SVERIGES RIKSBANK
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SVERIGES RIKSBANK

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DECEMBER 2003

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Intersectoral Wage Linkages in Sweden

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Sveriges Riksbank Working Paper Series
No. 158
December 2003

Abstract

The purpose of this study is to investigate if the wage setting in certain sectors of the Swedish economy influences the wage setting in other sectors. The theoretical background is the Scandinavian model of inflation, which states that the wage setting in the sectors exposed to international competition should influence the wage setting in the sheltered sectors of the economy. The Johansen maximum likelihood cointegration approach is applied to quarterly data on Swedish sector wages for the period 1980:1–2002:2. Different vector error correction (VEC) models are created based on assumptions of which sectors are and which sectors are not exposed to international competition. The wage adaptability between sectors is then tested by imposing restrictions on the estimated VEC models. Finally, Granger causality tests are performed in the different restricted/unrestricted VEC models to test for sector wage leadership. The empirical results indicate large wage adaptability between manufacturing, construction, wholesale and retail trade, the central government sector and the municipalities and county councils sector. This is in line with the assumptions of the Scandinavian model. Furthermore, the empirical results indicate low wage adaptability between the financial sector and manufacturing, and between the financial sector and the two public sectors. The Granger causality tests provide strong evidence of the existence of intersectoral wage causality, but no evidence of a wage leading role in line with the assumptions of the Scandinavian model for any of the sectors.

Keywords: Sector wage linkages, wage leadership, wage adaptability, Scandinavian model of inflation, exposed and sheltered sectors, vector error correction (VEC) models.

JEL classification: C32, J30, J51, J52.

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I want to thank Malin Adolfson, Tor Jacobson, Henry Ohlsson, Eskil Wadensjö, and the seminar participants at Swedish Institute of Social Research and Sveriges Riksbank for valuable comments. I am also grateful to Christina Eurén, National Mediation Office, and Jonas Färnstrand, Statistics Sweden, for providing some of the data. The software package Structural VAR – version 0.16-1, programmed by Anders Warne, has mainly been used in the empirical section. The responsibility for any remaining errors is, of course, my own. The views expressed in this paper are those of the author and should not be interpreted as reflecting the views of the Executive board of Sveriges Riksbank.

1. Introduction

Does wage setting in certain sectors of the economy influence wage setting in other sectors? What is the economic interest for analysing possible sector wage linkages? An answer to these questions is that the development of unit labour costs can be of relevance for stabilisation policy. If the growth of wage costs is higher than the productivity growth, due to for instance influence between different sectors in the wage setting, this could lead to higher price inflation. One example is the cancellation in October 2002 of the third year in the three year wage settlement between the Municipal Workers' Union (*Svenska Kommunalarbetarförbundet*), the Association of Local Authorities (*Svenska Kommunförbundet*) and the Federation of County Councils (*Landstingsförbundet*). If the cancellation and the new wage agreement will affect the wage formation in the rest of the economy it is of relevance for stabilisation policy.

The purpose of this study is to analyse if the wage setting in certain sectors of the economy influence the wage setting in other sectors. If this is the case, which sectors are the wage leaders and which are the wage followers? Thus, the object is to give an idea about the structure of wage interaction between different sectors in Sweden.

Some research concerning sector wage linkages has been produced during the 1990's. Holmlund and Ohlsson (1992), Jacobson and Ohlsson (1994) and Tägtström (2000) are examples of studies in this field, looking into Swedish data. In the studies by Holmlund and Ohlsson, and Jacobson and Ohlsson the wage linkages between the private sector, the central government sector and the municipalities and county councils sector are investigated. In the study by Tägtström the private sector is divided into the manufacturing industry and the "non-manufacturing" private sector. The public sector is also divided into the central government sector and the municipalities and county councils sector in Tägtström´s study. All three studies indicate that the private sector, or the manufacturing industry, is a wage leader in relation to the other sectors in Sweden. The studies by Holmlund and Ohlsson, and Jacobson and Ohlsson also indicate that wage setting in the municipalities and county councils sector affects wage setting in the central government sector. This result is not found in

Tägtström (2000). In contrast, Tägtström finds that wage setting in the central government sector affects the "non-manufacturing" private sector wage setting.

In the present study more disaggregated data are used compared to these previous studies. The private sector is divided into four sub-sectors; (*i*) manufacturing, (*ii*) construction, (*iii*) wholesale and retail trade, and (*iv*) the financial sector. The aggregate private sector is also used in the empirical analysis. The public sector is divided into two sectors, the central government sector and the municipalities and county councils sector, as in the prior studies cited above. The study here uses official wage statistics from Statistics Sweden in contrast to the prior studies. Furthermore, the estimation period is up-dated compared to the prior studies. Finally, the econometric methodology in the study here differs to some extent from the methodology in the previous studies.[1] In the study here formal tests for wage leadership are carried out in a multivariate error correction framework.

The empirical results indicate large wage adaptability between manufacturing, construction, wholesale and retail trade, and the two public sectors. This is interpreted as to be in line with the assumptions of the Scandinavian model. The financial sector wage setting is interpreted to be independent of the wage setting in the other sectors. Furthermore, the Granger causality tests provide strong evidence of intersectoral wage causality, but there is no evidence of a wage leading role in line with the assumption of the Scandinavian model for any of the sectors.

The rest of the paper is organized as follows: In Section 2 the theoretical model is presented. Section 3 presents the empirical method and provides the empirical results. In particular, Section 3 provides tests results for sector wage adaptability and sector wage leadership. Finally, in Section 4 the study is summarised and some conclusions are drawn.

[1] In Holmlund and Ohlsson (1992) and Tägtström (2000) possible wage leadership is tested by univariate Granger causality tests. The empirical approach in the study here is close to the approach in Jacobson and Ohlsson (1994). In both studies a multivariate error correction approach is used, which enables one to analyse the wage interaction between different sectors simultaneously. In Jacobson and Ohlsson weak exogeneity tests of a restricted VEC model are used to test for possible wage leadership. In the study here multivariate Granger causality tests of restricted/unrestricted VEC models are used to test for possible wage leadership.

2. The theoretical background

In the mid 1960's the Norwegian economist Aukrust developed a disaggregated model for pricing behaviour and wage setting in the Norwegian economy.[2] The model can be used both as a positive ex post model for the actual wage setting process and as a normative ex ante model for input in the wage negotiations. Similar models were in the late 1960's developed by Swedish and Finnish economists.[3] The models became internationally known as the "Scandinavian model of inflation" or the "Scandinavian model".[4]

The model is based on some crucial assumptions. The first assumption is that the different sectors of the economy are exposed or sheltered to international competition.[5] This means that the sectors of the economy can be distinguished into what Aukrust called "exposed sectors" and "sheltered sectors".[6] One problem with this assumption is that the composition of industries in the exposed and sheltered sectors has changed over time. Factors such as deregulation of markets and probably also the membership in the European

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[2] Aukrust called the model the (Norwegian multisector) price income model (PRIM). See Aukrust (1970a, 1970b, 1977).

[3] The Swedish version of the PRIM model was the so called EFO-model. The model was developed by the research department directors of the Central Organisation of Salaried Employed (*TCO*) Edgren, the Swedish Employer Organisation (*SAF*) Faxén and the Swedish Trade Union Confederation (*LO*) Odhner. See Edgren, Faxén and Odhner (1973). The Finnish variant of the model was the so called "Input-output framework" and it was developed for the Bank of Finland by the economists Halttunen and Molander. See Halttunen and Molander (1972).

[4] Similar models to the "Scandinavian model of inflation" were later developed by economists for application in the economies of, for example, the Netherlands, France, United States and Australia. See Aukrust (1977) for references.

[5] The exposure to international competition concern traded goods but also to some extent domestic services. For instance, tourist services in Sweden compete with tourist services abroad.

[6] One main difference between the models underlying the Scandinavian model is the subdivision of the sectors into exposed and sheltered sectors. In the original version of the PRIM model the economy is divided into six sectors. In the revised version of the model, the PRIM II model, the economy is divided into seven sectors. In the PRIM II model the four exposed sectors are fisheries, manufacturing, shipping and other export-oriented sectors, while the three sheltered sectors are agriculture, construction and other sheltered sectors. See Ringstad (1972). In the EFO-model the Swedish economy is divided into nine subsectors. The four exposed sectors are fishing, forestry, mining and manufacturing (except parts of the food product industry, and the beverage and tobacco industries) and foreign transportation. The five sheltered sectors are construction, agriculture, the electricity, gas and water supply sector, some parts of the food product industry (see above), and public and private services. In a version of the EFO-model, the so called FOS-model, public and private services are divided into two subsectors. See Faxén, Odhner and Spånt (1988). Spånt is the research department director of *TCO*. Finally, in the Finnish model the economy is divided into four sectors. The two exposed sectors are forestry and competitive production (bulk of manufacturing); and the two sheltered sectors are agriculture and non-competitive production.

Union have played an important role in this structural process. Industries such as, for example, telecom, finance, electricity and the beverage industry are today exposed to foreign competition to a greater extent than say for two decades ago and may now be categorized as exposed sectors. Also technological innovations can have changed which sectors should be considered as exposed and which sectors should not. For example, IT-innovations, such as the development of internet, have probably increased the exposure to foreign competition for the Swedish wholesale and retail trade.

A second assumption behind the Scandinavian model is staggering of wage decisions. According to the model wage increases in the exposed sectors should be transmitted to wage increases in the sheltered sectors of the economy. This implies that wage decisions in the exposed and sheltered sectors must not be taken simultaneously.

A third crucial assumption is fixed domestic and foreign exchange rates. Thus, one objective with the Scandinavian model was to explain trends in the national wage and price levels under the assumptions of exogenously given exchange rates and world market prices. This is the positive ex post role of the model. The model can also in fixed exchange rate policy regimes have a normative ex ante role for the wage and price setting in order to maintain the relations between domestic and foreign exchange rates.

The monetary policy regime shift in 1992–93, when the Swedish Krona started to float and an inflation target was adopted, meant that there was no ex ante normative role for the model in the wage and price setting anymore. But there are some indications that the idea behind the Scandinavian model has still lived on in the wage negotiations in Sweden. For instance, in the bargaining rounds of 1995, 1998 and 2001 the labour market parties in the export-oriented manufacturing industry were the first to conclude agreements (see Table A1 in Appendix A).[7] Furthermore, in the analysis of 2001's bargaining round by the

[7] In some preparatory papers for wage negotiations by union confederations the idea behind the Scandinavian model is still discussed. In the recommendations by the Swedish Trade Union Confederation for the wage demands at the prospect of the 1998's bargaining round the wage leading role of the manufacturing industry is toned down. In the recommendations it is argued that the economic internationalisation has given a restriction on the price development in more sectors of the Swedish economy than the manufacturing industry. This, in turn, means that the sector has not such a wage leading role anymore. Furthermore, in the wage demand recommendations by the Swedish Trade

National Mediation Office it is also concluded that the negotiated wage levels in the manufacturing industry were to a large extent accepted as a norm for the rest of the labour market.[8]

Based on the three assumptions Aukrust set up a two-sector model in order to describe the mechanism behind the long-term movement of wages and prices in an economy subject to strong price impulses from abroad. The model consists of three relations for the determination of wages and prices in the economy. The first relation states that the nominal wage costs in the exposed sectors are given by the sum of the exogenously given world market prices and the productivity in the exposed sectors. The second relation is that the setting of nominal wage costs (or nominal wages) in the exposed sectors lead the setting of nominal wage costs (or nominal wages) in the sheltered sectors. Finally, the prices in the sheltered sectors are given by the nominal wage costs adjusted for productivity in these sectors. Thus, the following long-run wage- and price-relations are assumed:

(1) $wc_t^E = p_t^E + q_t^E$,

(2a) $wc_t^S = wc_t^E$ or

(2b) $w_t^S = w_t^E$,

(3) $p_t^S = wc_t^S - q_t^S$,

where sub-index t denotes point of time t, $wc^E\left(w^E\right)$ denotes nominal wage costs (nominal wages) in the exposed sectors, p^E world market price, q^E productivity in the exposed sectors, $wc^S\left(w^S\right)$ nominal wage costs (nominal wages) in the

Union Confederation at the prospect of the 2001's bargaining round two restrictions on the scope of wage rises are discussed. The first (and most important) restriction is that the wage increases should be in line with the established inflation target. The second restriction is that the wage development in the sectors exposed to international competition should be the guideline for the rest of the economy. However, in the platform for wage demands by the unions in the manufacturing industry at the prospects of 2001's bargaining round, the wage leading role of the manufacturing industry is emphasized. See LO (1997, 2000) and Facken inom industrin (2000).

[8] See National Mediation Office (2002).

sheltered sectors, p^S prices in the sheltered sectors, and q^S productivity in the sheltered sectors.

The focus in the empirical analysis will be on equation (2b), i.e. the intersectoral nominal wage linkages.[9] The nominal wages in (2b) can be decomposed as:

$$(4) \qquad w^S_{nt} + w^S_{dt} = w^E_{nt} + w^E_{dt},$$

where w^E_n and w^S_n denote negotiated wages in the exposed and the sheltered sectors respectively; w^E_d and w^S_d denote wage drift terms in the two sectors, respectively. Thus, the transmission of wage increases from the exposed to the sheltered sectors can be divided into two channels, namely the central/intermediate central negotiations and the local wage formation.[10] It is reasonable to think that the negotiated wage adaptability between sectors is larger in the case of central negotiations than in the case of intermediate central negotiations. The main transmission mechanism of wage increases in the case of intermediate central negotiations is probably by a so called "information-effect" (or "jealousy-effect").[11] This means that information about the level of negotiated wage increases in one sector of the labour market affects the wage setting in other sectors of the labour market. Wage increases could also be transmitted through the local wage formation and the wage linkage should then be assigned

[9] The availability of data determines the use of nominal wages. A nominal wage cost variable is probably more in line with the theoretical model. A possible statistical measure of nominal wage costs is nominal wages including both negotiated and statutory social contributions. But data for negotiated and statutory social contributions are only available from 1992 at Statistics Sweden. It should also be noted that this data concerns the aggregate private sector and the level of negotiated social contributions can differ between sectors.

