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Discussion Papers

Tandem between the Finnish and the Swedish Economics – and its Break-up in 2008

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Discussion Paper No. 408
January 2017

ISSN 1795-0562

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HECER
Discussion Paper No. 408

Tandem between the Finnish and the Swedish Economics – and its Break-up in 2008*

Abstract

The aggregate economic development of Finland and Sweden defined by the growth of the real Gross Domestic Products (GDPs) advanced in tandem for a long time. The current paper provides a descriptive statistical analysis producing stylized facts of the co-development of the two neighboring countries. Using various statistical techniques, the paper documents that the tandem is over. The paper identifies the break-up point in 2007 when the financial crisis started to culminate peaking in 2008-2009. The key test on the duration of the economic tandem will be provided by the forecast ability of the statistical vector autoregressive model to be identified and estimated for GDPs of the two countries. The stability of the model is used as a statistical criterion. A rich set of results on the comparative volatility and instability, the steepness of recessions, and the diverging welfare of the two economies are reported. In particular, it is estimated that the cumulative welfare gap between the countries, measured by the cumulative prediction error of the model in the post-tandem period 2008/1 - 2015/1 is 47.9 per cent.

JEL Classification: C32

Keywords: economic tandem, welfare gap, time-series analysis

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* The authors are grateful to Tuomas Malinen for providing the data and helpful suggestions for the current study.

1. Introduction

In policy debates, the development of the Finnish and Swedish economy is often compared. The aggregate economic development of Finland and Sweden for long advanced in tandem. One can refer to Figures 1 and 2 which present the development of the real GDP indices of these economies. Using various statistical techniques, the current paper documents that the tandem is over. As far as we know, our paper is the first one which produces such a comparison using statistical time series methods.[1]

Competing hypotheses for the break-up of the tandem are many. Abstracting from differences in history, a number of hypotheses can be organized in terms of one particular point of view: economic policies in large. As a consequence, the economic structures prevailing in the latter part of the research period exhibit remarkable divergence though the resource base has not deviated substantially. An important implication of such divergence is linked to the different risk tolerance of the economies making the Swedish economy less vulnerable to asymmetric shocks. Examples of those policies include the different timing of the adjustment of the agricultural sectors in the context of the membership in European Union. Moreover, while Finland hasted its membership in the European Monetary Union, Sweden abstained from the membership for the reason that its labor markers were not flexible enough to justify the membership, not at least among the first.[2] Yet, and regardless of abstaining from the participation in the monetary union, Sweden was ready to carry out labor market reforms with increasing flexibility to accommodate external shocks in the contracts and gearing to the conditions of common markets than Finland.[3] Consequently, the palette of the policy instruments available for Sweden is greater as it can resort to domestic monetary policy as an instrument of the stabilization policy which is not available for Finland.[4]

The research issues to be addressed in the current paper include the following. First, what regularities can one identify on the volatility and instability of the two economies over the research period? Second, what message do the statistical analyses suggest about the nature of the economic tandem before its break-up? Third, what is the timing of the break-up of the tandem and how is it related to the economic crisis in 2007-2008? Fourth, what are the structural shifts in the two economies to potentially explain the observed development? Fifth, what is the size of the cumulative welfare loss of the regressed Finnish economy when compared with the advanced progress of the Swedish economy?

The data for this study are quarterly and seasonally adjusted real GDP indices for 1960/1-2015/1 and the paper introduces and estimates a VAR model for these data.[5] The key test on the duration of the economic tandem will be provided by the forecast ability of the statistical vector autoregressive (VAR) model to be identified and estimated. The stability of the model is used as a statistical criterion when identifying the timing of the end of the tandem. Subsequently, the one-step forecasts of the

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[1] Vihriälä and Suni (2015) have provided an ingenious analysis of the role of euro on the relative development.

[2] EMU: A Swedish Perspective (1977). Söderström (2008) re-evaluated subsequently Swedish membership in EMU. He concluded that country-specific shocks have been important for the fluctuations in the Swedish economy since 1993, implying that EMU membership could be costly. His model also indicated that the exchange rate has to a large extent acted to destabilize, rather than stabilize the Swedish economy, pointing to the costs of independent monetary policy with a flexible exchange rate. The evidence is therefore not conclusive about whether or not participation in the monetary union would be advantageous for Sweden.

[3] Kauhanen (2015).

[4] During the financial crisis, Sweden benefited from its floating exchange rate in 2009. Its currency depreciated from its 9,4 EUR/SEK level about 20 % protecting the Swedish current account surplus during the demand shock. It appreciated subsequently. In 2016, the Swedish krone again depreciated (by 10 per cent) against euro.

[5] A statistical analysis was also carried out using a stochastic difference equation. However, the results were not qualitatively different from the results achieved from the VAR-model of the current paper.

estimated VAR model after 2007/4 are reported.[6] The paper identifies the break-up point in 2007 when the financial crisis started to culminate peaking in 2008-2009. It turns out that the predictions based on a model estimated up to 2007/4 yield poor predictions after the suggested break-up. The lengthy and remarkable co-development between these two economies lasted more than 40 years.[7]

The following findings are reported. First, in the Finnish economy the extreme changes were larger than in Sweden between the 1970s and 2000. Second, the recession in the early 1990s was much deeper in the Finnish economy than in the Swedish economy. Third, a very short-term variation in the Swedish economy has been tenser than in the Finnish economy. Fourth, the downturn in the Finnish economy was much deeper than in the Swedish economy in 2009. Fifth, there is a further observation to be made: the relative changes over quarters used to be much bigger in the 1960s and in the 1970s than subsequently in the later decades. This observation points to the increased stability of both economies despite the economic crises in the latter part of the data period. The results are based on log-differences (which are approximately the same as the relative differences). Sixth and the most important, it is estimated that the cumulative welfare gap between the countries, measured by the cumulative prediction error of the model in the post-tandem period 2008/1 - 2015/1 is 47.9 per cent. In the final section, the results are linked to the differing policy stance of the two economies. The descriptive statistical analysis cannot be used to differentiate between the various hypothesis in the causal sense. Yet, it helps to identify regularities and differences in the outcome of the economic development which help to link the development to the background policy choices.

The paper is organized as follows: Section 2 describes the data, i.e., the GDP series of Finland and Sweden 1960/1-2015/1. In Section 3, we investigate the time series properties of the GDP series. Section 4 introduces the VAR model used to justify our argument of the break-up of the tandem of the economies of Finland and Sweden. In Section 5, we give the estimation results from the VAR model and the major conclusions which can be derived from the estimation results. In Section 6, we comment on the estimation results and conclusions reported in Section 5. The estimate for the welfare gap of the lagging Finnish economy after the break-up of the tandem given by the VAR model is reported in Section 7. Finally, Section 8 contains the conclusions. The paper contains two appendices. Appendix A1 gives additional information of the recursive least squares (RLS) method utilized in the estimation of the VAR model of the paper. In Appendix A2, we give some further information about the estimation results is given in Section 5.

