Regional growth and unemployment. The validity of Okun's law for the Finnish regions

Kangasharju, A.; Tavera, C.; Nijkamp, P.

2011

Faculty of Economics and Business Administration

Regional growth and unemployment. The validity of Okun's law for the Finnish regions

Research Memorandum 2011-6

Aki Kangasharju
Christophe Tavéra
Peter Nijkamp

vrije Universiteit amsterdam

REGIONAL GROWTH AND UNEMPLOYMENT

The Validity of Okun's Law for the Finnish Regions

Aki Kangasharju
VATT
Helsinki
Finland
aki.kangasharju@vatt.fi

Christophe Tavéra
CREM
Rennes
France
christophe.tavera@univ-rennes1.fr

Peter Nijkamp
VU University
Amsterdam
The Netherlands
pnijkamp@feweb.vu.nl

Abstract:

This paper offers a concise critical overview of Okun's Law, with particular attention for its relevance in open economic systems of regions. Based on an extensive set of economic data for Finnish regions, the existence of cointegration is tested by using alternative statistical methods, viz. the residual-based test and the conditional error correction model. A novelty of the paper is to combine a method of hidden cointegrations with a method of removing cross-sectional dependence. After correcting for hidden cointegrations and cross-sectional dependence, both statistical methods used yield almost similar results and confirm cointegration for the relevant data on Finnish regions. This long-run relationship in Finland appears to be very similar to that found elsewhere in the literature.

Key words: Okun's Law, (hidden) cointegration, asymmetry, residual-based test, conditional error correction model, regional growth

Pn380akct

1. Okun's Law Revisited

The seminal paper by Okun (1962) on the relationship between GDP growth and unemployment has prompted many scientific discussions over the past decades. 'Okun's Law' stipulates that this relationship is symmetric and that a three percent increase in real GDP is associated with a one percentage point decrease in unemployment, provided at least that the unemployment level is above the natural rate. Okun's Law presupposes essentially a macroeconomic correlation between the level of economic activity in the goods market and that in the labour market over the business cycle.

Okun's Law has obvious implications for macroeconomic policy, as it is often used as a benchmark for measuring the cost of unemployment rise (see e.g. Moosa 1997a). In addition, this law may be helpful in determining an optimal (or desirable) growth rate for the economy, which is needed as critical information for formulating monetary policy rules and other business cycle policies (Gordon 2010).

While there seems to be consensus on the negative correlation between unemployment and GDP movements, the order of magnitude of this correlation appears to show quite some variation in different studies. Various recent empirical studies point out that Okun's Law varies substantially across countries, over different time periods and over the phases of a business cycle in such a way that it seems plausible to model it as a non-linear relationship (see e.g. Altig 1997, IMF 2010, Daly and Hobijn 2010, Crespo-Cuaresma 2003, Silvapulle et al. 2004). These authors argue that the coefficient in Okun's Law varies according to recessions and expansions of the economy and that the effect of cyclical output on cyclical unemployment is significantly higher in case of a downturn in the economy.

Other features of Okun's Law, viz. its order of magnitude and its symmetry, have also met criticism. For example, by using a static framework and by imposing exogenously an asymmetry threshold on the unemployment variable, Lee (2000) tests the (a)symmetric behaviour of Okun's Law for yearly data on 16 OECD countries and finds significantly higher coefficients for various countries (e.g. Finland, Japan, the USA). Next, Mayes and Viren (2002) emphasize asymmetry in the behaviour of the labour market and demonstrate that rapid downturns in the economy have more than proportionate effects on unemployment, partly because of the mismatch between the relevant sectors and the regions where the jobs and unemployment show up. Another explanation for the asymmetry in Okun's Law is given by Harris and Silverstone (2001), who emphasize the asymmetric responses among heterogeneous production sectors in terms of job creation and job destruction when faced with economic shocks.

The above mentioned observations question some basics of Okun's Law, in particular its linearity and its symmetry assumption. The limitations mostly highlighted in the literature are threefold: (i) the short-run analysis framework for linking output and unemployment gaps relative to their natural (equilibrium) level; these results are sensitive to the choice of the trend-cycle decomposition method and do not incorporate long-run feedback effects between goods and labour markets; (ii) the a priori assumed short-term exogeneity of unemployment and output in investigating the statistical correlation between these two variables; (iii) the statistical restriction to aggregate (macroeconomic) variables, without any consideration of region-specific characteristics in both the product and the labour markets and how different markets behave over the business cycle; (iv) under conditions of hysteresis and related factors – where fired workers tend to have re-employment difficulties after longer unemployment spells – a drop in GDP may produce a higher rise in unemployment rates relative to a case when GDP increases.