[10] Central negotiations refer to wage negotiations between the central organisations of the Swedish labour market, such as for example negotiations between the Swedish Employer Organisation (*SAF*), the Swedish Trade Union Confederation (*LO*), the central bargaining organisation for private sector white-collar workers (*PTK*) including unions from the Central Organisation of Salaried Employed (*TCO*), the Central Organisation of Professional Associations (*SACO*) and the union for middle management (*SALF*). For a compilation of central bargaining areas, see Calmfors and Forslund (1990). Intermediate central negotiations refer to wage negotiations between employer and employee organisations in different industries, such as for example the Metal Workers Union (*Metall*) and the Association of Swedish Engineering Industries (*Verkstadsföreningen*). Local wage formation refers to wage setting at individual work places.

[11] For more reading about "jealousy-effects" in the wage setting, see Uddén-Jondal (1993).

to the wage drift term. One transmission mechanism in this case is a competition-situation between sectors for labour with no sector-specific human capital.

The wage adaptability between sectors is probably affected by changes in the sectoral labour market situation. If the labour market situation in one sector of the economy changes during a bargaining round it is reasonable to believe that the wage adaptability between this sector and other sectors of the labour market is weakened.[12] During for instance the 2001's bargaining round the labour market situation gradually worsened (in at least some sectors) which probably affected the wage outcomes in the negotiations.[13]

3. Empirical analysis[14]

The wage data used in this study are described in Appendix B. The wage data are from official wage statistics by Statistics Sweden. Data from two different wage surveys are used to construct the wage series. A description of how the wage series are constructed is provided in the Appendix. Appendix B also contains statistics for the labour market coverage of the wage data, a summary of the wage statistics and a comparison between three measurements of wage increases in Sweden. Two of the measurements in the comparison are used to construct the wage series in this study.

The estimation period is 1980:1–2002:2. Graphs of the wage series in levels, first and second differences are provided in Appendix C. The wage series in levels exhibit smooth trending behaviour over the whole sample period but with a change in the slope in the beginning of the 1990's. Consistent with this the series in first differences seem to fluctuate with a higher mean value up to around

[12] A proxy for the sectoral labour market situation is the membership open unemployment rate, i.e. the number of openly unemployed members of a certain union eligible for benefits from the unemployment insurance funds in relation to the total number of members in this union. Data for the membership open unemployment rate are available at the National Labour Market Board. The sectoral labour market situation is however not taken into account in the empirical analysis in the study here.

[13] In the analysis by the Mediation Authority there was however a tendency against higher negotiated wage outcomes in the end of 2001's bargaining round. This could according to the Mediation Authority have had to do with that these agreements concerned industries which have historically had a small degree of local wage formation or no local wage formation at all. See National Mediation Office (2002).

[14] The software packages Structural VAR–version 0.16-1 and PcGive–version 10.0 have been used in the empirical section. The Structural VAR package has been programmed by Anders Warne and it can be downloaded at http://texlips.hypermart.net/warne/code.html.

1991–93 and a lower value thereafter.[15] In the empirical analysis the wage series in first differences are interpreted as stationary series with mean shifts, which means that the nominal wage levels are interpreted as $I(1)$ with broken linear trends.

Some hypothesises that will be tested in this Section is if the aggregate private sector, the manufacturing industry, construction, the financial sector, and the wholesale and retail trade are wage leaders in relation to the central government sector and the municipalities and county councils sector. Another hypothesis is if one of the private sub-sectors is wage leader in relation to the other private sub-sectors. This will also be tested. Therefore the following vectors are set up:

(5.1) $$X'_{1t} = \left[w_t^P \quad w_t^{CG} \quad w_t^{MC} \right]',$$

(5.2) $$X'_{2t} = \left[w_t^M \quad w_t^{CG} \quad w_t^{MC} \right]',$$

(5.3) $$X'_{3t} = \left[w_t^C \quad w_t^{CG} \quad w_t^{MC} \right]',$$

(5.4) $$X'_{4t} = \left[w_t^W \quad w_t^{CG} \quad w_t^{MC} \right]',$$

(5.5) $$X'_{5t} = \left[w_t^F \quad w_t^{CG} \quad w_t^{MC} \right]',$$

(5.6) $$X'_{6t} = \left[w_t^M \quad w_t^C \quad w_t^W \quad w_t^F \right]',$$

where w_t^P, w_t^M, w_t^C, w_t^W, w_t^F, w_t^{CG} and w_t^{MC} are the log nominal wages in the private sector; manufacturing; construction; wholesale and retail trade; finance; the central government sector; and the municipalities and county councils sector, respectively. The set up with vectors including three or four variables instead of a set up with one vector including all (six) wage variables is performed to avoid over-parameterisation when estimating the models.

The following type of vector error correction (VEC) model is set up for each of the vectors (5.1)–(5.6):

[15] The slowdown in wage growth rates could have to do with the fall in labour demand, the Rehnberg agreement during the period 1991-1992 and the adoption of an inflation target in 1993.

(6.1)–(6.6) $$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha\beta' X_{t-1} + \mu + \Phi_0 D_t + \Phi_1 Ds_t + \varepsilon_t \ ,$$

where Δ is the first difference operator, X_t is a $(p \times 1)$ vector containing the p number of log nominal wage series,[16] sub-index k is the lag-length of the unrestricted VAR model, sub-index t denotes the point of time, μ is a $(p \times 1)$ vector of constants, D_t is a $(p \times 1)$ vector of seasonal dummy variables, Ds_t is a $(p \times 1)$ vector of mean-shift dummy variables[17], Γ_j are $(p \times p)$ short-run parameter matrices, $\alpha\beta'$ is a $(p \times p)$ long-run parameter matrix and ε_t is a $(p \times 1)$ vector of random disturbances assumed to be Gaussian errors with zero mean and a covariance matrix Σ, i.e. $\varepsilon_t \sim iid[0, \Sigma]$. In the long-run part of the model α represents the speed of adjustment to long-run equilibrium, while $\beta' X_{t-1}$ are the r number of cointegration relations.

The rest of the empirical section is organized as follows: In Section 3.1 the VEC models are specified on basis of residual and cointegration test results. In Section 3.2 the wage adaptability between sectors are tested by imposing restrictions on the estimated β–matrices in the VEC models. Finally, in Section 3.3 Granger causality tests for wage leadership are carried out.

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[16] $p = 3$ in models (6.1)–(6.5) and $p = 4$ in model (6.6).

[17] The mean-shift dummy Ds_t (= 1 for 1993:1, …., 2002:2, 0 otherwise) is assumed to capture both the change in the wage negotiation procedure and the change in monetary policy. At this time the Swedish Employer Organisation (*SAF*) abandoned the central negotiations. This meant a shift from three levels to two levels in the wage bargaining. Thus from this point of time wages were only negotiated at the intermediate central level and the local level. In November 1992 the Swedish Krona started to float and in January 1993 the Riksbank announced an inflation target. It is reasonable to believe that the change in monetary police led to a structural change in the wage formation due to changes of the labour market organisations' inflation expectations. The Ploberger-Krämer-Kontrus test for structural stability suggests short-run parameter instability in around 1992–93 but short-run parameter stability thereafter. For more information about the test, see Ploberger, Krämer and Kontrus (1989).

3.1. Model specification: Lag order determination and test of the cointegration rank

The model specification procedure starts with by determining the lag-order of the VEC models. The lag-order is determined from information criteria and on basis of the properties of the residuals (i.e. if the residuals are serially uncorrelated and if they are approximately normally distributed). The multivariate information criteria used for the lag order determination are the Akaike information criterion, the Schwarz criterion and the Hannan-Quinn criterion.[18] The properties of the residuals are tested by a multivariate version of the serial correlation likelihood ratio test and the Shenton-Bowman/Doornik-Hansen test for normality.[19]

The test results for the lag-order determination are presented in Tables D1-D3 in Appendix D. Due to lack of space the test results for the VEC model (6.1) are discussed in this Section. When determining the lag-order it is important to consider not only that the residuals should have white noise properties but also that the models should not be over-parameterised. The lag-order determination starts by analysing the information criteria. The multivariate information criteria suggest lag-order 6 for the VEC models.

Most important when deciding the lag-length is the properties of the residuals. In the likelihood ratio tests of autocorrelation of order 1, denoted LR (1) in Tables D1-D3, the null hypothesis of serially uncorrelated residuals cannot be rejected in any of the VEC models with r = 1, 2, and k = 2, …, 6. In the likelihood ratio tests of autocorrelation of order 4, denoted LR (4) in Tables D1-D3, the null hypothesis of serially uncorrelated residuals can be rejected at the ten per cent at lag-order 4 for the VEC models with r = 1, 2. In the normality tests the test statistics are lowest at lag-length 6 for the VEC models with r = 1, 2. On the basis of the residual behaviour and the risk of over-parameterisation, lag-order 4 is chosen for the VEC model (6.1) with r = 1, 2. On the same

[18] See Akaike (1969), Schwarz (1978), and Hannan and Quinn (1979).

[19] The test for normality is a multivariate version of the univariate Shenton-Bowman test, see Shenton and Bowman (1977), and Doornik and Hansen (1994).

considerations lag-order 4 is chosen for the VEC models (6.2)–(6.5) with $r = 1, 2$, and for the VEC model (6.6) with $r = 1–3$.

The next step is to determine the cointegrating rank (r) of the estimated long-run parameter matrices $\alpha\beta'$ in models (6.1)–(6.6). If $\alpha\beta'$ has reduced rank, i.e. in the models with three variables (6.1)–(6.5) $r = 1$ or 2, and in the model with four variables (6.6) $r = 1$, 2 or 3, then the estimated equations (6.1)–(6.6) are interpretable as vector error correction models.

Tests results for cointegration rank are provided in Table 3.1. The test is a likelihood ratio test, namely the trace test, derived in Johansen (1988, 1991).

Table 3.1. Cointegration rank test results

Null hypothesis	*(6.1)* $X'_{1t} = [w_t^P \; w_t^{CG} \; w_t^{MC}]'$ Trace	Eigenvalue	*(6.2)* $X'_{2t} = [w_t^M \; w_t^{CG} \; w_t^{MC}]'$ Trace	Eigenvalue	*(6.3)* $X'_{3t} = [w_t^C \; w_t^{CG} \; w_t^{MC}]'$ Trace	Eigenvalue
$r = 0$	30.41	0.1883	29.18	0.1935	26.04	0.2015
$r \leq 1$	12.47	0.1316	10.69	0.1019	6.69	0.0745
$r \leq 2$	0.33	0.0038	1.45	0.0167	0.04	0.0004

Null hypothesis	*(6.4)* $X'_{4t} = [w_t^W \; w_t^{CG} \; w_t^{MC}]'$ Trace	Eigenvalue	*(6.5)* $X'_{5t} = [w_t^F \; w_t^{CG} \; w_t^{MC}]'$ Trace	Eigenvalue	*(6.6)* $X'_{6t} = [w_t^M \; w_t^C \; w_t^W \; w_t^F]'$ Trace	Eigenvalue
$r = 0$	34.00	0.2143	38.18	0.2594	77.38	0.3781
$r \leq 1$	13.26	0.1425	12.35	0.1337	36.53	0.2730
$r \leq 2$	0.05	0.0005	0.01	0.0001	9.12	0.0890
$r \leq 3$					1.10	0.0127

Note: Critical values at the 90 (95) per cent quantile are for the four variable model: $r = 0$: 43.95 (47.21), $r \leq 1$: 26.79 (29.68), $r \leq 2$: 13.33 (15.41) and $r \leq 3$: 2.69 (3.76), and for the three variable models: $r = 0$: 26.79 (29.68), $r \leq 1$: 13.33 (15.41), $r \leq 2$: 2.69 (3.76). The critical values are from Osterwald-Lenum (1992).

When interpreting the trace test results it can be advisable to consider how many cointegration relations (r) and common driving trends $(p-r)$[20] that can be expected from theory. The prior economic hypothesis $(r = 2, p - r = 1)$ for models

[20] This follows the Stock and Watson approach, where the focus is on testing for the number of common driving trends (s) instead of the number of cointegrating relations (r). The relation between these statistical concepts can be written $s = p - r$, where p is the number of variables in the models. See Stock and Watson (1988).

(6.1)–(6.5) and $\left(r=3, p-r=1\right)$ for model (6.6) could be interpreted as to be consistent with the long-run relations stated in the Scandinavian model. Consider for example model 6.1. From theory two cointegration relations can be expected in the model, namely the long-run relations $w^P = w^{CG}$ and $w^P = w^{MC}$. Two cointegration relations mean that one common driving trend is present in the model. The common driving trend in the model can be interpreted as the sum of world market prices and the aggregate private sector productivity, which drives the nominal wage- and price-setting in the economy. Finding one common driving trend in model (6.1) can, therefore, be interpreted to be consistent with the theory.