2. Data and its description

To start the descriptive analysis, it is appropriate to resort to the enclosed Figure 1 with the quarterly real GDP data of the two economies.[8] There are several key observations to be reported.

Since early 1960s, the development of the GDP has been rather similar. The first oil crisis of 1973-1974 resulted in a prolonged and similar slowdown of the GDP growth in both economies but the second oil crisis in 1979 had only a temporary shock effect in the two economies. The development was somewhat different in the recession years of the early 1990s. The Finnish economy was more

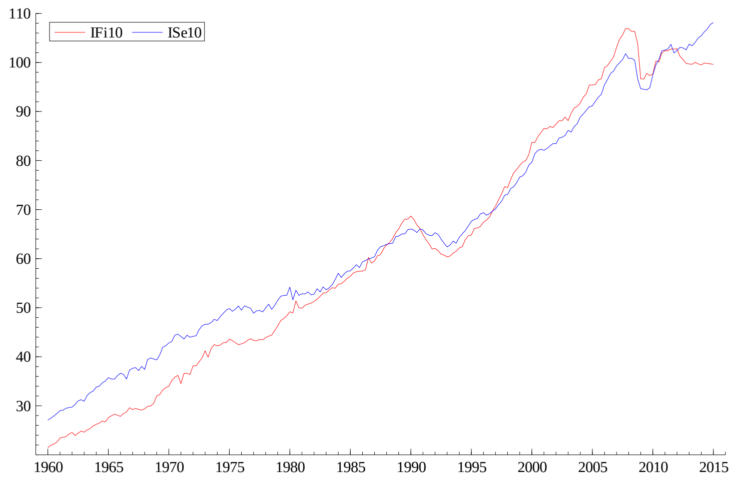
[6] The approach is analogous to our earlier paper on euro economies vs US economy and Finland vs the other euro countries, cf. Kanniainen et al. (2014).

[7] The divergence of the economic paths since 2011 is reflected in all key macroeconomic variables. The growth of the real GDP has been 2.5 – 2.8 per cent in Sweden while Finland has suffered from negative growth over several years. The public debt is 40 per cent in Sweden and 65 per cent in Finland relative to GDP. While the public finances in Sweden are in balance, the deficit in Finland is almost 2.5 per cent. The employment ratio of people between 15-64 years exceeds 76 per cent, it is less than 70 per cent in Finland. Finally, while the Finnish rate of unemployment is around 9 per cent, it is less than 7 per cent in Finland.

[8] We have also analyzed the per capita GDP series. However, the results from this exercise were not qualitatively different from the results achieved from the real aggregate GDP series.

vulnerable to the shocks in that period with a substantial pre-recession boom followed by a deeper downturn during the recession.[9]

Figure 1. Quarterly and seasonally adjusted real GDP indices of Finland (IFi10) and Sweden (ISe10), 1960/1-2015/4 (2010 = 100).



The statistical tests of the current paper were carried out using three different years as the starting points, i.e. 1960, 1985, and 1995. Yet, the statistical results turned out to be rather similar in the data including also the recession years of the 1990s. For this reason and for reason that the links to the global economy have been intensified during the second globalization phase, it was found appropriate to focus on the post 1995 development in the subsequent statistical analyses. The links to the global economy were strengthened when the capital markets were liberalized in the 1980s. Moreover, the statistical properties of the estimated model turned out to be sufficiently stable in the data for both economies after 1995 – up to the break-up of the tandem.

Some additional observations can be noticed. After the recession years of the 1990s, the growth of the Finnish economy actually was faster than the growth of the Swedish economy.[10] Second, the effects of recessions both in the early 1990s and in 2007-2009 have typically been larger in the Finnish economy compared with those in the Swedish economy. This supports the view expressed above: The Swedish economy is more diversified by its structure making the economy less vulnerable to asymmetric shocks.

As the total income in both economies fell dramatically in 2009, the Swedish trough was much shorter and the losses more limited than those of the Finnish economy.[11] The Swedish economy was much better equipped with macroeconomic risk insurance mechanisms both in terms of her private export sectors augmented by its macro policies, i.e. fiscal policy and monetary policy. In Finland, the economy was much less diversified: there was the traditional forestry and there was Nokia!

After the trough between 2009 and 2011, the economic recovery was still rather similar. During 2011 the tandem, however, breaks dramatically. We refer to Figure 2 which is an enlargement of the left part of Figure 1. Since 2012, the Finnish economy has been substantially lagging the Swedish one. While Sweden has caught up with the level of 2008 top income during 2011, the Finnish economy is

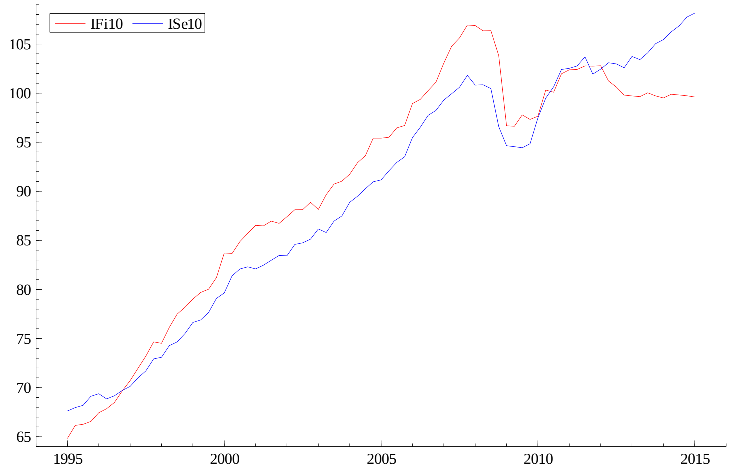
[9] The greater vulnerability of the Finnish economy may have to do with its structural weaknesses like the dependence of the Soviet trade, the role of the agricultural sector, the slowness of the urbanization process, the long-standing exchange rate policy based on fixed exchange rates with the repeated devaluation-inflation cycles.

[10] Two reasons obviously explain this: the larger devaluation of the Finnish markka in the early 1990s and the rise of the Nokia cluster.

[11] In the VAR model, this difference is more dramatic than in the difference equation,

till lagging behind in 2016. There is quite a strong agreement between the economists that structural reforms would be needed to facilitate the return of the economy to a growth path.

Figure 2. The quarterly and seasonally adjusted real GDP indices of Finland (IFi10) and Sweden (ISe10), 1995/1-2015/4 (2010 = 100).



3. The time series properties of the GDP series

This section presents a more detailed time series analysis of the GDP series of Finland and Sweden to dig deeper in the co-movement of the two economies. The GDP series are nonstationary having strong upward trends.

The differences and log-differences of the GDP series

In order to look at the time series properties of the series more closely, it is advisable to look into the differenced series. They indeed appear stationary although both have strong oscillations as well as prominent troughs and peaks (see Figures 3 and 4). These anomalities can be dated in recession times or other economic turmoils. The log-differences (i.e. approximately the relative differences) of the GDP series can be seen in Figures 5 and 6. Note that the relative heights of the troughs and peaks in the log-differenced series seem to have lowered after 1985, while this phenomenon does not appear in the ordinary differences.