The current economic recession has recentely prompted a new debate on the association between GDP changes and unemployment, not only from a macroeconomic perspective, but also from a (multi-) regional perspective. A good illustration of this issue can be found in Finland, a country which – in contrast to its past prosperous development – faced in 2009 a drop of 8% in its GDP, while it may likely grow only 1 % in 2010 (Finnish Ministry of Finance 2010). These unfavourable growth prospects are a reason for deep concern on the future employment situation in this country and its regions. If Okun's Law would be strictly valid, Finland will encounter a problematic labour market development in the near future. Clearly, if a strict linear relationship does not hold, other determinants will impact on the future unemployment rate (see also Freeman 2001, Gordon 1984, Moosa 1997b, Knoester 1986). Therefore, the reliability of Okun's coefficients is not only of paramount importance for macroeconomic policy, but also for the regional distribution of unemployment rates in an open spatial system. Thus, a regional focus on Okun's Law is warranted. In addition, economic growth tends to exhibit more fluctuations at a regional scale than at a national scale due to spatial interdependencies and lower economic diversity of regions, so that also local public finances may show more variability and hence may have more variations at a spatially disaggregated level. Furthermore, differences in regional economic structures – for instance, labour-intensive regional economies dominated by the public sector versus capital-intensive or export-oriented regions – may lead to different orders of magnitude of Okun's Law, so that economic fluctuations may have heterogeneous effects on regional (or local) tax bases and hence on public expenditures in case of a variety in regional economies within a national system (see also Machin and Van Reenen 1998, Moosa 1997b, Paldam 1987, Paley 1993). This issue is also related to endogenous regional economic growth analyses (see Stimson et al. 2010).

In order to potentially uncover geographical structural differences in the responsiveness of labor markets to changes in output and to benefit from the larger variation in output and unemployment at a regional level, some authors have recently tried to pay also attention to the regional aspects of Okun's Law (see e.g. Freeman 2000, Christopoulos 2004, Adanu 2005, Villaverde and Maza 2007). The present paper takes these arguments further and presents a new regional statistical analysis inspired by Okun's Law that allows for long-run asymmetries between output and unemployment in a multiregional system within a hidden cointegration framework, which does not need an a priori assumption on the exogeneity of either of these variables nor any trend-cycle decomposition procedure. Finally, the paper will take the cross-sectional dependence into account (in particular, whether a certain type of Okun correlation in one region will affect the Okun relationship in other regions). The new Okun model will be applied to 74 Finnish Labour market regions over the past 30 years.

In the light of the previous observations we aim to develop an amended statistical model representing Okun's Law that meets the following two conditions: (i) it should be able to identify or represent the existence of both linear and non-linear relationships between regional GDP and regional unemployment rates, and (ii) it should be able to take into consideration the extent to which Okun's relationship depends on the region's own characteristics and those of others (cross-sectional or spatial dependence). For this objective we combine a hidden conintegration approach by Gordon (2010) to accommodate asymmetries with a method by Pedroni (2004) to remove cross-sectional dependence. Our statistical analysis of time series of key variables will be based on a cointegration approach. The relationship is modelled utilising time series rather than cross-sectional variations in order to avoid taking a priori stances on the exogeneity of either

GDP or unemployment. However, in a system of small open regional economies, cross-sectional dependence is crucial to take into account as well.

2. Two Statistical Approaches and the Data

2.1 Hidden cointegrations

To model Okun's Law in case of asymmetry (with non-linear correlations) we will now present the following time series analysis of two I(1)-distributed variables, GDP_t and the unemployment rate UN_t (with a possible drift):

$$UN_t = UN_{t-1} + u_t = UN_0 + \sum_{i=1}^{t} u_i$$

and (1)

$$GDP_t = GDP_{t-1} + u_t = GDP_0 + \sum_{i=1}^{t} v_i,$$

where v_t and u_t are both white noise terms with zero means, meaning that u does not depend on UN and v is independent of GDP. Regardless of non-correlation within equations there can be correlations between them. If the association between these two time series variables was linear, we would define the following Engle and Granger (1987) linear cointegration formula (see also Attfield and Siverstone 1997, 1998, Granger and Yoon 2002, Pedroni 2000):

$$\sum_{i=1}^{t} u_i - \beta \sum_{i=1}^{t} v_i = 0, \qquad (2)$$

meaning that the linear relationship between UN and GDP is stationary over time, although both variables have their own unit roots.