In the trace test the null hypothesis of no cointegration relation is rejected at the five or ten per cent level for all models except model (6.3). The null hypothesis of at most one cointegration relation is rejected at the five per cent level for model (6.6). The trace test suggests two cointegration relations in model (6.6), one cointegration relation in models (6.1), (6.2), (6.4) and (6.5), and no cointegration relation in model (6.3).

However, in the trace test the null hypothesis of at most one cointegration relation is close to be rejected at the ten per cent level for several of the models (6.1)–(6.5) and the null hypothesis of at most two cointegration relations is relatively close to be rejected in model (6.6). For this reason it can also be useful to use additional information when determining the cointegration rank. Additional information can for instance be the size of the eigenvalue roots of the matrices $\alpha\beta'$, the size of the t-values of the α-coefficients and the graphs of the possible cointegration relations of the VEC models with the $r^{th}+1$ vector included.

Table E1, Table E2 and Figure E1 in Appendix E provide the size of the seven largest eigenvalue roots, the t-values of the α-coefficients and graphs of the possible cointegration relations of the VEC models (6.1)–(6.5) with $r=3$ and of the VEC model (6.6) with $r=4$, respectively. Due to lack of space only the results of VEC model (6.1) with $r=3$ are discussed in this Section. The eigenvalue root 0.86 could be interpreted as not being a unit root which then does support one common driving trend and two cointegrating relations in the VEC model.

Furthermore, if the t-values of the α-coefficients are small, then one would not gain a lot by including the $r^{th}+1$ vector as a cointegration relation in the model. The highest t-value in each column of the α-matrix of VEC model (6.1) with $r=3$ is 3.0, 3.1 respectively 0.5. The size of the t-values supports two cointegrating relations in the VEC model. Finally, the graphs of the potentially cointegrating relations can be used as additional information to the trace test. The graphs are provided in Appendix E. Two of the graphs show mean-reverting behaviour, while the third shows some evidence of drift. The additional information indicates that there should be two cointegrating relations in VEC model (6.1). On basis of the prior economic hypothesis, the trace test results and the additional information $r=2$ is chosen for each of models (6.1)−(6.5) and $r=3$ is chosen for model (6.6).

3.2. Testing restrictions on the beta-matrices: Wage adaptability between sectors

The Scandinavian model states that wages in the exposed and sheltered sectors should be related one-to-one in the long-run, i.e. full wage adaptability between the sectors in the long-run. Whether the sector wages are one-to-one long-run related can be tested by imposing linear restrictions on the estimated β-matrices in the VEC models.

The test procedure for models (6.1)−(6.5) is the following: Firstly, restrictions are imposed on both cointegration relations in each of the models. Secondly, restrictions are imposed on just one of the cointegration relations and the remaining one is left unrestricted in each of the models. The test procedure for model (6.6) is the following: Firstly, restrictions are imposed on all three cointegration relations. Secondly, restrictions are imposed on two of the cointegration relations and the remaining one is left unrestricted. Thirdly, restrictions are imposed on just one of the cointegration relations and the remaining ones are left unrestricted.

Table 3.3 provides the null hypothesis, the imposed restrictions on the estimated β-matrices and the likelihood ratio test results. The test results are interpreted in the following way: If a null hypothesis of one or several one-to-one long-run relations between wages in different sectors can be rejected at the ten per cent level it is interpreted as low wage adaptability between the present sectors. Otherwise the wage adaptability is interpreted as high. This means that the wage adaptability is considered as high between manufacturing and the two public sectors; construction and the two public sectors; wholesale and retail trade and the central government sector; and between manufacturing, construction and the wholesale and retail trade. The results could be a result of the bargaining system in Sweden. Several of the unions in these sectors belong to the Swedish Trade Union Confederation (*LO*). The wage setting in the sectors have been centralised to a large part. Furthermore, in the intermediate central negotiations *LO* has provided recommendations for wage demands to the member unions. The recommendations have to a large extent been adopted by the member unions.

The test results of models (6.1) and (6.5) indicate low wage adaptability between the aggregate private sector and the public sectors; and between the financial sector and the two public sectors. The finding that the wage adaptability between the financial sector and the public sectors is low could be a main factor behind the low wage adaptability between the aggregate private sector and the two public sectors, i.e. an aggregation problem in the data.

The test results of model (6.6) with two of the cointegration relations restricted indicate low wage adaptability between the financial sector and the other private sub-sectors. One possible explanation for the low wage adaptability between the financial sector and the other private sub-sectors is that the composition of the financial sector workforce has differed from the composition of the workforce in the others sectors. The share of white-collar workers in the financial sector was during the period 1993–2001 around 80 per cent, while it was 20–40 per cent in the other private sub-sectors.[21] However, the test results of model (6.6) with just one cointegration relation restricted indicate large wage adaptability between the financial sector and construction; and between the

[21] Data for the number of employees in each worker category is not available at Statistics Sweden for the two public sectors. Data for the number of employees in each worker category is not available at Statistics Sweden before 1993 for the financial sector. See Table B1.2 in Appendix B.

financial sector and the wholesale and retail trade. This contradictory result is hard to explain.

Table 3.3. Linear restrictions on the estimated β-matrices

Null hypothesis	*Restriction*	*LR-statistic*	*p-value*
(6.1) Private sector, central government, municipalities and county councils $X'_{1t} = \left[w_t^P \quad w_t^{CG} \quad w_t^{MC} \right]'$			
$w_t^{CG} = w_t^P$ and $w_t^{MC} = w_t^P$	$\hat{\beta}' = \begin{bmatrix} 1 & -1 & 0 \\ 1 & 0 & -1 \end{bmatrix}'$	8.09	0.018
$w_t^{CG} = w_t^P$	$\hat{\beta}' = \begin{bmatrix} 1 & -1 & 0 \\ \beta_{21} & \beta_{22} & \beta_{23} \end{bmatrix}'$	4.03	0.045
$w_t^{MC} = w_t^P$	$\hat{\beta}' = \begin{bmatrix} 1 & 0 & -1 \\ \beta_{21} & \beta_{22} & \beta_{23} \end{bmatrix}'$	8.09	0.004
(6.2) Manufacturing, central government, municipalities and county councils			
$X'_{2t} = \left[w_t^M \quad w_t^{CG} \quad w_t^{MC} \right]'$			
$w_t^{CG} = w_t^M$ and $w_t^{MC} = w_t^M$	As above.	3.22	0.200
$w_t^{CG} = w_t^M$	As above.	0.34	0.558
$w_t^{MC} = w_t^M$	As above.	2.12	0.145
(6.3) Construction, central government, municipalities and county councils $X'_{3t} = \left[w_t^C \quad w_t^{CG} \quad w_t^{MC} \right]'$			
$w_t^{CG} = w_t^C$ and $w_t^{MC} = w_t^C$	As above.	2.10	0.350
$w_t^{CG} = w_t^C$	As above.	1.81	0.178
$w_t^{MC} = w_t^C$	As above.	2.09	0.148
(6.4) Wholesale and retail trade, central government, municipalities and county councils			
$X'_{4t} = \left[w_t^W \quad w_t^{CG} \quad w_t^{MC} \right]'$			
$w_t^{CG} = w_t^W$ and $w_t^{MC} = w_t^W$	As above.	11.71	0.003
$w_t^{CG} = w_t^W$	As above.	1.87	0.171
$w_t^{MC} = w_t^W$	As above.	8.04	0.005
(6.5) Finance, central government, and municipalities and county councils $X'_{5t} = \left[w_t^F \quad w_t^{CG} \quad w_t^{MC} \right]'$			
$w_t^{CG} = w_t^F$ and $w_t^{MC} = w_t^F$	As above.	13.95	0.001
$w_t^{CG} = w_t^F$	As above.	11.08	0.001
$w_t^{MC} = w_t^F$	As above.	12.28	0.001

Table 3.3 continued

Null hypothesis	*Restriction*	*LR-statistic*	*p-value*
(6.6) Manufacturing, construction, wholesale and retail trade, and finance $X'_{6t} = \left[w_t^M \quad w_t^C \quad w_t^W \quad w_t^F \right]'$			
$w_t^C = w_t^M$, $w_t^W = w_t^M$, $w_t^F = w_t^M$, $w_t^C = w_t^W$, $w_t^C = w_t^F$ and $w_t^W = w_t^F$	$\hat{\beta}' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}'$	18.84	0.000
$w_t^C = w_t^M$, $w_t^W = w_t^M$ and $w_t^C = w_t^W$	$\hat{\beta}' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & -1 & 0 \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	2.17	0.338
$w_t^C = w_t^M$, $w_t^F = w_t^M$ and $w_t^C = w_t^F$	$\hat{\beta}' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & 0 & 0 & -1 \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	17.37	0.000
$w_t^C = w_t^W$, $w_t^C = w_t^F$ and $w_t^W = w_t^F$	$\hat{\beta}' = \begin{bmatrix} 0 & 1 & -1 & 0 \\ 0 & 1 & 0 & -1 \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	9.00	0.011
$w_t^C = w_t^M$	$\hat{\beta}' = \begin{bmatrix} 1 & -1 & 0 & 0 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	2.15	0.143
$w_t^W = w_t^M$	$\hat{\beta}' = \begin{bmatrix} 1 & 0 & -1 & 0 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	2.11	0.146
$w_t^F = w_t^M$	$\hat{\beta}' = \begin{bmatrix} 1 & 0 & 0 & -1 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	5.72	0.017
$w_t^W = w_t^C$	$\hat{\beta}' = \begin{bmatrix} 0 & 1 & -1 & 0 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	1.96	0.161
$w_t^F = w_t^C$	$\hat{\beta}' = \begin{bmatrix} 0 & 1 & 0 & -1 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	0.03	0.869
$w_t^F = w_t^W$	$\hat{\beta}' = \begin{bmatrix} 0 & 0 & 1 & -1 \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \end{bmatrix}'$	0.93	0.334

3.3. Testing for Granger causality: Sector wage leadership

The Scandinavian model states that the wage setting in the exposed sectors should lead the wage setting in the sheltered sectors. Possible wage leadership can be tested by the use of Granger causality tests. Wage leadership can be tested within the theoretical framework by restricting the cointegration relations in the VEC models (6.1)–(6.6) to one-to-one long-run relations. Based on the test results in Section 3.2 the following one-to-one long-run relations are imposed when subsequently testing for Granger causality: $w_t^{CG} = w_t^M$ and $w_t^{MC} = w_t^M$ on model (6.2); $w_t^{CG} = w_t^C$ and $w_t^{MC} = w_t^C$ on model (6.3); $w_t^{CG} = w_t^W$ on model (6.4); and $w_t^C = w_t^M$, $w_t^W = w_t^M$ and $w_t^C = w_t^W$ on model (6.6). No restrictions are imposed on models (6.1) and (6.5).[22]

Granger causality due to the definition provided in Granger (1969) can be tested within a vector error correction model. For instance the VEC model (6.1), with $k = 4$ and $r = 2$, has the following short run parameter matrices (Γ_j) and the long-run parameter matrix $(\alpha\beta')$:

$$(7) \qquad \Gamma_j = \begin{bmatrix} \Gamma_{j,11} & \Gamma_{j,12} & \Gamma_{j,13} \\ \Gamma_{j,21} & \Gamma_{j,22} & \Gamma_{j,23} \\ \Gamma_{j,31} & \Gamma_{j,32} & \Gamma_{j,33} \end{bmatrix} \text{ and } \alpha\beta' = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \end{bmatrix},$$

where sub-index j is the lag-length of the VEC model. Testing Granger causality in this VEC model means that the following restrictions will be tested (and the corresponding null hypothesis within squared parentheses):

$$\Gamma_{1,12} = \Gamma_{2,12} = \Gamma_{3,12} = \alpha_{11}\beta_{12} = \alpha_{12}\beta_{22} = 0 \quad \left[w^{CG} \textit{ does not Granger} - \textit{cause } w^P\right]$$

$$\Gamma_{1,13} = \Gamma_{2,13} = \Gamma_{3,13} = \alpha_{11}\beta_{13} = \alpha_{12}\beta_{33} = 0 \quad \left[w^{MC} \textit{ does not Granger} - \textit{cause } w^P\right]$$

$$\Gamma_{1,21} = \Gamma_{2,21} = \Gamma_{3,21} = \alpha_{21}\beta_{11} = \alpha_{22}\beta_{21} = 0 \quad \left[w^{P} \textit{ does not Granger} - \textit{cause } w^{CG}\right]$$

[22] The ten per cent level is used to determine whether or not one or several one-to-one restrictions should be imposed on the long-run relations in the VEC models.

$$\Gamma_{1,23} = \Gamma_{2,23} = \Gamma_{3,23} = \alpha_{21}\beta_{13} = \alpha_{22}\beta_{33} = 0 \quad \left[w^{MC} \textit{ does not Granger} - \textit{cause } w^{CG}\right]$$

$$\Gamma_{1,31} = \Gamma_{2,31} = \Gamma_{3,31} = \alpha_{31}\beta_{11} = \alpha_{32}\beta_{21} = 0 \quad \left[w^{P} \textit{ does not Granger} - \textit{cause } w^{MC}\right]$$

$$\Gamma_{1,32} = \Gamma_{2,32} = \Gamma_{3,32} = \alpha_{31}\beta_{12} = \alpha_{32}\beta_{22} = 0 \quad \left[w^{CG} \textit{ does not Granger} - \textit{cause } w^{MC}\right]$$

The results of the Granger causality tests are provided in Table 3.4.