The volatilities of the GDP series

The paper comes up with the unexpected finding that although the volatility of the Finnish GDP has more prominent peaks than the Swedish GDP, the volatility of the Swedish GDP seems to fluctuate somewhat more than that of the Finnish economy, i,e, changes between larger peaks seem to be minor in the Finnish data especially in the 70's and 80's. This observation be seen by looking at the differenced GDP series in Figures 3 and 4. This is also confirmed by the log-differenced GDP series in Figures 5 and 6.

It is also interesting to see that the relative volatilities of the two economies seem to have shrunk after the 1960s and 1970s with one prominent exception, which can be dated to the start of the present economic crisis in 2007. For the evidence for this, see Figures 7 and 8.

Figure 3. Differences of the real GDP index of Finland (DIFi10), 1960/2-2015/1.

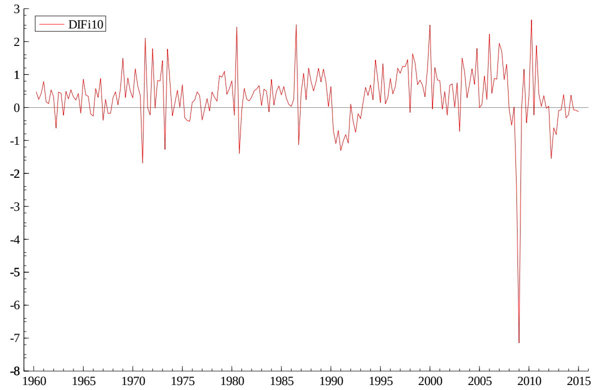


Figure 4. Differences of the real GDP index of Sweden (DISe10), 1960/2-2015/1.

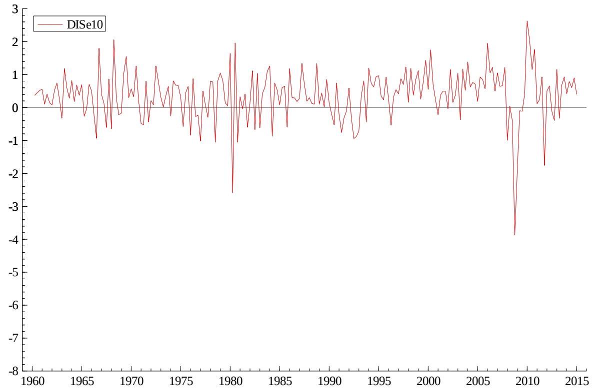


Figure 5. Log-differences of the real GDP index of Finland (LDIFi10), 1960/2-2015/1.

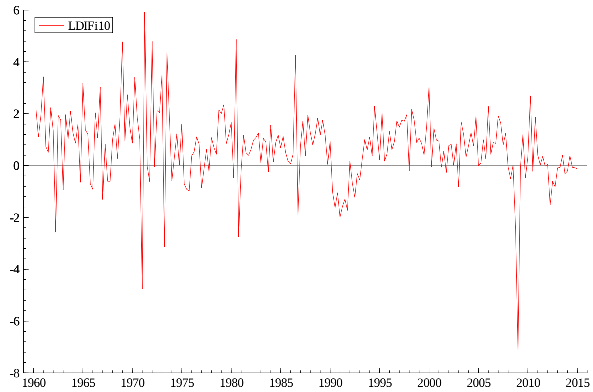


Figure 6. Log-differences of the real GDP of Sweden (LDISe10), 1960/2-2015/1.

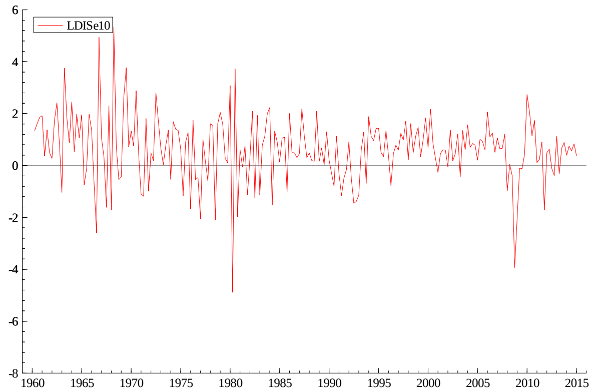


Figure 7. The volatility of the log-differences of the real GDP index of Finland (SdLDIFi10), 1960/2-2015/1.

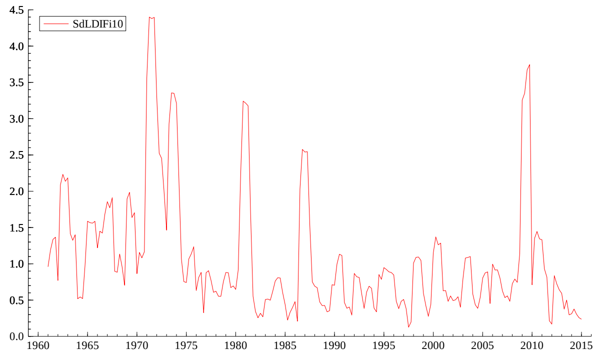
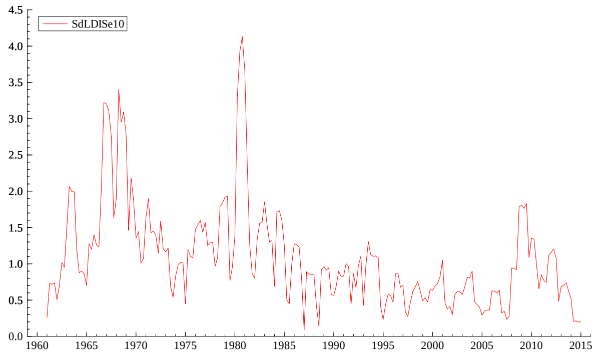


Figure 8. The volatility of the log-differences of the real GDP index of Sweden (SdLDISe10), 1960/2-2015/1.



The difference of the two GDP series

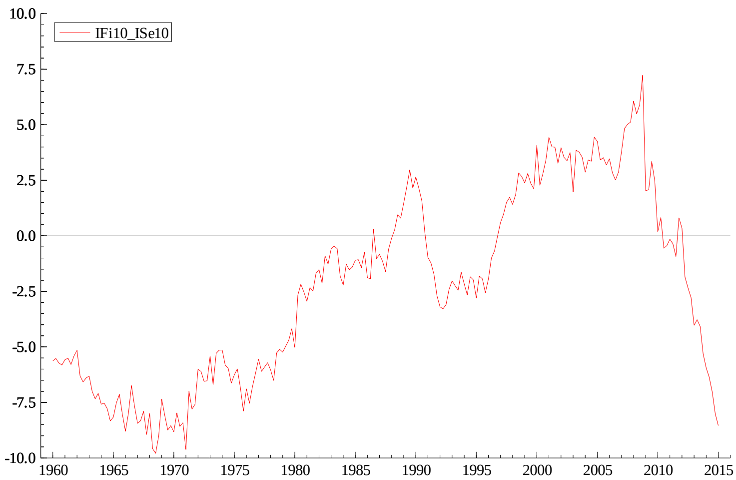
In order to construct a gross yardstick for the retardment of the Finnish economy with respect to the Swedish economy we have computed the difference of the real GDP indices of Finland and Sweden, see Figure 9. We can see from this figure that the growth of Finnish economy has in general moved closer to the Swedish economy in the 1970s and 1980s. The same development can be seen to have happened also in the 2000s before the year 2008. During the economic crises in the early 1990s and after the 2008, this development has ceased.