If it appears that the variables do not have a cointegration relationship, their sub-components may still have it (see Gordon 2010). In such a case the relationship is non-linear. In general, a hidden cointegration takes place among two variables, if their components are mutually cointegrated. To look for hidden cointegrations in the present case, let us decompose UN into two components:

$$u_i^+ = \max(u_i, d)$$

$$u_i^+ = \min(u_i, d) \quad (3)$$

where d is an a priori given threshold value. The same holds for v_i. Consequently, we have

$$u_i = u_i^+ + u_i^- - d$$
$$v_i = v_i^+ + v_i^- - d \quad (4)$$

On the basis of the expressions presented above and assuming d=0, we may now apply the following decomposition:

$$UN_t = UN_0 + u_t^+ + u_t^-$$
$$GDP_t = GDP_0 + v_t^+ + v_t^-, \quad (5)$$

where u_t^+ and v_t^+ are the cumulative sums of positive shocks in period t, while the negative counterparts are the cumulative sums of negative shocks on UN and GDP, respectively.

2.2 Database

The previous analysis framework has been used to analyse the existence and relevance of Okun's Law for the 74 travel-to-work areas, TTWAs, in Finland. Our data base covers annual time series information on GDP (value added) and the unemployment rate during the period 1976-2006.

The long run relationship between unemployment rate and GDP would be easy to estimate, if both series were stationary and stable in a sense that they would not have breaks in the data generating process. However, it appears that both aggregate series are highly non-stationary and non-stable (Figure 1). Therefore, a simple regression of unemployment on the log of GDP would yield highly unreliable results.

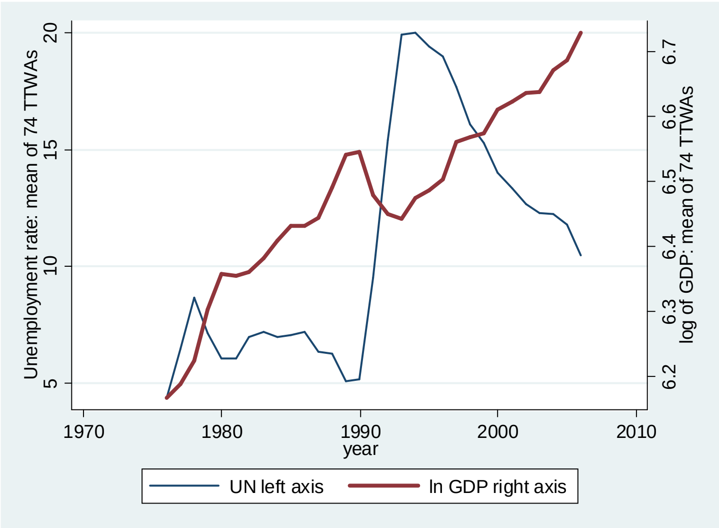

Figure 1. Time patterns of unemployment and GDP

It is noteworthy that a decomposed series appears to show a slightly better behaviour. However, there are still breaks in the positive UN series, u^+, and in the aggregate series, UN. While the negative component, u^- , appears to look much better, it also has a break in the early 1990s, when the series levels off for the years when the aggregate unemployment rises all over Finland (see Figure 2).

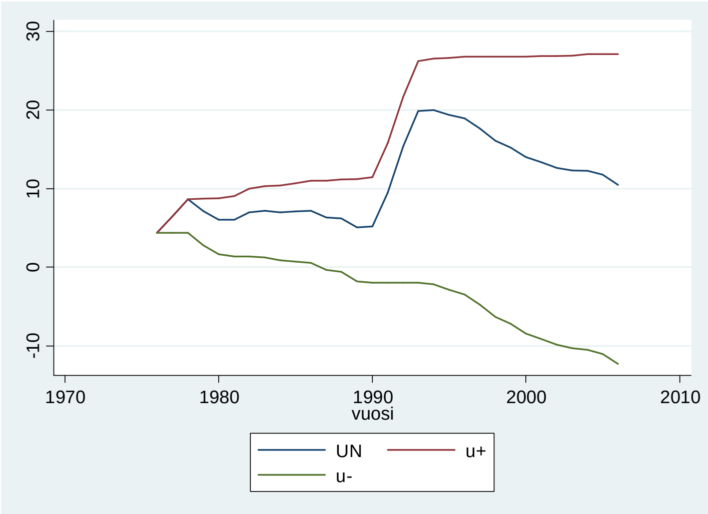

Figure 2. A decomposed mapping of unemployment

Next, we will offer a picture of the decomposed GDP series, v^+ and v^-. This time pattern appears to demonstrate a reasonably good behavior (see Figure 3).