Table 3.4. Granger causality

Null Hypothesis	*Wald (p-value)*	*Null Hypothesis*	*Wald (p-value)*
(6.1) Private sector, central government, municipalities and county councils $X'_{1t} = \left[w_t^P \quad w_t^{CG} \quad w_t^{MC}\right]'$			
$w_t^P \xrightarrow{non} w_t^{CG}$	33.73 (0.00)	$w_t^{CG} \xrightarrow{non} w_t^{MC}$	4.97 (0.29)
$w_t^P \xrightarrow{non} w_t^{MC}$	8.02 (0.09)	$w_t^{MC} \xrightarrow{non} w_t^{P}$	4.64 (0.33)
$w_t^{CG} \xrightarrow{non} w_t^{P}$	8.95 (0.06)	$w_t^{MC} \xrightarrow{non} w_t^{CG}$	22.82 (0.00)
(6.2) Manufacturing, central government, municipalities and county councils $X'_{2t} = \left[w_t^M \quad w_t^{CG} \quad w_t^{MC}\right]'$			
$w_t^M \xrightarrow{non} w_t^{CG}$	16.00 (0.00)	$w_t^{CG} \xrightarrow{non} w_t^{MC}$	9.24 (0.06)
$w_t^M \xrightarrow{non} w_t^{MC}$	2.71 (0.61)	$w_t^{MC} \xrightarrow{non} w_t^{M}$	3.57 (0.47)
$w_t^{CG} \xrightarrow{non} w_t^{M}$	11.59 (0.02)	$w_t^{MC} \xrightarrow{non} w_t^{CG}$	10.92 (0.03)
(6.3) Construction, central government, municipalities and county councils $X'_{3t} = \left[w_t^C \quad w_t^{CG} \quad w_t^{MC}\right]'$			
$w_t^C \xrightarrow{non} w_t^{CG}$	25.80 (0.00)	$w_t^{CG} \xrightarrow{non} w_t^{MC}$	15.99 (0.00)
$w_t^C \xrightarrow{non} w_t^{MC}$	11.13 (0.03)	$w_t^{MC} \xrightarrow{non} w_t^{C}$	2.03 (0.73)
$w_t^{CG} \xrightarrow{non} w_t^{C}$	5.75 (0.22)	$w_t^{MC} \xrightarrow{non} w_t^{CG}$	12.43 (0.01)
(6.4) Wholesale and retail trade, central government, municipalities and county councils $X'_{4t} = \left[w_t^W \quad w_t^{CG} \quad w_t^{MC}\right]'$			
$w_t^W \xrightarrow{non} w_t^{CG}$	26.34 (0.00)	$w_t^{CG} \xrightarrow{non} w_t^{MC}$	12.88 (0.01)
$w_t^W \xrightarrow{non} w_t^{MC}$	14.12 (0.01)	$w_t^{MC} \xrightarrow{non} w_t^{W}$	2.08 (0.72)
$w_t^{CG} \xrightarrow{non} w_t^{W}$	5.95 (0.20)	$w_t^{MC} \xrightarrow{non} w_t^{CG}$	20.11 (0.00)
(6.5) Finance, central government, municipalities and county councils $X'_{5t} = \left[w_t^F \quad w_t^{CG} \quad w_t^{MC}\right]'$			
$w_t^F \xrightarrow{non} w_t^{CG}$	4.91 (0.30)	$w_t^{CG} \xrightarrow{non} w_t^{MC}$	13.24 (0.01)
$w_t^F \xrightarrow{non} w_t^{MC}$	3.66 (0.45)	$w_t^{MC} \xrightarrow{non} w_t^{F}$	4.82 (0.31)
$w_t^{CG} \xrightarrow{non} w_t^{F}$	33.57 (0.00)	$w_t^{MC} \xrightarrow{non} w_t^{CG}$	8.76 (0.07)

Note: The null hypothesis $x \xrightarrow{non} y$ denotes that variable *x* is Granger non-causal for variable *y*.

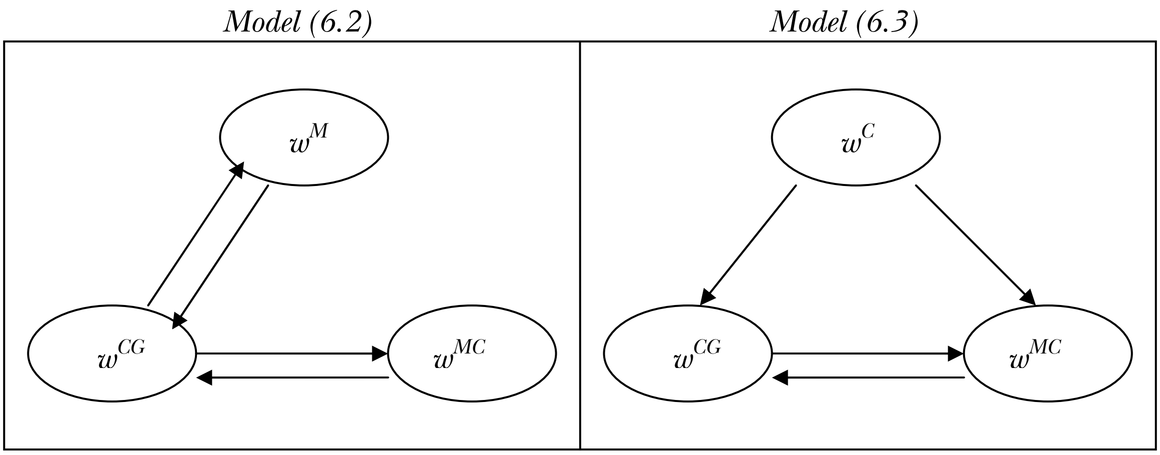
Table 3.4 continued

Null hypothesis	Wald (p-value)	Null hypothesis	Wald (p-value)
(6.6) Manufacturing, construction, wholesale and retail trade, finance $X'_{6t} = \left[w_t^M \quad w_t^C \quad w_t^W \quad w_t^F \right]'$			
$w_t^M \xrightarrow{non} w_t^C$	4.63 (0.33)	$w_t^W \xrightarrow{non} w_t^M$	12.22 (0.02)
$w_t^M \xrightarrow{non} w_t^W$	42.76 (0.00)	$w_t^W \xrightarrow{non} w_t^C$	2.50 (0.64)
$w_t^M \xrightarrow{non} w_t^F$	21.23 (0.00)	$w_t^W \xrightarrow{non} w_t^F$	8.60 (0.07)
$w_t^C \xrightarrow{non} w_t^M$	16.43 (0.00)	$w_t^F \xrightarrow{non} w_t^M$	7.49 (0.11)
$w_t^C \xrightarrow{non} w_t^W$	17.40 (0.00)	$w_t^F \xrightarrow{non} w_t^C$	4.83 (0.31)
$w_t^C \xrightarrow{non} w_t^F$	3.76 (0.44)	$w_t^F \xrightarrow{non} w_t^W$	11.90 (0.02)

Note: The null hypothesis $x \xrightarrow{non} y$ denotes that variable x is Granger non-causal for variable y.

Since the one-to-one long-run relation stated by the Scandinavian model holds for models (6.2)–(6.4) and (6.6), the Granger causality results for these models are most interesting from a theoretical point-of-view. Simplified schemes of the Granger causality test results for the restricted VEC models (6.2) and (6.3) are provided in Figure 3.1.

Figure 3.1. Intersectoral wage linkages due to the results of the Granger causality tests in the restricted VEC models (6.2) and (6.3)



The Granger causality test results for model (6.2) show that manufacturing wages only Granger-cause the central government sector wages, not the municipalities and county councils sector wages. Central government sector wages however also Granger-cause manufacturing wages. So there is no wage leadership for the manufacturing sector. Wages in the central government sector and the municipalities and county councils sector Granger-cause each other in model (6.2). This means that there is no wage leadership for any of the public sectors. So the Granger causality tests for model (6.2) support a causality structure that contradicts the long-run relation (2b) of the Scandinavian model.

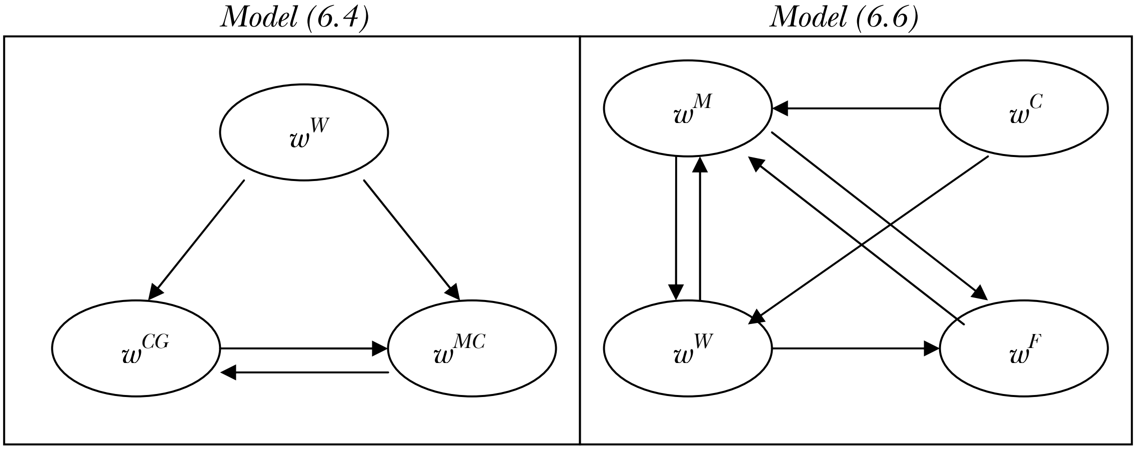
The test results of model (6.2) can to some extent[23] be compared to the Tägtström´s (2000) results. Like the results in Tägtström manufacturing has a wage leading role in relation to the central government sector. However, no wage leading role for manufacturing in relation to the municipalities and county councils sector is found in the study here. Furthermore, in the study here central government sector wages and the municipalities and county councils sector wages Granger-cause each other, and central government sector wages Granger-cause manufacturing wages. This is not the case in Tägtström´s study.

The Granger test results for model (6.3) indicate that construction is a wage leader to the two public sectors. This result could be in line with the Scandinavian model if construction is an exposed sector and the two public sectors are sheltered sectors. But the test results also indicate that wages in the central government sector and the municipalities and county councils sector Granger-cause each other. If both public sectors are sheltered sectors then the causality structure contradicts the long-run relation (2b) of the Scandinavian model. The causality structure between the two public sectors means also that the wage leading role for construction cannot be interpreted to be in line with the assumptions of the Scandinavian model.

Simplified schemes of the Granger causality test results for the restricted VEC models (6.4) and (6.6) are provided in Figure 3.2.

[23] In Tägtström "non-manufacturing" private sector wages are also incorporated in the model.

Figure 3.2. Intersectoral wage linkages due to the results of the Granger causality tests in the restricted VEC models (6.4) and (6.6)



The same conclusions drawn from the Granger causality tests for model (6.3) can be drawn for model (6.4). For model (6.6) the interest from a theoretical point-of-view is the Granger causality test results for wages in manufacturing, construction and wholesale and retail trade (due to the acceptance of the one-to-one long-run wage relations between these sectors). According to the test results construction has a wage leading role in relation to manufacturing and the wholesale and retail trade. According to the assumptions of the Scandinavian model this implies that construction ought to be exposed to international competition to a higher extent than the two other private sub-sectors. The test results also indicate that wages in manufacturing and the wholesale and retail trade Granger-cause each other.

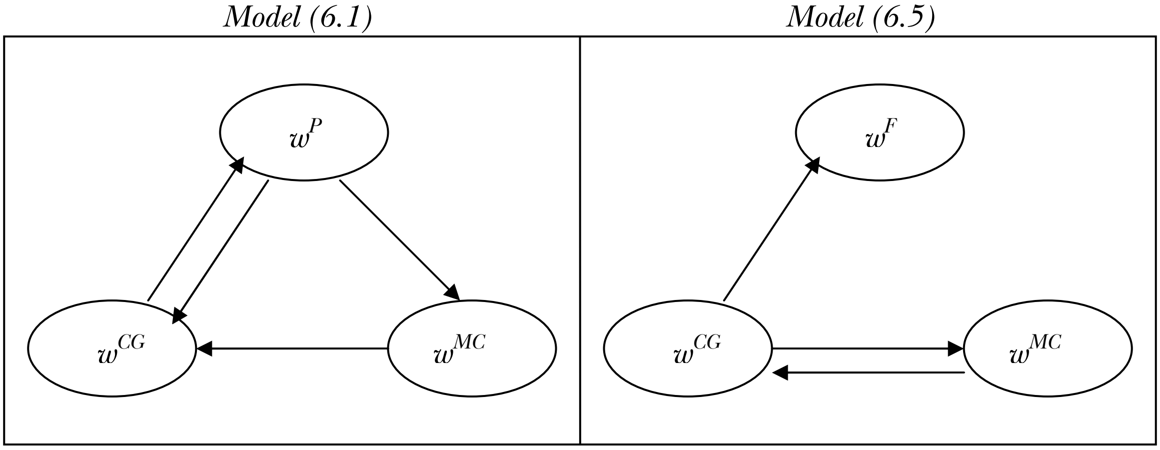
The Granger causality test results for models (6.2) and (6.6) indicate that manufacturing is not a wage leader in relation to any of the other sectors and that the sector is a wage follower in relation to construction. *A priori* one would expect manufacturing to be a wage leader in relation to the other sectors for the present sample period. The reason is that employees and employer organisations in sub-sectors to the manufacturing sector has been the first ones to conclude wage agreements in five of six intermediate central bargaining rounds during the sample period (see Table A1 in Appendix A).[24]

[24] For instance, in 2001's bargaining round some of the wage agreements of importance for the sectors in the study here was the following (arranged due to the signing dates): blue-collar workers in the chemical industry (16 January), blue-collar workers in the engineering industry (8 February), blue-collar workers in the wholesale and retail trade (6 April), employees in hotels and restaurants (22

The Granger causality test results for models (6.3) and (6.6) indicate that construction is a wage leader in relation to manufacturing, wholesale and retail trade and the public sectors. One explanation for this could be that the construction industry has a type of wage system, including for instance piece wages that are frequently renegotiated (in about every 10th week), that could make construction wage setting more influential to wage setting in the other sectors.