As the yardstick of the retardation of the Finnish economy, we have computed the cumulative sum of the differences of the real GDP-indices of Finland and Sweden from two time points onwards, 2008/1 and 2012/1. The cumulative sum of the differences of the GDP indices between 2008/1 and 2015 is –25.7, and between 2012/1 and 2 015/1 is –59.7. These numbers should be compared with the estimate for the retardation obtained from the VAR model of this paper in Section 5.3.

To compare the economic development between Finland and Sweden in 1960-2015, it is helpful to consider first differences in the GDP volumes. There are several stages where the development has been quite different. What Figure 9 suggests is that the Finnish economy had in the early 1970s a much lower starting point than the Swedish economy. However, throughout the 1970s and the 1980s, the Finnish economy was successfully catching up the Swedish economy until the deep recession in the 1990s hit. The subsequent second stage of the catching up process started in the second half of the 1990s when the success of Nokia company created a growth spurt of more than 10 years for the Finnish economy. The economy was hit by a sudden shock in the 2009 analogous to a symptom of the Dutch decease creating a long-lasting divergence between the two economies.

The cumulative sum of the differences of the real GDP indices between 2008/1 and 2015 is –25.7, and between 2012/1 and 2015/1 is –59.7. These “losses” when calculated relative to the GDP are not minor figures. These findings will be subsequently compared with the estimate for the relative loss based on the estimated model.

Figure 9. Difference IFi10-ISe10 of the real GDP indices of Finland (IFi10) and Sweden (ISe10), 1960/1-2015/4.



4. The statistical model and its estimation: methodology

The next task is to introduce **a statistical time-series model and the recursive estimation** based on it. We work with a VAR-model which is *atheoretic*. The model to be studied is therefore interpreted as non-causal. It is employed to highlight the *divergence process* of the two economies. Moreover, as the purpose of the study is to provide a measure for how much the development of one of the countries is lacking behind the development of the other country, working with variables in levels rather than differences is found appropriate. Therefore, the traditional argument based on the risk of spurious correlations when the levels of the variables are used is not valid in the current context.[12]

The findings reported in this paper are based on the ***vector autoregressive model*** (VAR-model)[13] which can be written as

$$(1)\qquad \begin{cases} y_{1t} = \gamma_1 + \sum_{i=1}^{p} \alpha_{1i} y_{1t-i} + \sum_{i=1}^{p} \beta_{1i} y_{2t-i} + \varepsilon_{1t} \\ y_{2t} = \gamma_2 + \sum_{i=1}^{p} \alpha_{2i} y_{1t-i} + \sum_{i=1}^{p} \beta_{2i} y_{2t-i} + \varepsilon_{2t} \end{cases} \quad , \quad t = 1, 2, \ldots, T$$

$$\varepsilon_{kt} \sim n.i.d.(0, \sigma_k^2)\ ,\ k = 1, 2$$

$$\text{cov}(\varepsilon_{1t}, \varepsilon_{2t'}) = 0\ ,\ t \neq t'$$

where y_1 is the real GDP index of Finland and y_2 is the real GDP index of Sweden. The number of lags p (after some testing) was chosen to be 4.

The ***vector autoregressive model*** (the VAR-model) of this paper was estimated by using the ***recursive least squares*** (RLS) method. The RLS method is just the ***ordinary least squares*** (OLS) method where the computations are made recursively (or iteratively). The RLS method can be considered a special case of the ***Kalman Filter***. Further information of the estimation method is given in Appendix A1 and the estimation results are given in Section 5 and in Appendix A2.[14]

5. Estimation results and evaluation of the VAR-model

5.1 Diagnostics and stability of the model: results from the total data period, 1995/1-2015/1

Figures 1 and 2 above suggest that there is a break-up of the tandem towards the end of 2007. Indeed, when the total data period 1995/1-2015/1 is used to estimate the VAR model specified above, the model is very poor in terms of the statistical criteria; what is crucial for our argument, the recursive Chow tests show that the estimated VAR model is unstable. It is identified that the instability begins at the end of 2007.

(i) Estimation results and diagnostic tests

The estimated coefficients and their significance plus the coefficients of determination and the correlation between the residual series from the two estimated equations are reported in Table A2.1 of Appendix A2. We also report test results for the significance of the two variables of the model and the significance of the lag structure in Appendix A2.

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[12] We note that the models were also estimated – if only to check the results – using differences and log-differences.

[13] We have also tried stochastic difference equations with various lag lengths. However, the results were not qualitatively different from the results obtained from the VAR-model applied in this paper.

[14] All calculations are made by PcGive program, see PcGive Manuals.

Below we give the results of the most important diagnostic tests for the validity of the estimated model.

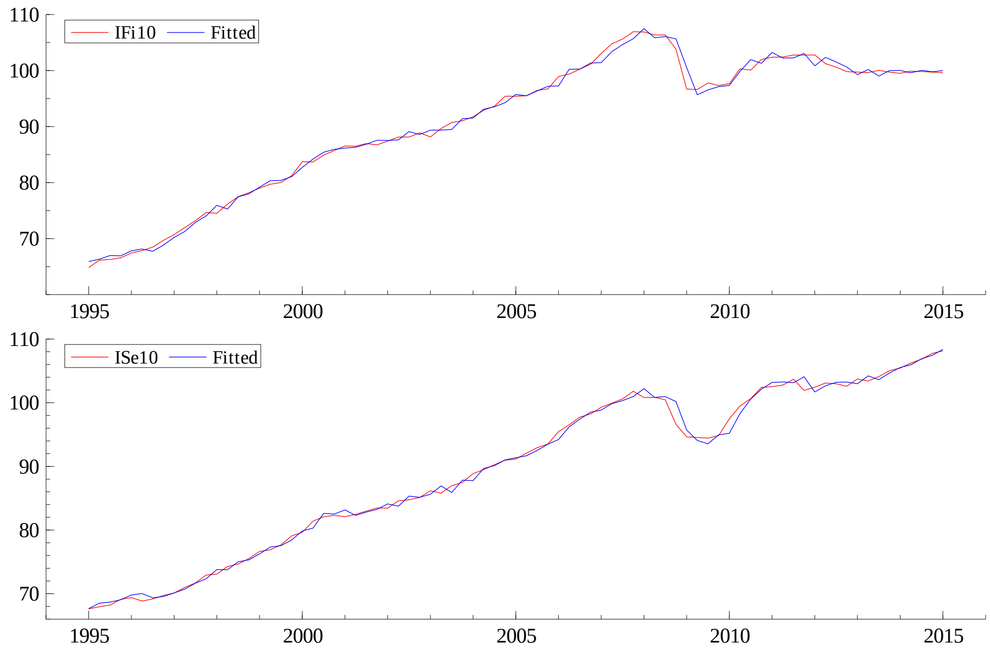
Diagnostic tests (vector tests)

LM test for autocorrelation	$p = 0.009$
LM test for Normality	$p = 0.000$
LM-test for heteroscedasticity 1	$p = 0.064$
LM-test for heteroscedasticity 2	$p = 0.000$

Based on the diagnostic tests, the residuals of the estimated model are strongly correlated, they are non-normal and they are heteroscedastic. These findings can be confirmed visually by looking at the residuals and the autocorrelations and the partial autocorrelations of the residuals of the estimated models. However, these figures are not reported here.