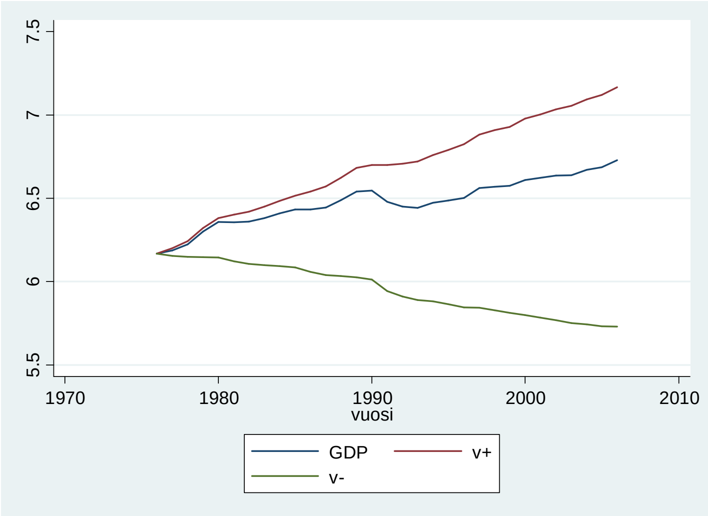

Figure 3. A decomposed mapping of GDP

It should be noted that even more non-reliability emerges from cross-sectional dependence. Beside time series dynamics, the Okun's Law relationship in an open regional economy may easily be affected by developments in other regional economies. Simple spatial correlations reveal that it is indeed important to take spatial dependencies into account. Using average values for each cross-sectional unit over the 30 years of investigation reveals a clear spatial correlation. For example, regions with a high unemployment rate tend to have adjacent neighbours with high unemployment and vice versa (see Figure 4).

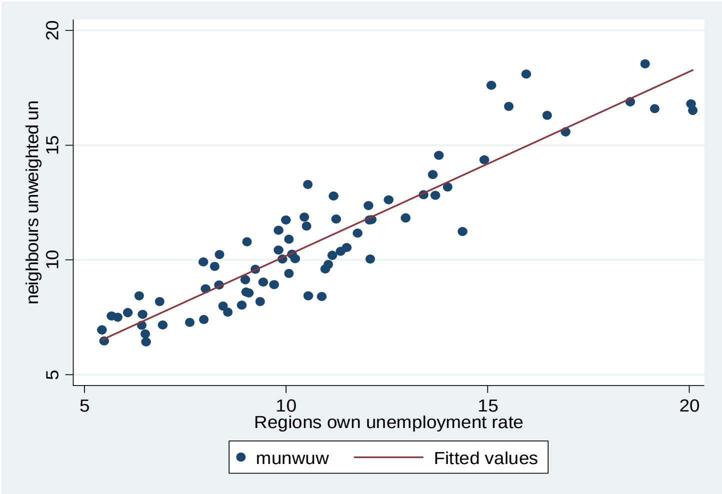

Figure 4. Spatial correlation in unemployment

2.3 Correcting for cross-sectional dependence

To account now for these correlations, we relate each variable to the annual country average, a procedure which is now common in econometrics panel data analysis with long time series and a high number of cross-sections. To do this, the threshold value d (introduced in (3) above) is no longer equal to 0, but equals the annual average across the cross-sectional (areal) units. As a consequence, the value of the positive unemployment rate series, u+, in 1977 is equal to that for 1976 plus the change in 1977, if the change in the region in question is higher than the average. Otherwise, the change is 0 and the value in 1977 equals that of 1976. The opposite applies to the negative series. If the change is lower than the average, the value is subtracted from the value in 1976, otherwise the change is 0. Using this logic the entire time series can be computed for each TTWA, obtaining variables uk^+, uk^-, vk^+ and vk^-, where k refers to the value relative to the country average. In other words, the method used combines the hidden cointegration framework with the Pedroni-style method to remove cross-sectional dependence.

Relating the variables to the country averages makes them look clearly non-stationary but stable (see Figures 5 and 6). Application of unit root tests (results available upon request) confirms this visual finding. As our time series is non-stationary, the long-run relationship is estimated using two alternative cointegration approaches.