Simplified schemes of the Granger causality test results for the unrestricted VEC models (6.1) and (6.5) are provided in Figure 3.3.

Figure 3.3. Intersectoral wage linkages due to the results of the Granger causality tests in the unrestricted VEC models (6.1) and (6.5)



The Granger causality test results for model (6.1) can be compared to the results of Holmlund and Ohlsson (1992), and Jacobson and Ohlsson (1994). All three studies find that the aggregate private sector has a wage leading role in relation to the central government sector and the municipalities and county councils sector, and that municipalities and county councils sector wages Granger-cause central government sector wages. The test results of this study and the study by Holmlund and Ohlsson also indicate that central government sector wages Granger-cause aggregate private sector wages.

Finally, the Granger causality test results for model (6.5) indicate that central government wages Granger-cause financial sector wages. This is a

April), blue-collar workers in construction (24 April), employees in the central government sector (24 April), blue-collar workers in the municipalities and county councils sector (23 April, 11 May), and white-collar workers in banks and other financial institutions (2 November). For more information, see National Mediation Office (2002, 2003).

surprising result in relation to the likelihood ratio test results of the restricted β-matrices, which indicated low wage adaptability between the financial sector and the central government sector.

4. Summary and conclusions

In this study possible wage linkages between different sectors of the Swedish economy are investigated. The Scandinavian model of inflation is used as a theoretical background. The model states that the wage setting in the sectors exposed to international competition should influence the wage setting in the sheltered sectors. Six different models with sectoral wage data are set up to test for this.

In the empirical analysis a multivariate cointegration approach is used, which means that vector error correction models are estimated. The main purpose of the empirical analysis is to test for two central assumptions in the Scandinavian model of inflation. The first assumption is the one-to-one long-run wage relation between the exposed and sheltered sectors of the economy. To test for this restrictions are imposed on the long-run relations (β-matrices) in the VEC models. If the one-to-one long-run relations are supported by the tests these will be imposed in the estimated VEC models. The second assumption is a wage leadership for the exposed sectors of the economy. To test for this Granger causality tests are performed in the VEC models. By performing Granger causality tests in the VEC models with imposed one-to-one long-run relations it is possible to test for wage leadership in line with the theoretical framework.

The one-to-one long-run relations between sector wages are supported for the wage relations between manufacturing, construction, wholesale and retail trade and the two public sectors. These test results are in line with the assumptions of the Scandinavian model. But the test results could also be a result of the bargaining system in Sweden. Several of the trade unions in these sectors are members to the Swedish Trade Union Confederation (*LO*). The support for the one-to-one long-run relations could be the results of policies of wage equalization by *LO*. The test results also indicate low wage adaptability between the financial sector and manufacturing, and between the financial sector and the two public sectors.

The Granger causality tests provide strong evidence of the existence of intersectoral wage causality, but no clear evidence of a wage leading role in line with the assumptions of the Scandinavian model for any of the sectors. One possible explanation is a time-varying sector wage leadership during the sample period. A hypothesis in this case is that sectors with periods of excess demand for labour are wage leaders during such periods. If this is the case one should analyse shorter sub-samples with monthly data instead. A problem with such an empirical approach is the lack of data.

In future research it would be interesting to study wage linkages not only between sectors but also between white-collar workers and blue-collar workers in different sectors. The reason for this is that it is possible that wage linkages are stronger within these worker categories than between them. It would also be interesting to study only how negotiated wages (maybe including negotiated social contributions) for different worker categories and sectors affect each other. The reason for this is that it is possible that wage linkages are stronger for negotiated wages than for the wage drift. The problem with the above suggested empirical expansions is the lack of data.

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Appendix A: A summary of wage agreements in Sweden 1980–2003

Table A1. Wage agreements and wage outcomes in Sweden 1980–2003

Agreement period	*Negotiation level/characteristics etc.*	ΔW^{n} *	ΔW *	Δw *
1980	One-year central agreement.	7.8	9.5	-4.4
1981-82	Two-year central agreement.	5.5	7.7	-3.1
1983	One-year central agreement. The central agreement did not encompass the Metal Workers Union (*Svenska Metallindustriarbetareförbundet*) and the Association of Swedish Engineering Industries (*Verkstadsföreningen*).	4.6	6.5	-2.5
1984	One-year intermediate central agreements. The Metal Workers Union and the Employers´ Association of Swedish Mine Owners (*Järnbruksförbundet, Gruvornas Arbetsgivareförbund*) are the first to reach an agreement.	5.6	7.9	-0.2
1985	One-year central agreement.	4.1	7.5	0.0
1986-87	Two-year central agreement.	4.8	7.5	3.3
1988	One-year intermediate central agreements. The Industrial Workers' Union (*Svenska Fabriksarbetareförbundet*) and the Swedish Employer Organisations General Industrial Group (*Svenska Arbetsgivareföreningens Allmänna Industrigrupp*) are the first to reach an agreement.	4.2	6.5	0.4
1989	Two-year central agreement. Central agreement did not encompass the engineering industry.	6.2	9.8	1.3
1991-92	The Rehnberg (two-year) agreement. The Rehnberg group, included Bertil Rehnberg and former chief negotiators from *SAF, LO, TCO* and *SACO*, delivered a proposal for a stabilisation agreement. Almost all of the social partners concluded stabilisation agreements with little or no divergence from the proposal.	2.7	4.7	-1.4
1993-94	Two-year intermediate central agreements. The union for employees in the wholesale & retail trade (*Handels*) and the employer organisations in the wholesale & retail trade (*HAO-förbunden*) are the first to reach an agreement. Inflation targeting central bank.	1.2	3.0	-0.6
1995-97	Three-year intermediate central agreements. The Swedish Paper Workers Union (*Pappers*) and the Swedish Forest Industries Federation (*Sveriges Skogsindustriförbund*) are the first to reach an agreement. Inflation targeting central bank.	3.4	4.7	3.2
1998-2000	Three-year intermediate central agreements. Negotiations in the manufacturing industry took place under the jurisdiction of the Industrial agreement (*Industrins Samarbetsavtal*). The Metal Workers Union (*Metall*) and the Association of Swedish Engineering Industries (*Verkstadsföreningen*) are the first to reach an agreement. Inflation targeting central bank.	2.6	3.5	2.8
2001-03	Three-year intermediate central agreements. The industrial agreement plus other "negotiation order agreements" (*förhandlingsordningsavtal*). New legislation about mediation and the authority National Mediation Office was introduced (in 2000). The Industrial Workers' Union (*Industrifacket*) and the Almega Industrial and Chemical Association (*Almega Industri och Kemi*) are the first to reach an agreement. Inflation targeting central bank.	2.5**	4.3**	1.6**

Note: The first labour market organisations to reach agreements in the intermediate central bargaining rounds in the table concerns blue-collar workers. Blue-collar worker unions have usually concluded agreements before white-collar workers unions in the intermediate central bargaining rounds. The white-collar workers unions that were the first to conclude agreements belong mainly also to the manufacturing industry. The exception is in 1993 when white-collar workers in the wholesale and retail trade were the first to conclude an agreement among the white-collar workers unions. More information about the bargaining rounds in Sweden are given in for instance Elvander, Nils (1988), *Den Svenska modellen. Löneförförhandlingar och inkomstpolitik 1982-1986 (The Swedish model. Wage bargaining and income policy 1982-1986)*, Allmänna Förlaget, Stockholm, and Elvander, Nils and Holmlund, Bertil (1997), *The Swedish Bargaining System in the Melting Pot. Institutions, Norms and Outcomes in the 1990's*, Arbetslivsinstitutet, Solna.

*) ΔW^{n} = negotiated wage increase, ΔW = nominal wage increase and Δw = real wage increase. The statistics concerns the average wage increases (annual percentage changes) for the total economy and for the agreement period.
**) The wage increases concerns only 2001. The agreements in 2001 were mainly concluded for a three year period.
Sources: Confederation of Swedish Enterprise, National Institute of Economic Research, Statistics Sweden and Sveriges riksbank.

Appendix B: The data

B1. The construction of the wage series, the labour market coverage and a summary of the statistics

In this study annual data from the statistics of wage structure (*Strukturlönestatistiken*) and quarterly data from the short term wage statistics (*Konjunkturlönestatistiken*) are used to construct the wage series.[25] The annual data have been transformed to quarterly data by the use of the following inputs: the size of central/intermediate central negotiated wages, the dates of the wage revisions, estimations of the size and the periodicity of retroactive wage payments, and assumptions on the size and the periodicity of the wage drift. The data transformed into quarterly data is called "the processed data from statistics of wage structure" (*bearbetad partsstatistik, bearbetad Strukturlönestatistik*).[26] This data set is used for the period 1980:1–1992:4 (see Table B1.1). For the period 1993:1–2002:2 (1992:1–2002:2 for the central government sector and the municipalities and county councils sector) the official short term wage statistics are used.

The wage series are processed in the following way: The average hourly earnings for blue-collar workers are multiplied by 165 to achieve average monthly earnings. The average monthly wage series for blue-collar and white-collar workers are weighted by

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[25] The wage data from statistics of wage structure and the short term wage statistics are both obtained from sample surveys concerning the private sector and total surveys concerning the public sector. The survey population in the statistics of wage structure is individuals while it is work places, firms, institutions etc. in the short term wage statistics. The average monthly wage series in the short term wage statistics are obtained from the total wage sum (for full time monthly wages) divided by the number of full time employees at each work place. The average hourly wage series for blue-collar workers in the private sector are obtained from the total wage sum divided by the numbers of hours worked at each work place. For more information about the wage concepts, surveys etc., see for instance statistical reports AM 17, AM 38, AM 49 and the statistical yearbook of salaries and wages from Statistics Sweden.

[26] National Institute of Economic Research (1990, 1995) provides more information about the data set with the processed data from the statistics of wage structure. Part of the data set was produced during the work with the reports SOU 1988:35 and SOU 1990:63 by 1987's wage committee. Thereafter the data set has been updated until the production of the official short term statistics started in 1993. See National Institute of Economic Research (1990), "Att mäta löneutvecklingen" ("To measure wage development") in *Konjunkturläget – Specialstudier, Maj 1990 (The Swedish Economy – Occasional Studies, May 1990)*, pp. 27-55; National Institute of Economic Research (1995), "Lönestatistik – En jämförande studie" ("Wage statistics – A comparative study") in *Konjunkturläget – Specialstudier, Maj 1995 (The Swedish Economy– Occasional Studies, May 1995)*, pp. 51-68; SOU (1988:35), *Offentlig lönestatistik – Behov och produktionsformer, Delbetänkande från 1987 års lönekommitté (Public wage statistics – The needs and the way of production)*, Stockholm; and SOU (1990:63), Svensk Lönestatistik, Betänkande från 1987 års lönekommitté (Swedish wage statistics – Report from the 1987's Wage Committe), Stockholm.

the number of employees in each job category. This concerns the wage series for manufacturing etc. (C+D+E); construction (F); wholesale and retail trade etc. (G+H); and finance etc. (J+K).

Table B1.1. The original data series. Sources, periods and sectors.

Variable	*Source/Period*	*Sectors (SNI-code)*
Wages – Original series		
Average monthly wage (w-c workers).	Processed data from statistics of wage structure (*bearbetad partsstatistik, bearbetad Strukturlönestatistik*), Statistics Sweden /1980:1–1993:4.	Mining, quarrying and manufacturing, electricity, gas and water supply (C+D+E). Construction (F). Wholesale and retail trade (G). Banking industry (J 65). Insurance companies (J 66). Central government sector. Municipalities & county councils sector.
Average monthly wage (b-c workers).	As above.	As above.
Average monthly earnings including commissions etc. (w-c workers).	Short term wage statistics (*Konjunkturlönestatistiken*), Statistics Sweden/1992:1–2002:2 and 1993:1–2002:2.	Mining, quarrying and manufacturing, electricity, gas and water supply (C+D+E). Construction (F). Wholesale and retail trade, hotels and restaurants (G+H). Finance, insurance, real estate and business services (J+K). Central government sector. County councils. Municipalities.
Average hourly earnings including overtime pay (b-c workers).	As above.	As above.
Weights		
Number of employed blue-collar/white-collar workers.	Labour market statistics, Statistics Sweden/1980–2001, 1993–2001.	Mining, quarrying and manufacturing, electricity, gas and water supply (C+D+E). Construction (F). Wholesale and retail trade, hotels and restaurants (G+H). Financing, insurance, real estate and business services (J+K).
Number of employees.	The business register, Statistics Sweden/1980–1993.	Banks and other financial institutions (65). Insurance companies (66).
Number of employees.	Labour market statistics, Statistics Sweden/1992–2001.	County councils. Municipalities.