The actual and the fitted values of the estimated model are reported below in Figure 10.

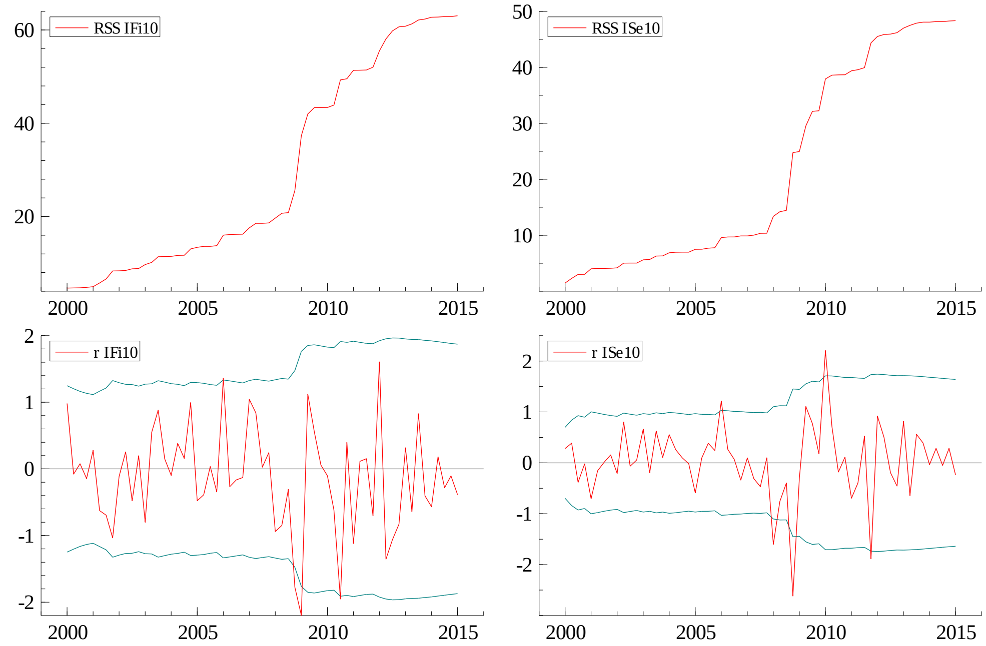
Figure 10. VAR-model, *p* = 4, 1995/1-2015/1, Actual and fitted values



(ii) Stability of the estimated VAR-model: Recursive graphics

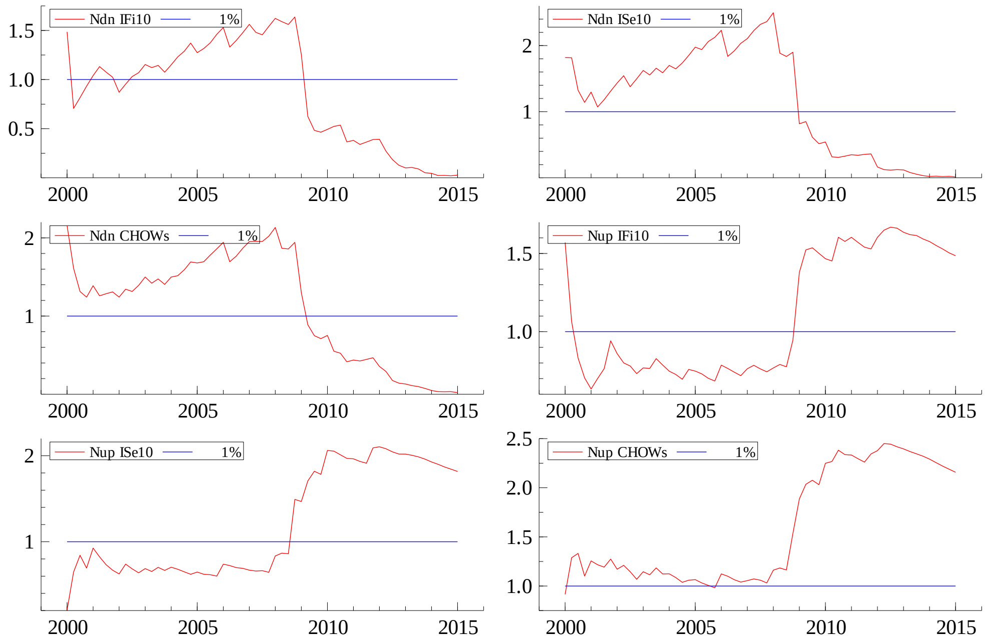
The findings are dramatic: There is remarkable jump in the recursive residual sums of squares in the beginning of 2008, see Figure 11 below.

Figure 11. VAR-model, p = 4, 1995/1-2015/1, Recursive graphics: Residual sum of squares, 1-step residuals



Moreover, the stability of the model and its predictive power disappear completely in 2007-2008, see below the scaled Chow tests.[15]

Figure 12. VAR-model, p = 4, 1995/1-2015/1, Recursive graphics: Forecast Chow tests



[15] Note that the values of the Chow-test statistics are scaled so that the values exceeding the blue line at the level 1 indicate instability or loss of the predictive power of the model.

5.2 Diagnostics and stability of the model: Estimation results during the tandem: 1995/1-2007/4

The estimation of the VAR model (in levels) is now carried out with the shorter data in 1995/1-2007/4 and forecasting the GDP values in the time-points 2008/1-2015/1.

(i) Estimation results and diagnostic tests

The estimated coefficients and their significance plus the coefficients of determination and the correlation between the residual series from the two estimated equations are reported in Table A2.2 of Appendix A2. We also report test results for the significance of the two variables of the model and the significance of the lag structure in Appendix A2.

