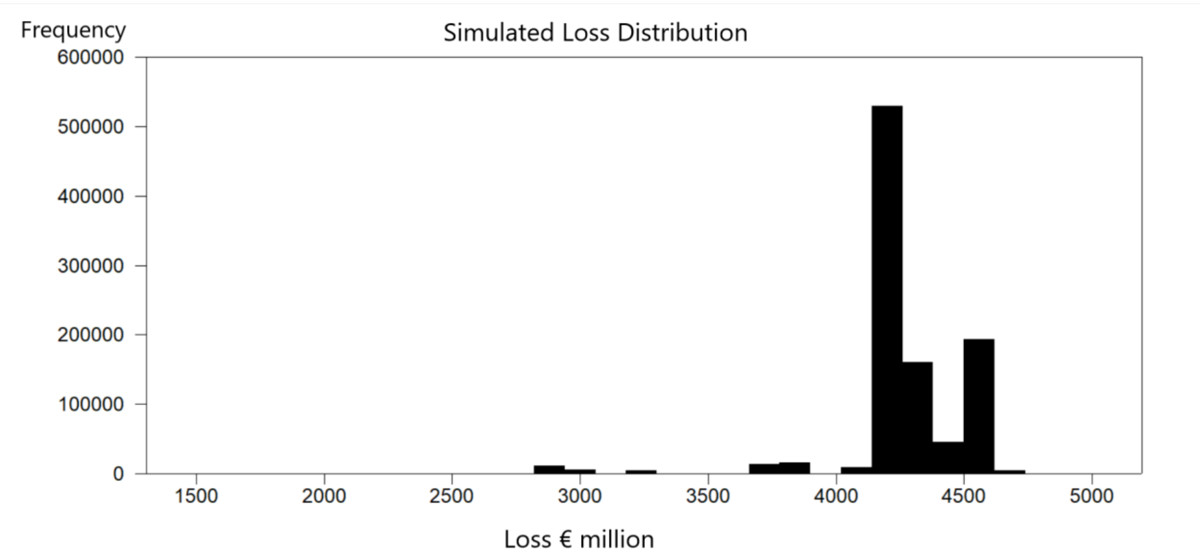

Figure 9. Loss distribution in the crash scenario based on the multifactor model (with 1 million simulations).

5.2. Results for the Housing Fund Guarantees

In addition to the Finnvera guarantee position, the other main component of the overall general government guarantee exposure is housing market guarantees, which amounted to 14.7 billion euros at the end of 2018 (see Table 2 in section 3.2). The majority of the exposure is in rental housing and it is concentrated by clients – the 20 largest counterparties account for about 45% of the exposure – and by the largest cities.

House prices diverge strongly between geographical areas and between cities and areas surrounding metropolitan growth centers. This is of great concern for general economic wellbeing. The concentration of the guarantee position in the largest cities, and especially Helsinki, implies that as long as house prices in the largest cities continue to rise or at least do not decline, the risks of the guarantee position should be rather limited. However, the risks increase immediately if house prices in the largest cities (also) start to decline. Analogously to the case of the Finnvera exposure, our analysis for the housing guarantee exposure is also based on the Vasicek factor model. The risk position of the housing market guarantees is extremely hard to evaluate, and we have to make some simplifying assumptions. In all our analyses, we approximate the default probabilities by BBB rating class (0.16%)[10] and we assume that it is unique to all the guaranteed firms. Furthermore, we use a very conservative loss-given-default measure of 70%. The main macroeconomic risk factor in our analyses is change in real GDP by geographical areas and the value of the guarantee portfolio is based on the development of housing prices in these areas. The default correlations are calculated for the geographic values of the variables analyzed.