The average monthly wage series for the banking industry, insurance companies, municipalities and county councils are weighted by the number of employees in each sector. The weighted average monthly wage series for the banking industry (J 65) and for insurance companies (J 66) during the period 1980:1–1992:4 is used as a proxy for the average monthly wage series in the financial sector etc. (J+K).[27] Furthermore, the weighted average monthly wage series in the wholesale and retail trade (G) during the

[27] According to the labour market statistics and the business register from Statistics Sweden the employees in banks and insurance companies represented in 1993 about 38 per cent of the total employment in the sector J+K.

period 1980:1–1992:4 is used as a proxy for the average monthly wage series in the wholesale and retail trade, hotels and restaurants (G+H).[28] The construction of the wage data set means that all employees in the public sector and almost 80 per cent of the employees in the private sector are covered (see table B1.2).[29]

Table B1.2. Sectoral employment in Sweden, 1982, 1993 and 2001. Per cent of total employment

Sector	*1982*	*1993*	*2001*
Manufacturing etc. (C+D+E)	28.0	21.5	19.8
Blue-collar workers	19.4	13.7	12.0
White-collar workers	8.6	7.8	7.8
Construction (F)	5.6	4.5	5.2
Blue-collar workers	4.3	3.5	3.8
White-collar workers	1.2	1.0	1.4
Wholesale and retail trade (G)	8.8	11.0	11.8
Blue-collar workers	4.6	6.6	6.2
White-collar workers	4.1	4.4	5.6
Wholesale and retail trade; hotels and restaurants (G+H)	9.3	13.1	14.4
Blue-collar workers	5.0	8.5	8.4
White-collar workers	4.2	4.6	6.0
Finance, insurance etc. (J+K)	n.a.	7.0	13.3
Banking industry (J 65).	1.5	1.9	1.6
Insurance companies (J 66)	1.2	0.8	0.5
Blue-collar workers (J+K)	n.a.	1.5	2.5
White-collar workers (J+K)	n.a.	5.4	10.8
Other private sectors*	n.a.	8.2	14.0**
Private sector	46.9	54.3	66.7
Blue-collar workers	30.9	30.4	31.5
White-collar workers	16.0	23.9	35.3
Central government sector	21.4	10.1	5.9
Municipalities and county councils sector	31.6	35.6	27.4
Municipalities	17.5***	25.6***	21.2
County councils	13.6	10.0	6.2
Public sector	53.1	45.7	33.3

Note: The total employment levels according to labour market statistics are only available back to 1982. n.a. = observation is not available. *) The other private sectors are agriculture, hunting, forestry and fishing (A+B), transport, storage and communication (I); and education, healthcare, and social and personal services (M+N+O). **) Including the Church of Sweden (from 2000), privatized hospitals and the state railway company (from 2001). ***) Including the Church of Sweden.
Sources: Computations based on the labour market statistics and the business register, Statistics Sweden.

Table B1.3 shows a summary of means and standard deviations for the wage series. The financial sector has the highest average monthly wages, while the municipalities

[28] According to the labour market statistics from Statistics Sweden the employees in the wholesale and retail trade represented in 1992 about 87 per cent of the total employment in the sector G+H.
[29] The data set do not contain average monthly wage series for the private sectors agriculture, hunting, forestry and fishing (A+B); transport, storage and communication (I); and education, healthcare, and social and personal services (M+N+O).

and county councils sector has the lowest average monthly wages during the period 1980:1–2002:2. The standard deviation (divided by the mean value) of wages during the period is highest in the finance sector while it is lowest in the municipalities and county councils sector.

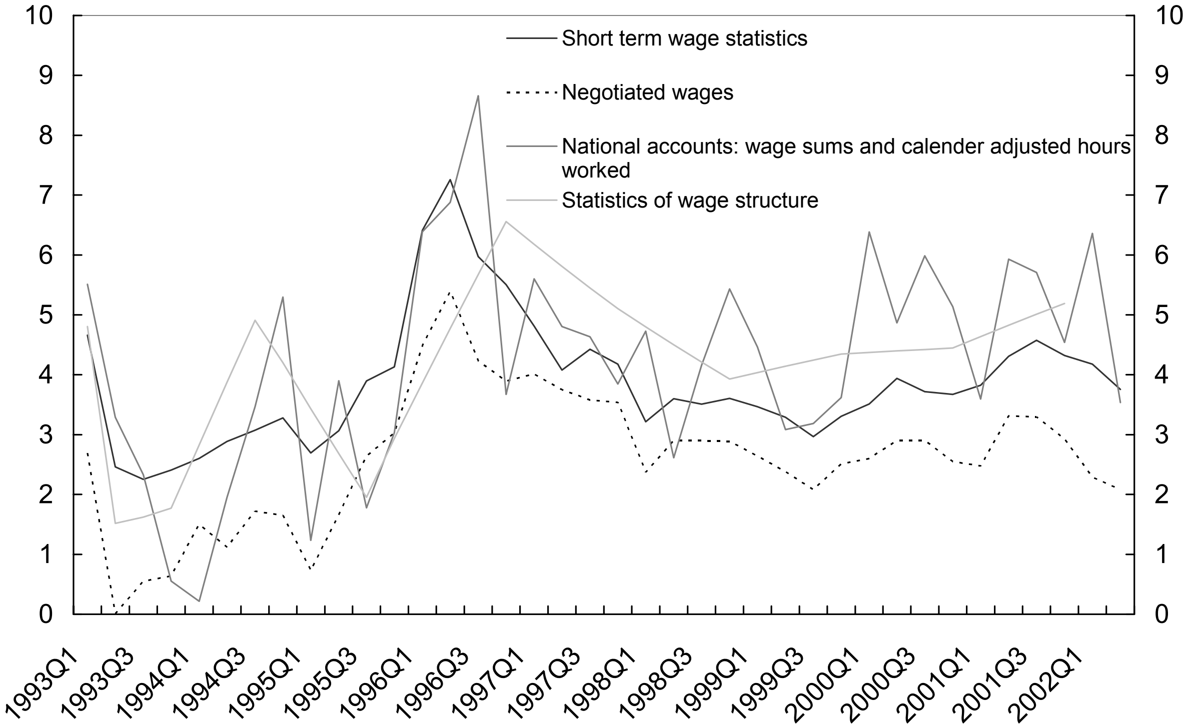
Table B1.3. Monthly wages 1980:1–2002:2

Variable	*Mean*	*Std. dev.*
Private sector	13858.9	4895.0
Manufacturing etc.	13950.6	5005.8
Construction	13430.1	4804.2
Wholesale and retail trade etc.	12857.3	4344.8
Finance, insurance etc.	15382.5	5811.0
Central government sector	14482.2	5145.2
Municipalities and county councils sector	12144.6	4014.3

B2. Three measurements of wage increases in the Swedish economy

It is of concern to know that different statistical measurements of nominal wages incorporate different wage components. Figure B2.1 shows some measurements of wage increases in the Swedish economy, namely the nominal wage development according to (*i*) short term wage statistics, (*ii*) statistics of wage structure and (*iii*) wage sums divided by (calendar adjusted) number of hours worked according to the national accounts statistics. The figure also shows a series for the development of negotiated wages.

Figure B2.1. Three measurements of actual nominal wage increases and one of negotiated wages increases in the Sweden



Annual percentage change

Note: Short term wage statistics: The series is weighted with wage sums for private sector blue-collar workers, private sector white-collar workers, central government sector, county councils and municipalities.

Statistics of wage structure: The annual series is transformed into a quarterly series by linear interpolation. The data observation in the fourth quarter each year is the annual data observation. The reason for this is that in the survey wages are measured for most of the sectors/industries/type of workers during the period September–November each year.

Negotiated wages: Intermediate centrally negotiated wages are weighted by the number of full-time employees in each sector/industry/type of worker.

Sources: National Institute of Economic Research, National Mediation Office, Statistics Sweden and the Riksbank.

In the short term wage statistics and the statistics of wage structure different types of commissions and overtime pay are included in the wage measure. The statistics of wage structure also includes wage bonuses and different types of fringe benefits. The wage sum statistics includes all the wage components mentioned above plus components such as sickness wages and severance payments.[30]

[30] Using sickness payments as a component in the wage sum statistics means that the wage series become dependent on political decisions concerning the sickness benefit system. For instance, in 1992 the sickness benefit system was reformed in Sweden. The employers had to pay a sickness wage during the first two weeks of an employees´ sickness period. Other examples are the introduction of a day of qualifying for sickness wage/benefit in 1993, the reduction of the compensation level (from 90 to 75 per cent) in the sickness wage/benefit system in 1996 and the temporarily extension of the sickness wage period (to four weeks) for employers in 1997. A comparison between wage development according to the short term wage statistics and wage development according to the national accounts

The wage development series obtained from the national account statistics and statistics of wage structure are in figure B2.1 sometimes below the series for negotiated wage increases. This is fairly reasonable for wage statistics concerning the total economy.[31] One explanation for this is that the wage sums and the wages from the statistics of wage structure are not adjusted for retroactive wage payments.[32] The short term wage statistics are continuously adjusted for retroactive wage payments. During a rolling 12 months revision period the preliminary wage outcomes are adjusted for retroactive wage payments before the outcomes become definitive. This is probably also the reason why the series is so highly correlated with the series for the development of negotiated wages.

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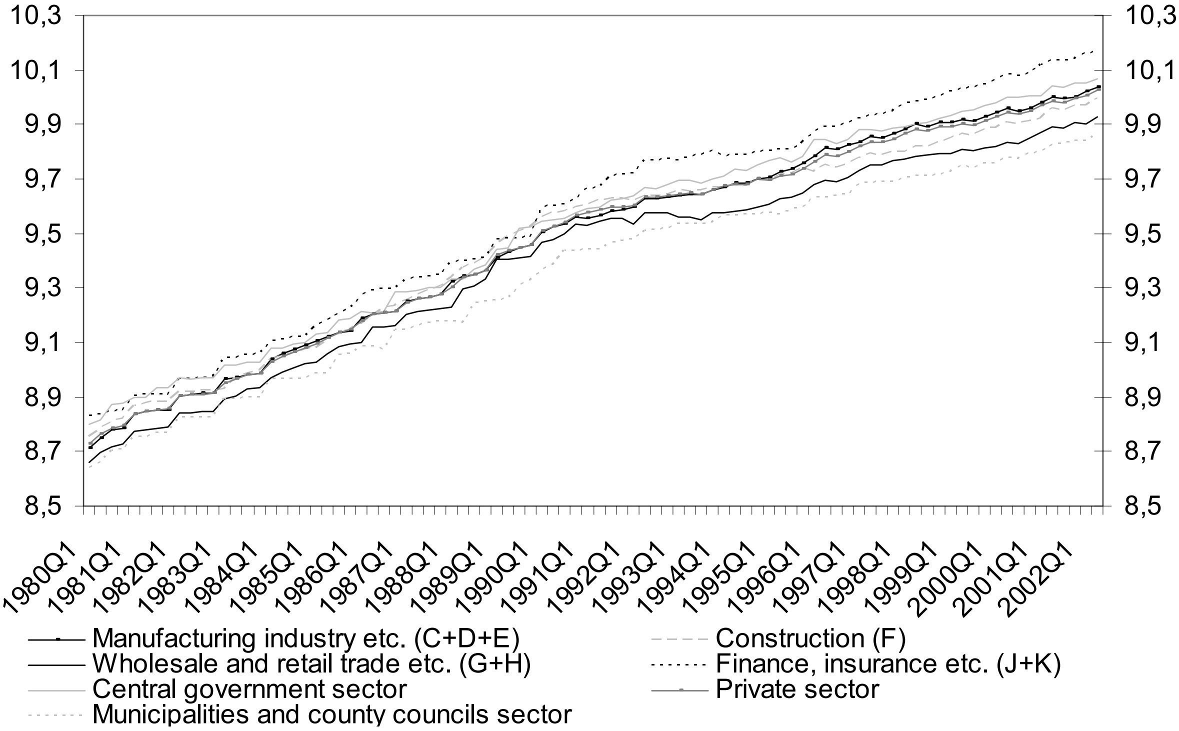
wage sums and hours worked statistics (with among others adjustments for reformations in the sickness wage/benefit system) can be found in National Institute of Economic Research (2000), ”Samhällsekonomiska förutsättningar för lönebildningen i Sverige” (”The economic conditions for wage formation in Sweden”) in *KI dokument nr 5 Oktober 2000 (NIER document No. 5 October 2000).*

[31] However, the actual wage outcome level has in some industries sometimes been below the negotiated wage level. For example, a survey by the Hotel and Restaurant Worker's Union (*Hotell och Restaurang Facket*) shows that between 1998 and 1999 the actual wage outcome for members of their union, the Commercial Employees Union (*Handelsanställdas Förbund*) and the Municipal Workers' Union were below the negotiated wage level. For instance, according to the union in the hotel and restaurant sector the turnover in personnel was extremely high in this sector during this period. This resulted in a negative "structural" wage drift as new recruits have often been given a lower wage than those who have left their posts. See Friberg, Kent and Uddén. Sonnegård, Eva (2001), "Changed wage formation in a changing world?", *Sveriges Riksbank Economic Review*, 2001:1, pp. 42-69.

[32] A retroactive wage payment is a payment for a period without an existing wage agreement. During a period without a new wage agreement the old wage agreement is valid. When a new agreement is concluded the difference between the new and old negotiated nominal wage levels is paid to the employees. Such a payment is called a retroactive wage payment.