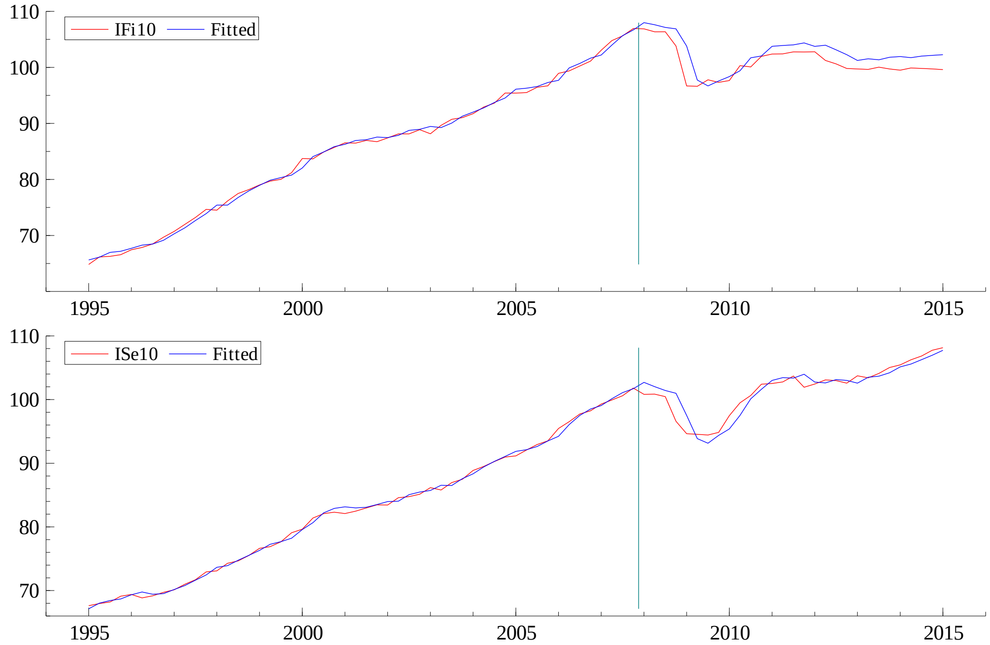
Below we give the results of the most important diagnostic tests for the validity of the estimated model.

Diagnostic tests (vector tests)

LM test for autocorrelation	$p = 0.164$
LM test for Normality	$p = 0.770$
LM-test for heteroscedasticity 1	$p = 0.999$
LM-test for heteroscedasticity 2	not enough observations

This time, the statistical properties are good: the model passes the diagnostic tests with flying colours. These findings can also in this case be confirmed visually by looking at the residuals and the autocorrelations and the partial autocorrelations of the residuals of the estimated models. However, these figures are not reported here. The actual and the fitted values of the estimated model are reported below in Figure 13. It should be noted that while the blue line describes the fitted values from the estimated model on the left side of the of the vertical line at point 2007/4, but the blue line describes the forecast values from the estimated model on the right side of this vertical line.

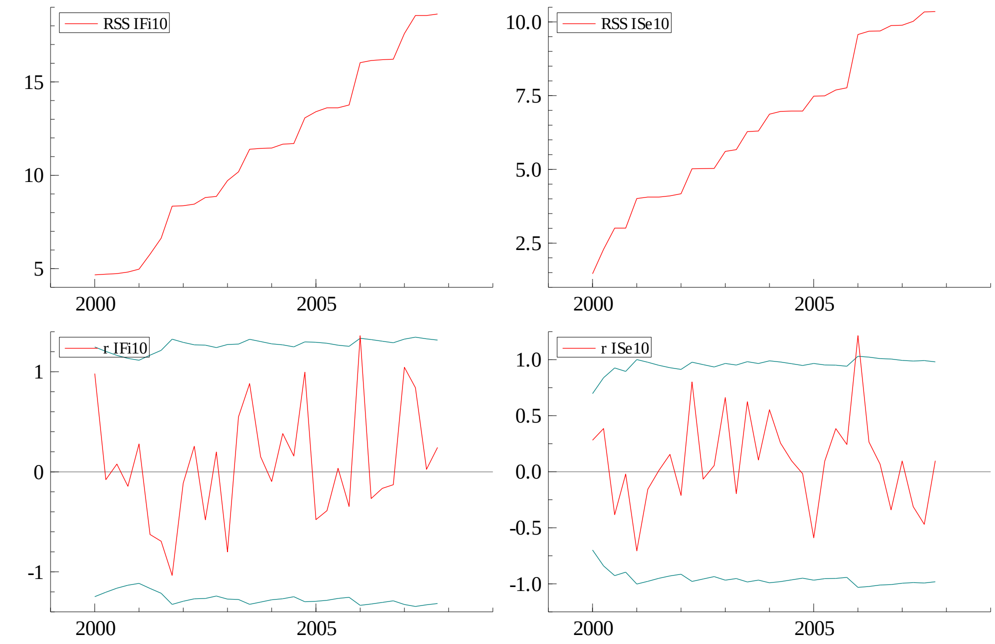
Figure 13. VAR-model, p = 4, 1995/1-2007/4, forecasts: 2008/1-2015/1, Actual and fitted values



(ii) Stability of the estimated VAR-model: Recursive graphics

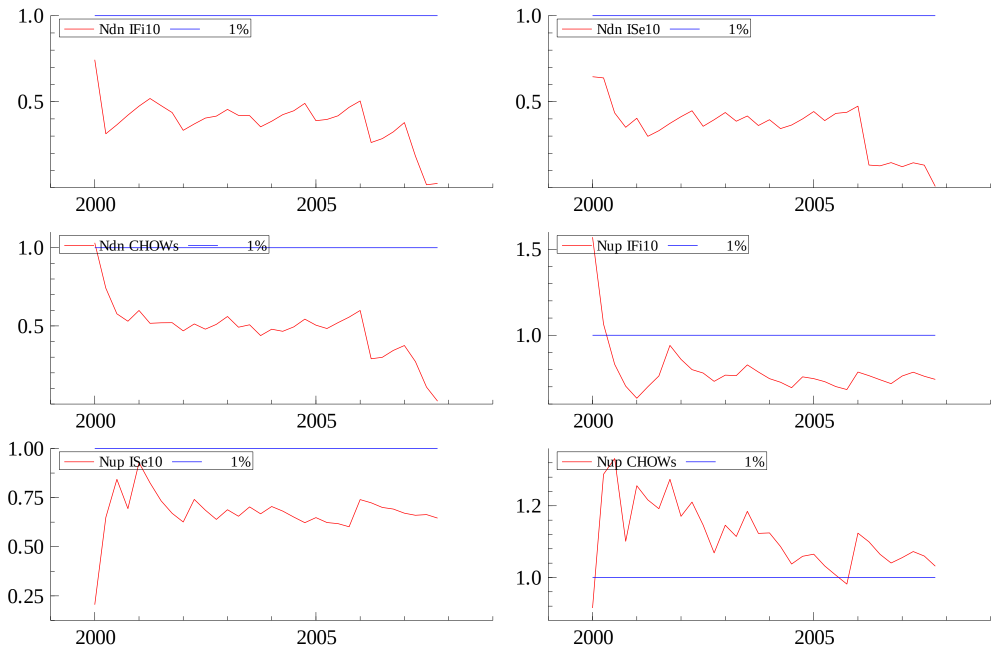
During the tandem period, the recursive residual sum of squares grows steadily without any jumps as it should be in a stable model, see Figure 14 below.