As we see from the risk estimates reported in Table 5, because the housing guarantee portfolio is concentrated in the growth cities (especially Helsinki), based on the current values of the macro factors, the risks are fairly moderate. However, as we see from the table, if the real GDP of all the cities (other than Helsinki) falls by 10%, the risk measures increase dramatically at all default probability levels. Furthermore, due to the high concentration of the housing guarantee portfolio in the Helsinki area, even a moderate decrease in the real growth rate of Helsinki results very high risk estimates for the ultimate 0.5% probability of default, where the expected shortfall is above 1 billion euros for a 1.5% decline in the real economic growth of Helsinki. Hence, based on our results, the strong real economic development of the Helsinki metropolitan region, and especially of Helsinki, is of extreme importance for the risks emanating from the Housing Fund guarantees in the Finnish state guarantee system. The effect of 1.06 billion euros on public finances corresponds to an additional burden of about 46% on the projected deficit of the government budget for 2020.

[10] As a reference for this choice, the current Standard & Poors rating of the largest company in the housing guarantee portfolio, i.e. SATO plc, is BBB, which implies a default probability of 0.16%.

Table 5. Risk measures (in meur) for the housing guarantee portfolio with three real growth scenarios.

	Current Economic Conditions		1.5% Decline in Helsinki area		10% Decline in all cities other than Helsinki	
Probability	VaR	CVaR	VaR	CVaR	VaR	CVaR
0.05	2.22	125.90	2.22	160.40	2.22	364.33
0.01	2.22	125.90	2.22	160.40	667.92	1351.24
0.005	470.52	712.21	470.52	1058.85	667.92	1351.24

6. Conclusions

In this report, we have analyzed the effects of financial market and macroeconomic risks on the expected losses of the Finnish state guarantee portfolio, focusing only on the two main components of the guarantees, i.e. export credit guarantees and housing market guarantees. Our main findings are as follows.

First, the Finnvera export-related guarantee portfolio seems to be well diversified internationally, which under favorable economic conditions in general reduces the overall effects of the risks emanating from global financial markets and macroeconomic developments. Out estimates for the expected shortfalls stemming from the risks regarding the guaranteed firms' country-level macro and financial market risks are actually lower than the Finnvera estimates for the credit risks. However, the key to these findings is that the Finnish export guarantee system (like all other countries' systems) enables the risk to be diversified through the guarantees given to large international firms that buy the products of Finnish companies. According to our results, this is actually one form of efficient international diversification, and in the Finnvera guarantee portfolio case it is essential for the reduction of the overall risk profile. *However, if the current alarming and rising risks in the global economy, based on e.g. the yet completely uncertain effects of Brexit and the escalation of the trade war between China and the U.S. should result in a systemic crisis similar to the global financial crisis (GFC), the effects on Finland's export guarantee risk exposure would be devastating. As a result, based on over 4.5 billion euros increase in the public funding needed to cover the losses from the export guarantee portfolio, the public sector finance situation would clearly suffer if all the macro and financial risks in the business environment and the countries of the guaranteed firms were to be realized on a similar scale as in 2007-2009.*

Furthermore, our results indicate that the role of the Housing Fund guarantees in the Finnish state guarantee system is also essential, and the risk exposure is most strongly connected to the real economic development of the Helsinki area, where over 50% of all the housing market guarantees have been given. If the Helsinki real growth rate declines by 1.5%, it may even have an effect of over 1 billion euros on the expected shortfall of the housing market guarantee portfolio. In addition, if the real growth of all the other main guaranteed city areas collapses by a dramatic 10% (which clearly is an overly depressive scenario, even though we actually have seen an overall annual Finnish real GDP change of minus 8% in the worst year of the GFC), the expected shortfall would be about 1.3 billion euros. As a reflective example, this would increase the projected government budget deficit for 2020 by about 58%.

All in all, it is clear that the strong increase in the two main components of the state guarantee portfolio in the last 10 years or so has also increased the risk exposure of public sector finances. Hence, for the sake of stabilizing this part of the public sector finance situation, the stability of both global real economic growth and the financial markets, and of the real economic development of the main Finnish city areas, especially Helsinki, is extremely important. Obviously, for checking the robustness of our results, forthcoming risk analysis of the Finnish guarantee portfolio would need to use for example the Global VAR models introduced by Pesaran et al. (2006), and also other methods, to enable closer scrutiny and parameterization of the role of contagion and the international dependence of macroeconomic and financial market conditions. However, our current results serve as a good starting point for these further analyses.

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