Appendix C: Graphs of the log nominal wage series

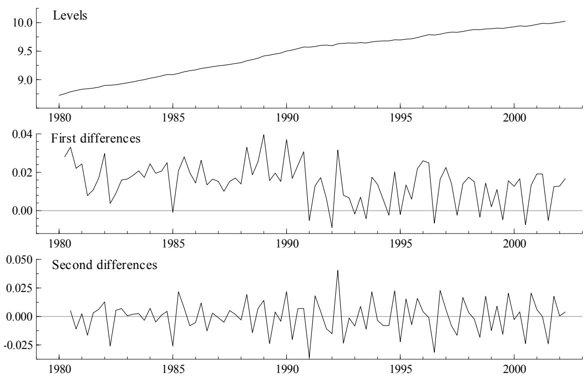
Figure C1. Nominal wages in different sectors of the Swedish economy



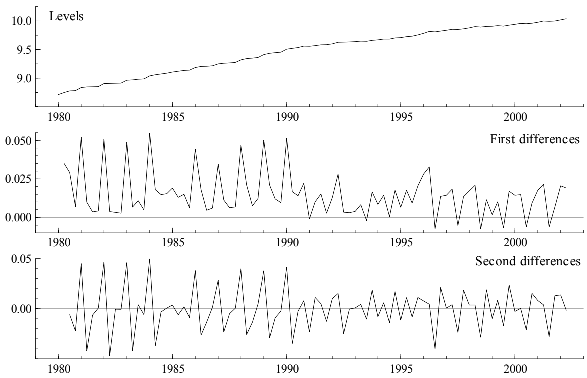
Log levels
Sources: Statistics Sweden and Sveriges riksbank.

Figure C2. Log nominal wages in levels, first differences and second differences for

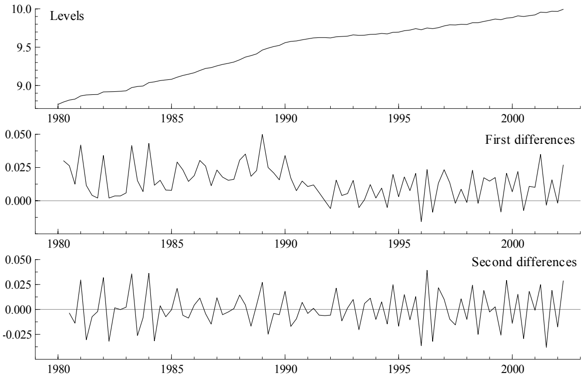
(a) private sector



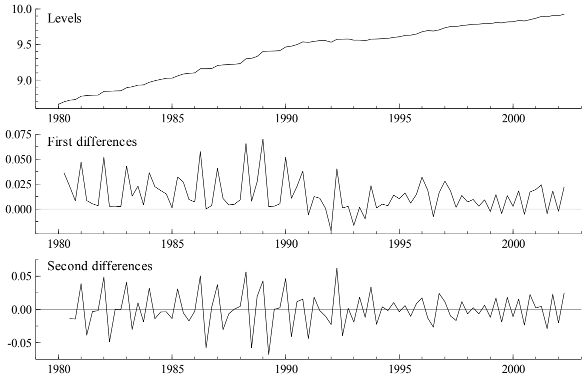
(b) manufacturing etc.



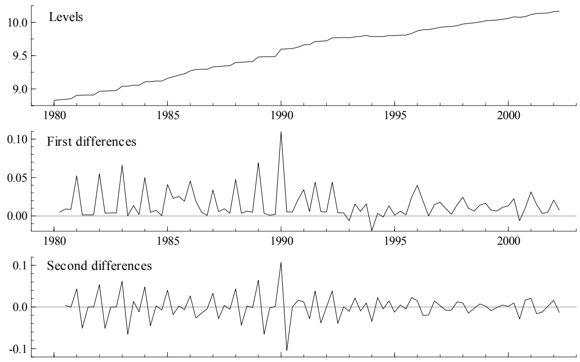
(c) construction



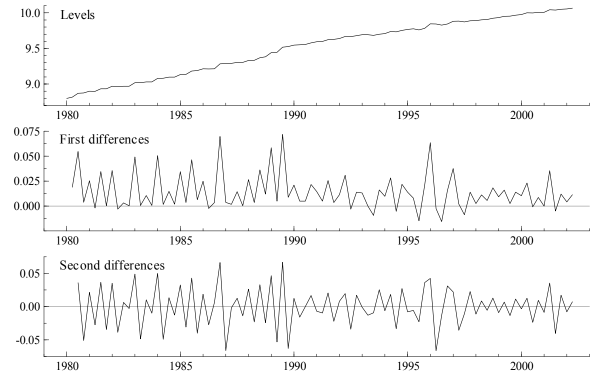
(d) wholesale and retail trade etc.



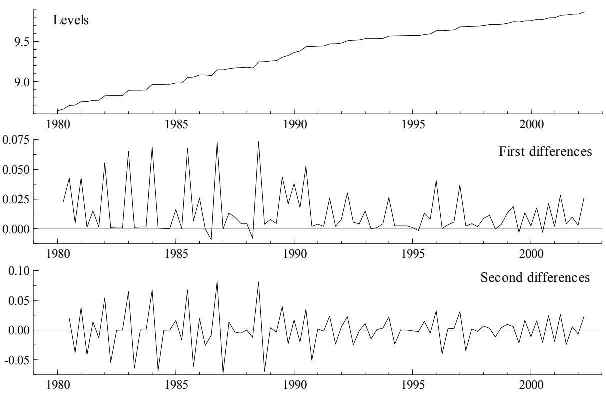
(e) financial sector etc.



(f) central government sector



(g) municipalities and county councils sector



Appendix D: Tables of lag order determination test results

Table D1. Lag order determination tests results (multivariate), VEC ($r = 1$)

Model *Number of lags*	*Serial correlation test LR (1) (p-value)*	*Serial correlation test LR (4) (p-value)*	*Normality test (p-value)*	*Akaike criterion*	*Schwarz criterion*	*Hannan-Quinn criterion*
(6.1) $X'_{1t} = \left[w_t^P \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	0.42 (1.00)	19.51 (0.02)	20.15 (0.00)	-21.62	-15.03	-18.96
$k = 3$	1.02 (1.00)	16.75 (0.05)	16.90 (0.01)	-22.07	-15.78	-19.54
$k = 4$	1.20 (1.00)	13.84 (0.13)	14.22 (0.03)	-22.47	-16.47	-20.05
$k = 5$	0.52 (1.00)	5.13 (0.82)	13.00 (0.04)	-22.88	-17.19	-20.59
$k = 6$	0.41 (1.00)	3.74 (0.93)	10.46 (0.11)	-23.32	-17.94	-21.16
(6.2) $X'_{2t} = \left[w_t^M \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	1.96 (0.99)	17.87 (0.03)	32.19 (0.00)	-21.32	-14.73	-18.66
$k = 3$	1.99 (0.99)	15.38 (0.08)	38.01 (0.00)	-21.87	-15.58	-19.34
$k = 4$	1.00 (1.00)	13.31 (0.15)	23.67 (0.00)	-22.28	-16.28	-19.86
$k = 5$	0.68 (1.00)	3.47 (0.94)	24.78 (0.00)	-22.68	-16.99	-20.40
$k = 6$	0.97 (1.00)	2.89 (0.97)	24.47 (0.00)	-23.05	-17.67	-20.89
(6.3) $X'_{3t} = \left[w_t^C \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	1.92 (0.99)	8.74 (0.46)	29.81 (0.00)	-21.10	-14.52	-18.45
$k = 3$	1.70 (1.00)	5.97 (0.74)	25.19 (0.00)	-21.67	-15.38	-19.14
$k = 4$	0.21 (1.00)	9.28 (0.41)	15.48 (0.02)	-22.09	-16.10	-19.68
$k = 5$	0.24 (1.00)	8.45 (0.49)	15.02 (0.02)	-22.40	-16.71	-20.11
$k = 6$	0.44 (1.00)	8.82 (0.45)	17.03 (0.01)	-22.70	-17.31	-20.53
(6.4) $X'_{4t} = \left[w_t^W \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	0.11 (1.00)	10.55 (0.31)	26.83 (0.00)	-20.57	-13.98	-17.91
$k = 3$	2.97 (0.97)	4.88 (0.84)	33.20 (0.00)	-20.98	-14.69	-18.45
$k = 4$	0.75 (1.00)	6.97 (0.64)	23.91 (0.00)	-21.49	-15.50	-19.08
$k = 5$	0.97 (1.00)	3.00 (0.96)	24.91 (0.00)	-21.85	-16.16	-19.56
$k = 6$	1.82 (0.99)	5.59 (0.78)	24.00 (0.00)	-22.36	-16.97	-20.19
(6.5) $X'_{5t} = \left[w_t^F \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	0.95 (1.00)	17.20 (0.05)	43.34 (0.00)	-20.65	-14.06	-18.00
$k = 3$	2.09 (0.99)	13.46 (0.14)	35.27 (0.00)	-21.16	-14.87	-18.63
$k = 4$	1.42 (1.00)	11.85 (0.22)	33.65 (0.00)	-21.61	-15.62	-19.20
$k = 5$	0.85 (1.00)	7.38 (0.59)	30.99 (0.00)	-22.01	-16.32	-19.72
$k = 6$	0.71 (1.00)	4.73 (0.86)	28.59 (0.00)	-22.32	-16.93	-20.15
(6.6) $X'_{6t} = \left[w_t^M \quad w_t^C \quad w_t^W \quad w_t^F \right]'$						
$k = 2$	2.84 (1.00)	27.06 (0.04)	58.58 (0.00)	-30.35	-21.68	-26.86
$k = 3$	0.93 (1.00)	25.67 (0.06)	58.84 (0.00)	-31.02	-22.86	-27.74
$k = 4$	2.12 (1.00)	18.20 (0.31)	58.15 (0.00)	-31.65	-24.00	-28.57
$k = 5$	3.64 (1.00)	7.23 (0.97)	24.77 (0.00)	-32.59	-25.47	-29.73
$k = 6$	3.14 (1.00)	9.09 (0.91)	25.27 (0.00)	-33.36	-26.76	-30.71

Table D2. Lag order determination test results (multivariate), VEC ($r = 2$)

Model *Number of lags*	*Serial correlation test LR (1) (p-value)*	*Serial correlation test LR (4) (p-value)*	*Normality test (p-value)*	*Akaike criterion*	*Schwarz criterion*	*Hannan-Quinn criterion*
(6.1) $X'_{1t} = \left[w_t^P \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	0.62 (1.00)	15.10 (0.09)	30.05 (0.00)	-21.90	-15.40	-19.28
$k = 3$	1.14 (1.00)	15.50 (0.08)	17.51 (0.01)	-22.32	-16.12	-19.82
$k = 4$	0.51 (1.00)	11.64 (0.23)	13.70 (0.03)	-22.68	-16.77	-20.30
$k = 5$	0.43 (1.00)	4.15 (0.90)	12.80 (0.05)	-23.07	-17.42	-20.82
$k = 6$	0.53 (1.00)	4.24 (0.90)	10.06 (0.12)	-23.53	-18.23	-21.40
(6.2) $X'_{2t} = \left[w_t^M \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	1.48 (1.00)	18.30 (0.03)	34.71 (0.00)	-21.60	-15.09	-18.98
$k = 3$	1.07 (1.00)	16.93 (0.05)	27.06 (0.00)	-22.10	-15.89	-19.60
$k = 4$	0.82 (1.00)	12.50 (0.19)	20.11 (0.00)	-22.45	-16.55	-20.08
$k = 5$	0.68 (1.00)	2.99 (0.96)	20.39 (0.00)	-22.85	-17.25	-20.60
$k = 6$	0.95 (1.00)	2.98 (0.97)	21.61 (0.00)	-23.22	-17.92	-21.09
(6.3) $X'_{3t} = \left[w_t^C \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	1.71 (1.00)	8.54 (0.48)	22.12 (0.00)	-21.28	-14.78	-18.67
$k = 3$	1.58 (1.00)	7.54 (0.58)	18.39 (0.01)	-21.82	-15.61	-19.32
$k = 4$	0.24 (1.00)	10.71 (0.30)	10.95 (0.09)	-22.24	-16.33	-19.86
$k = 5$	0.18 (1.00)	9.14 (0.42)	10.22 (0.12)	-22.54	-16.94	-20.29
$k = 6$	0.54 (1.00)	9.94 (0.36)	8.69 (0.19)	-22.84	-17.55	-20.71
(6.4) $X'_{4t} = \left[w_t^W \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	0.34 (1.00)	7.21 (0.61)	33.93 (0.00)	-20.83	-14.33	-18.21
$k = 3$	1.81 (0.99)	5.27 (0.81)	26.87 (0.00)	-21.23	-15.02	-18.73
$k = 4$	0.90 (1.00)	7.40 (0.60)	22.04 (0.00)	-21.71	-15.81	-19.34
$k = 5$	1.04 (1.00)	3.53 (0.94)	23.01 (0.00)	-22.05	-16.45	-19.80
$k = 6$	1.79 (0.99)	7.42 (0.59)	21.17 (0.00)	-22.58	-17.28	-20.45
(6.5) $X'_{5t} = \left[w_t^F \quad w_t^{CG} \quad w_t^{MC} \right]'$						
$k = 2$	0.56 (1.00)	16.91 (0.05)	43.08 (0.00)	-20.98	-14.47	-18.36
$k = 3$	0.70 (1.00)	12.55 (0.18)	30.68 (0.00)	-21.40	-15.19	-18.90
$k = 4$	1.04 (1.00)	10.29 (0.33)	29.20 (0.00)	-21.83	-15.92	-19.45
$k = 5$	0.71 (1.00)	7.38 (0.60)	27.31 (0.00)	-22.18	-16.58	-19.93
$k = 6$	1.03 (1.00)	5.11 (0.82)	25.52 (0.00)	-22.49	-17.20	-20.36
(6.6) $X'_{6t} = \left[w_t^M \quad w_t^C \quad w_t^W \quad w_t^F \right]'$						
$k = 2$	2.51 (1.00)	26.94 (0.04)	42.60 (0.00)	-30.60	-22.05	-27.16
$k = 3$	1.76 (0.00)	22.17 (0.14)	46.25 (0.00)	-31.29	-23.24	-28.05
$k = 4$	3.03 (1.00)	13.72 (0.62)	30.02 (0.00)	-32.06	-24.53	-29.03
$k = 5$	3.48 (1.00)	8.60 (0.93)	18.21 (0.02)	-32.89	-25.88	-30.07
$k = 6$	2.85 (1.00)	10.16 (0.86)	19.58 (0.01)	-33.63	-27.14	-31.02