Figure 14. VAR-model, *p* = 4, 1995/1-2007/4, forecasts: 2008/1-2015/1, Recursive graphics: Residual sum of squares, 1-step residuals



The stability of the model and its predictive power are now much better, see below the scaled Chow tests.[16]

Figure 15. VAR-model, *p* = 4, 1995/1-2007/4, forecasts: 2008/1-2015/1, Recursive graphics: Forecast Chow tests



[16] Note that the values of the Chow-test statistics are scaled so that the values exceeding the blue line at the level 1 indicate instability or loss of the predictive power of the model.

(iii) Assessing the forecast power of the estimated VAR-model

The VAR model is now used to produce forecasts for the post-tandem period 2008/1-2015/1, see below Figure 16. For the Swedish economy, the ability of the model to predict is very good. For the Finnish economy, it is poor: with 2009-2011 as an exception, the prediction exceeds systematically the actual observed figures. In terms of the parameter constancy forecast, the forecast χ^2-test gives $p = 0.000$. The forecast Chow-test and the CUSUM-test also indicate that the model has poor forecast ability during the period 2008/1-2015/1, see below.

Figure 16. VAR-model, *p* = 4, 1995/1-2007/4, forecasts: 2008/1-2015/1, Actual values and 1-step forecasts

Results from the parameter constancy forecast tests

Forecast χ^2-test	0.000
Chow test	0.003
CUSUM test	0.001

5.3 Estimate for the welfare loss of divergent economic development

The above Figure 16 on the one-step prediction errors can be used to provide a measure of the cumulative welfare loss to Finland of the divergent economic development between the two neighbouring countries. In terms of the indices, the estimate is 47.9. This is the cumulative percentage loss in the welfare during the post-tandem period 2008/1-2015/1.

6. Comments on the estimation results: Statistical properties

The statistical argument that the Finnish and Swedish economies developed more or less in the tandem until the beginning of present recession, but a break up has taken place when the recession began in 2007/4-2008/1, can be based on the estimation results from the VAR model (1), see Section 5.

When the model is estimated by using the full data 1995/1-2015/1, we can see that the diagnostic properties of the estimated model are extremely poor. What is important for our argument, is the fact that the model is not stable as indicated by the Figures 11 and 12, and that the instability can be pinpointed to the beginning of the present recession, i.e. to 2007/4-2008/1.

On the other hand, when the model is estimated by using only the data 1995/1-2007/4, we can see that the diagnostic properties of the estimated model are very good. What is most important for our argument, is the fact that the instability of the model has now almost totally disappeared as is indicated by the Figures 14 and 15.

Our argument is that the reason for these findings is that the economies of Finland and Sweden developed in the tandem until the beginning of the present recession, but this tandem has been broken up after that.

7. The Welfare Gap of the Lagging Finnish Economy

Given that the Finnish and Swedish economies have developed in tandem over a long period 1960 – 2007 i.e. half of the century, it is appropriate to use the development of the Swedish economy as the yardstick when estimating the cumulative welfare loss of the Finnish economy after the tandem broke down.

Regardless of the period and the model, the losses are great:

- Using the data for 1960/1-2007/4 and forecast period: 2008/1-2015/4 with one lag, the estimated loss amounts to 38.7 %.
- If the estimation period is cut to 1995-2007, the estimated loss amounts to 53.8 %.
- Using data on 1960-2007 with four lags, the estimated loss amounts to 29.8 %.
- Using data on 1995-2007 with four lags, the estimated loss amounts to 47.9 %.

Thus, shortening the data, the divergence of the economies is intensified. This may be associated with the success of Nokia and its subsequent fall.

8. Conclusions

Our study confirms the public view that the economic development of Finland has deviated dramatically from that in the neighboring Sweden particularly since 2012. In the preceding period, 2007-2011 differences started to develop. It is not only in comparison with the Swedish economy where the economic path of Finland has deviated from the reference. It is also the case that in comparison with the rest of the euro area – with Greece as the exception – the Finnish economy has been lagging for 3-4 years. To explain this development, one has to ask two fundamental questions. First, what were the asymmetric shocks which have resulted in such economic disappointment? Second, how did the economies reacted in the face of such shocks?

Both Finland and Sweden were dramatically hit by the international debt crisis which resulted in a substantial output loss. However, in 2009-2010 the Swedish currency depreciated substantially (20 per cent) relative to euro making the loss of exports smaller in Sweden than in Finland. The subsequent appreciation of the krona did not "eat up" this gain in the competitiveness. The Finnish competitiveness was tied to euro. The Bank of Finland and the Research Institute of the Finnish economy have produced figures showing that the competitiveness gap has since been 15-20 %. Relative to the rest of the euro area, there was no particular asymmetric shock against the Finnish economy. Relative to the Swedish economy, there was – given that Sweden had its own money.

As to the adjustment to the shocks, the Swedish economy was in a better position as its labor market institutions were transformed to a more efficient set-up. The economic realities are incorporated in the labor contracts where the norm of the wage policy was based on the competitiveness of the open (export) sector. In Finland, the negotiation round in 2007 was fatal: the wage hike directed to the nurses in the first place was spread in the other union members resulting in a substantial loss of competitiveness of the open sector. The cost pressures were intensified as the cost development in the intermediate domestic sectors resulted in a further loss of competitiveness in the export sector. Moreover, the labor market structures were petrified into the pre-EMU period in Finland and were

incompatible with the membership in the euro system. Why was this possible? One interpretation is that the dramatic success of Nokia since 1994 led the country to believe that no structural changes are needed. The rise of the Nokia cluster led to the development of the production structures in Finland narrower than in Sweden. This can be viewed as a kind of Dutch decease which jointly with the appreciation of euro relative to the US dollar led to the loss of competitiveness of the country. The rise in real wages exceeded that which would have been desirable. There was a repercussion in the fiscal policy. While Sweden could keep her debt ratio reasonable, the Finnish debt ratio started to grow both autonomously and as a result of fiscal policies which were targeted as counter cyclical measures.

Appendix A1. Model and its estimation

The ***vector autoregressive model*** (VAR-model)[17] used in the paper can be written as

$$(1) \qquad \begin{cases} y_{1t} = \gamma_1 + \sum_{i=1}^{p} \alpha_{1i} y_{1t-i} + \sum_{i=1}^{p} \beta_{1i} y_{2t-i} + \varepsilon_{1t} \\ y_{2t} = \gamma_2 + \sum_{i=1}^{p} \alpha_{2i} y_{1t-i} + \sum_{i=1}^{p} \beta_{2i} y_{2t-i} + \varepsilon_{2t} \end{cases} , \quad t = 1, 2, \ldots, T$$

$$\varepsilon_{kt} \sim n.i.d.(0, \sigma_k^2) \, , \, k = 1, 2$$
$$\text{cov}(\varepsilon_{1t}, \varepsilon_{2t'}) = 0 \, , \, t \neq t'$$

where y_1 is the real GDP index of Finland and y_2 is the real GDP index of Sweden. The number of lags p was chosen to be 4.

Estimation of the model

All computations and all figures in the paper were made by using the ***PcGive program***[18]. The VAR-model (1) was estimated by using the ***recursive least squares*** (RLS) method. The RLS method is just the ***ordinary least squares*** (OLS) method where the computations are made recursively. The RLS method is a special case of the ***Kalman Filter***.