Table D3. Lag order determination tests results (multivariate), VEC ($r = 3$)

Model *Number of lags*	*Serial correlation test LR (1) (p-value)*	*Serial correlation test LR (4) (p-value)*	*Normality test (p-value)*	*Akaike criterion*	*Schwarz criterion*	*Hannan-Quinn criterion*
(6.6) $X'_{6t} = \begin{bmatrix} w_t^M & w_t^C & w_t^W & w_t^F \end{bmatrix}'$						
$k = 2$	2.99 (1.00)	29.04 (0.02)	47.19 (0.00)	-30.77	-22.32	-27.37
$k = 3$	1.99 (1.00)	23.41 (0.10)	49.96 (0.00)	-31.47	-23.53	-28.27
$k = 4$	3.10 (1.00)	15.36 (0.50)	29.46 (0.00)	-32.25	-24.83	-29.26
$k = 5$	3.21 (1.00)	9.06 (0.91)	18.16 (0.02)	-33.07	-26.18	-30.30
$k = 6$	3.55 (1.00)	10.60 (0.83)	23.05 (0.00)	-33.81	-27.44	-31.25

Appendix E: Additional information to the trace test

Table E1. The seven largest eigenvalue roots of matrices $\alpha\beta'$ for VEC models (6.1)–(6.5) with $r = 3$ and for VEC model (6.6) with $r = 4$

(6.1) $X_{1t} = \begin{bmatrix} w_t^P \\ w_t^{CG} \\ w_t^{MC} \end{bmatrix}$	*(6.2)* $X_{2t} = \begin{bmatrix} w_t^M \\ w_t^{CG} \\ w_t^{MC} \end{bmatrix}$	*(6.3)* $X_{3t} = \begin{bmatrix} w_t^C \\ w_t^{CG} \\ w_t^{MC} \end{bmatrix}$	*(6.4)* $X_{4t} = \begin{bmatrix} w_t^W \\ w_t^{CG} \\ w_t^{MC} \end{bmatrix}$	*(6.5)* $X_{5t} = \begin{bmatrix} w_t^F \\ w_t^{CG} \\ w_t^{MC} \end{bmatrix}$	*(6.6)* $X_{6t} = \begin{bmatrix} w_t^M \\ w_t^C \\ w_t^W \\ w_t^F \end{bmatrix}$
1.00	0.99	1.00	1.00	1.00	0.99
0.86	0.90	0.87	0.80	0.85	0.89
0.79	0.78	0.82	0.80	0.78	0.88
0.69	0.72	0.77	0.80	0.76	0.88
0.69	0.72	0.77	0.71	0.76	0.79
0.65	0.62	0.73	0.71	0.65	0.69
0.65	0.62	0.73	0.66	0.65	0.69

Table E2. The t-values of the α-coefficients for VEC models (6.1)–(6.5) with $r=3$ and for VEC model (6.6) with $r=4$

(6.1) $X_{1t}' = \begin{bmatrix} w_t^P & w_t^{CG} & w_t^{MC} \end{bmatrix}'$

$$\begin{bmatrix} \underset{(1.3)}{-0.039} & \underset{(0.8)}{-0.056} & \underset{(0.5)}{-0.007} \\ \underset{(0.3)}{0.014} & \underset{(3.1)}{-0.278} & \underset{(0.1)}{-0.002} \\ \underset{(3.0)}{-0.139} & \underset{(2.2)}{-0.225} & \underset{(0.0)}{0.0007} \end{bmatrix}$$

(6.2) $X_{2t}' = \begin{bmatrix} w_t^M & w_t^{CG} & w_t^{MC} \end{bmatrix}'$

$$\begin{bmatrix} \underset{(1.3)}{-0.034} & \underset{(0.2)}{-0.007} & \underset{(1.0)}{-0.017} \\ \underset{(0.4)}{0.016} & \underset{(2.6)}{-0.120} & \underset{(0.4)}{-0.010} \\ \underset{(2.8)}{-0.113} & \underset{(2.0)}{-0.105} & \underset{(0.1)}{-0.002} \end{bmatrix}$$

(6.3) $X_{3t}' = \begin{bmatrix} w_t^C & w_t^{CG} & w_t^{MC} \end{bmatrix}'$

$$\begin{bmatrix} \underset{(0.3)}{-0.007} & \underset{(1.0)}{0.044} & \underset{(0.2)}{-0.001} \\ \underset{(1.2)}{0.041} & \underset{(1.8)}{-0.104} & \underset{(0.1)}{-0.001} \\ \underset{(3.9)}{-0.150} & \underset{(0.4)}{-0.024} & \underset{(0.1)}{-0.0005} \end{bmatrix}$$

(6.4) $X_{4t}' = \begin{bmatrix} w_t^W & w_t^{CG} & w_t^{MC} \end{bmatrix}'$

$$\begin{bmatrix} \underset{(0.9)}{0.066} & \underset{(1.4)}{0.122} & \underset{(0.2)}{-0.003} \\ \underset{(1.7)}{0.108} & \underset{(2.1)}{-0.160} & \underset{(0.1)}{-0.002} \\ \underset{(4.2)}{0.292} & \underset{(0.3)}{-0.028} & \underset{(0.0)}{-0.0006} \end{bmatrix}$$

(6.5) $X_{5t}' = \begin{bmatrix} w_t^F & w_t^{CG} & w_t^{MC} \end{bmatrix}'$

$$\begin{bmatrix} \underset{(4.4)}{-0.218} & \underset{(0.9)}{-0.027} & \underset{(0.0)}{-0.001} \\ \underset{(0.5)}{-0.030} & \underset{(0.3)}{0.011} & \underset{(0.1)}{-0.004} \\ \underset{(2.0)}{-0.119} & \underset{(2.5)}{0.085} & \underset{(0.0)}{-0.002} \end{bmatrix}$$

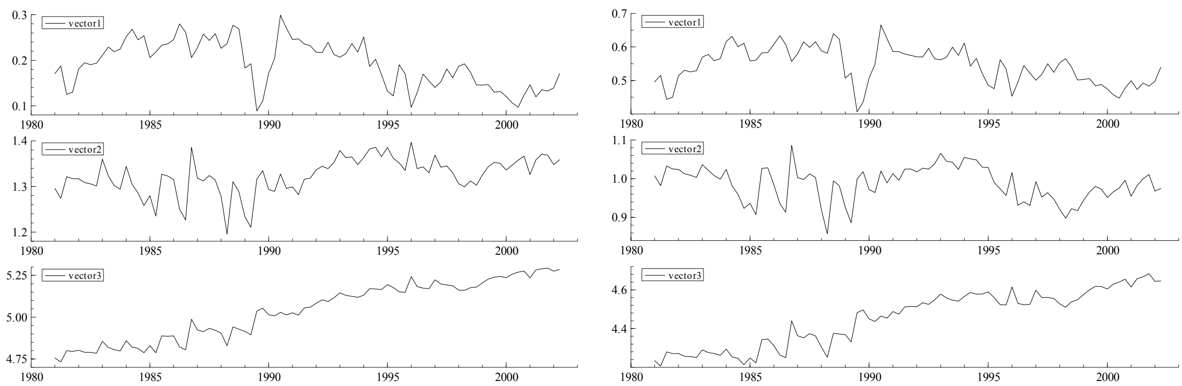
(6.6) $X_{6t}' = \begin{bmatrix} w_t^M & w_t^C & w_t^W & w_t^F \end{bmatrix}'$

$$\begin{bmatrix} \underset{(3.0)}{0.316} & \underset{(0.4)}{0.017} & \underset{(1.0)}{0.018} & \underset{(0.7)}{-0.015} \\ \underset{(1.1)}{0.134} & \underset{(0.7)}{-0.037} & \underset{(1.4)}{-0.028} & \underset{(0.7)}{-0.018} \\ \underset{(5.3)}{0.791} & \underset{(1.0)}{0.062} & \underset{(0.7)}{-0.018} & \underset{(0.4)}{-0.011} \\ \underset{(4.4)}{0.643} & \underset{(2.8)}{-0.168} & \underset{(0.8)}{0.019} & \underset{(0.3)}{-0.008} \end{bmatrix}$$

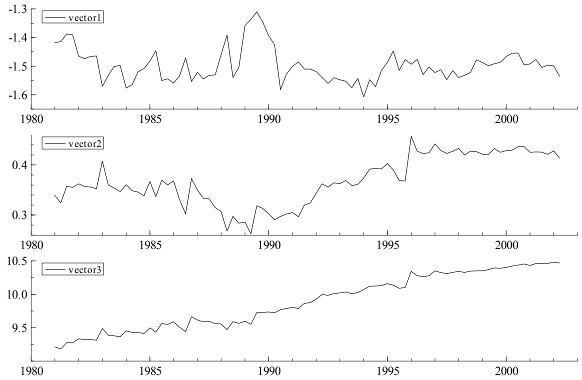
Figure E1. Graphs of possible cointegration relations for VEC models (6.1)–(6.5) with $r=3$ and for VEC model (6.6) with $r=4$

(a) (6.1) $X_{1t}' = \begin{bmatrix} w_t^P & w_t^{CG} & w_t^{MC} \end{bmatrix}'$

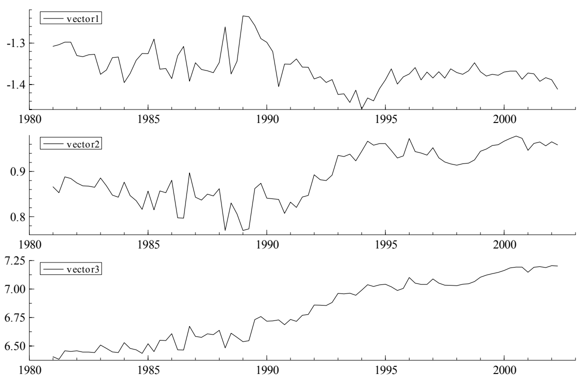
(b) (6.2) $X_{2t}' = \begin{bmatrix} w_t^M & w_t^{CG} & w_t^{MC} \end{bmatrix}'$



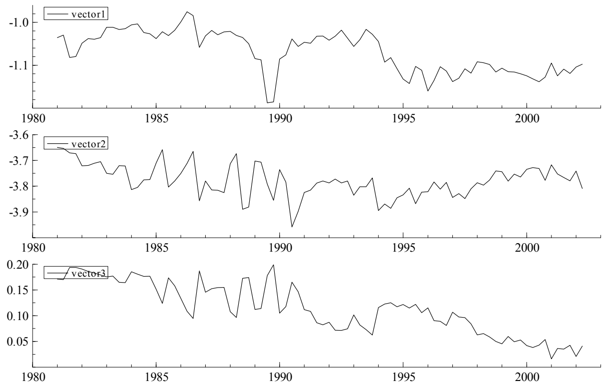
(c) (6.3) $X'_{3t} = \begin{bmatrix} w_t^{C} & w_t^{CG} & w_t^{MC} \end{bmatrix}'$



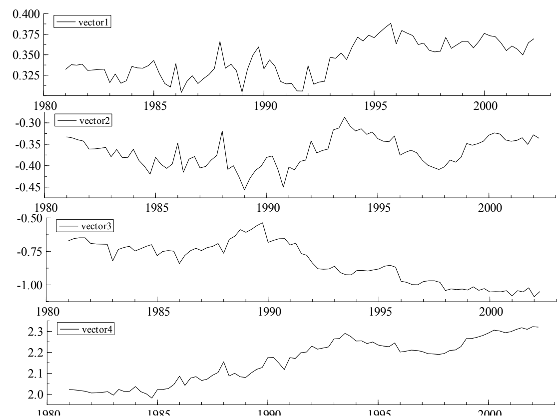
(d) (6.4) $X'_{4t} = \begin{bmatrix} w_t^{W} & w_t^{CG} & w_t^{MC} \end{bmatrix}'$



(e) (6.5) $X'_{5t} = \begin{bmatrix} w_t^{F} & w_t^{CG} & w_t^{MC} \end{bmatrix}'$



(f) (6.6) $X'_{6t} = \begin{bmatrix} w_t^{M} & w_t^{C} & w_t^{W} & w_t^{F} \end{bmatrix}'$



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ISSN 1402-9103 Riksbank Printing Office Stockholm 2003