Recursive estimation makes it possible to easily assess the stability (i.e. the constancy of the parameters) of the time series models. In recursive estimation, computations start by selecting some basic number of observations from the beginning of the time series and estimating the parameters of the model by the OLS method. In recursion steps, the OLS method is applied recursively by adding new observations to the model one observation at a time and updating the estimates of the coefficients accordingly. All the relevant estimation results and model diagnostics are updated at the same time.

[17] We have also tried stochastic difference equations with various lag lengths. However, the results were not qualitatively different from the results obtained from the VAR-model applied in this paper.
[18] For further information of the methods used, see PcGive Manuals.

Appendix A2. Estimation results

Reported results

The reported estimation results include the ***OLS-estimates*** of the coefficients of the model, the ***heteroscedasticity and autocorrelation consistent standard errors*** (HACSE's) of the coefficients and the corresponding ***t-values*** and ***p-values***. As additional information we report the ***coefficients of the multiple determination*** as well as the ***F-test*** results for the estimated model, for the explanatory power of the explanatory variables of the model, and for the lag structure of the model. The ***correlation*** of the residual series from the two estimated equations is also given.

Diagnostic tests

We report the results of the following (vector[19]) ***diagnostic tests*** for the assumptions on the model:

- ***Lagrange multiplier*** (LM) ***test for the error autocorrelation*** (with 12 lags in the auxiliary regression),
- ***LM test for normality*** of the errors,
- ***LM test 1 for the heteroscedasticity*** of the errors using squares,
- ***LM test 2 for the heteroscedasticity*** of the errors using squares and cross-products.

When the observations of 2008/1-2015/1 are forecast by the estimated VAR-model, we also report the results of the following ***parameter constancy forecast tests***:

- ***Forecast*** χ^2***-test***,
- ***Chow test***,
- ***CUSUM test.***

The diagnostic tests above can be considered as ***misspecification tests***. It should be noted that many tests mentioned above have also power against other types of deviation from the model assumptions than against the assumption for which the test in question has been constructed in the first place. For instance, the LM test for the error autocorrelation has also power against omitted variables.

Diagnostic graphics

In order to help the interpretation of the estimation results and the results of the diagnostic tests, we have looked at various graphical displays:

- ***Actual*** and ***fitted values***,
- ***Scaled residuals***,
- ***Actual values*** and ***1-step forecasts*** with error bars (only in the case that the observations 2008/1-2015/1 are forecast),
- ***Autocorrelations*** and ***partial autocorrelations*** of the residuals.

Recursive graphics

In order to assess more deeply the parameter constancy as well as the forecast power of the estimated model, we display various plots describing the results of the recursive estimation procedure used in the computations.

[19] All diagnostic tests were also made separately for the two equations of the model.

We display the following recursive plots:

- ***Residual sum of squares*** (RSS),
- ***1-step residuals***,
- ***Break-point*** **(**N-down**)** ***Chow tests***,
- ***Forecast*** (N-up) ***Chow tests***.

It should be noted that the values of the Chow test statistics in these plots are scaled so that the values of the test statistic which correspond to the 1 % level of significance correspond to the value 1.

Diagnostics and stability of the model: Estimation results from the total period: 1995/1-2015/1

Estimated coefficients and diagnostic tests

The estimated coefficients, their significance and the coefficients of determination and the correlation between the residual series from the two estimated equations are reported in Table A2.1.

Table A2.1. Estimation results from the VAR-model, *p* = 4, 1995/1-2015/1

Equation for Fi				
Coefficient	Estimate	HACSE.	t-HACSE	*p*
c_1	2.574	0.930	2.77	0.007
a_{11}	0.767	0.137	5.59	0.000
a_{12}	0.076	0.142	0.53	0.596
a_{13}	0.149	0.120	1.24	0.219
a_{14}	0.039	0.082	0.47	0.638
b_{11}	0.897	0.386	2.32	0.023
b_{12}	–0.650	0.458	–1.42	0.160
b_{13}	–0.147	0.194	–0.76	0.449
b_{14}	–0.161	0.137	–1.17	0.245
Equation for Se				
Coefficient	Estimate	HACSE.	t-HACSE	*p*
c_2	1.124	0.824	1.36	0.177
a_{21}	–0.088	0.119	–0.74	0.464
a_{22}	0.123	0.143	0.86	0.392
a_{23}	–0.179	0.104	–1.71	0.091
a_{24}	0.135	0.092	1.47	0.146
b_{21}	1.314	0.209	6.28	0.000
b_{22}	–0.186	0.225	–0.83	0.411
b_{23}	0.108	0.181	0.60	0.554
b_{24}	–0.237	0.205	–1.16	0.252

$R^2 = 0.999$ $R^2(Fi) = 0.997$ $R^2(Se) = 0.998$
Correlation of the residual series from the two equations = 0.486

Below we give test results of the significance of the two variables of the model and the significance of the lag structure.

Significance of the variables

F-test for the model	$p = 0.000$
Significance of Fi	$p = 0.000$
Significance of Se	$p = 0.000$
Significance of all lags up to 4	$p = 0.000$

Diagnostics and stability of the model:
Estimation results during the tandem: 1995/1-2007/4

Estimation results and diagnostic tests

The estimated coefficients, their significance and the coefficients of determination and the correlation between the residual series from the two estimated equations are reported in the enclosed Table A2.2.

Table A2.2. Estimation results from the VAR-model, *p* = 4, 1995/1-2007/4, forecasts: 2008/1-2015/1

Equation for Fi				
Coefficient	Estimate	HACSE.	t-HACSE	p
c_1	–0.910	1.089	–0.84	0.408
a_{11}	0.745	0.110	6.79	0.000
a_{12}	0.190	0.132	1.44	0.157
a_{13}	0.064	0.120	0.53	0.597
a_{14}	–0,104	0.109	–0.96	0.342
b_{11}	0.308	0.222	1.39	0.172
b_{12}	–0.061	0.254	–0.24	0.810
b_{13}	–0.113	0.225	–0.50	0.619
b_{14}	–0.007	0.215	–0.03	0.974
Equation for Se				
Coefficient	Estimate	HACSE.	t-HACSE	p
c_2	0.851	0.876	0.10	0.923
a_{21}	0.126	0.139	0.90	0.371
a_{22}	0.099	0.142	0.70	0.488
a_{23}	–0.103	0.126	–0.82	0.419
a_{24}	–0.078	0.111	–0.70	0.487
b_{21}	0.816	0.181	4.51	0.000
b_{22}	0.249	0.195	1.28	0.208
b_{23}	–0.069	0.189	–0.37	0.715
b_{24}	–0.037	0.189	–0.20	0.844

R^2 = 0.999 R^2(Fi) = 0.999 R^2(Se) = 0.999
Correlation of the residual series of the two equations = 0.224

Below we give test results of the significance of the two variables of the model and the significance of the lag structure.

Significance of the variables

F-test for the model $p = 0.000$
Significance of Fi $p = 0.000$
Significance of Se $p = 0.000$
Significance of all lags up to 4 $p = 0.000$

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