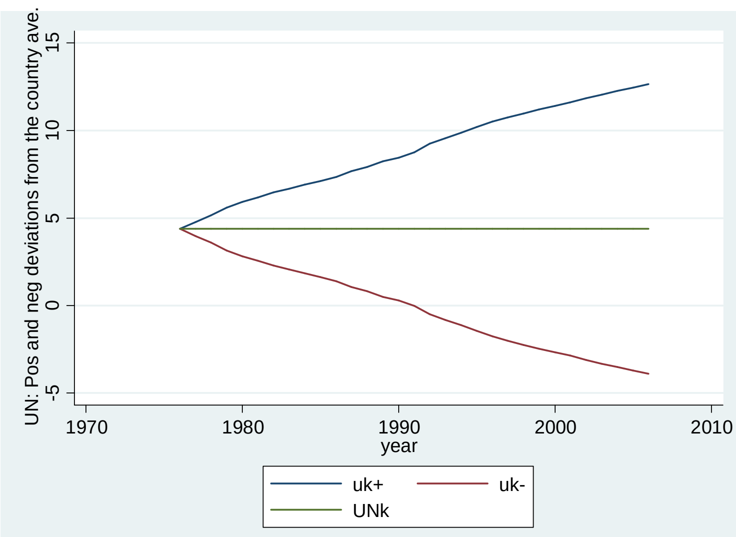

Figure 5. Positive and negative deviations from the annual country average of unemployment rate (average over TTWAs)

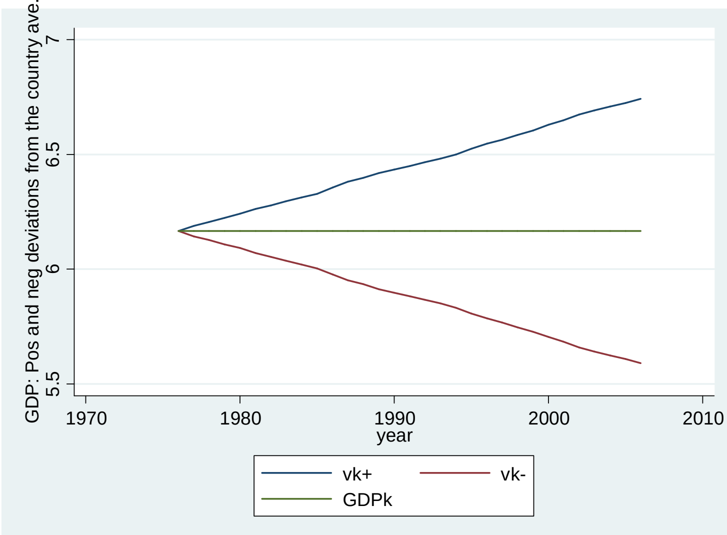

Figure 6. Positive and negative deviations from the annual country average of log(GDP), average over the TTWAs

3. Test Equations

The existence of cointegration will be tested now in two ways. First, the traditional residual-based test, based on Pedroni (2004), is used. According to this test, there is a long-run relationship between variables, if the residual is found stationary. For example, there is a long-run relationship between uk^+ and vk^-, if the error term ε is stationary in the following OLS regression:

$$uk^{+}_{i,t} = \gamma_{0,i} + \beta_i vk^{-}_{i,t-1} + \varepsilon^{+}_{i,t-1} \quad (6)$$

Second, a recently developed "structural" test will be applied, where a conditional error correction model for the variable of interest is designed (see Westerlund 2006). For example, there is a long-run relationship between uk^+ and vk^-, if the coefficient γ in the error-correction representation (7) is less than zero. More precisely, the null hypothesis of no cointegration for cross-sectional unit i is implemented as a test of the null H0 : $\gamma_{1,i} = 0$ versus H1 : $\gamma_{1,i} < 0$.

$$\Delta uk^{+}_{i,t} = \gamma_{0,i} + \gamma_{1,i}(uk^{+}_{i,t-1} - \beta_i vk^{-}_{i,t-1}) + \Sigma^{L}_{l=1}\alpha_{u,i,l}\Delta uk^{+}_{i,t-l} + \Sigma^{L}_{l=1}\alpha_{v,i,l}\Delta vk^{-}_{i,t-l} + e^{+}_{i,t-1} \quad (7)$$

In this case there is an economic interpretation for the long-run relationship presented in the parentheses of (7). Moreover, Westerlund (2006) has shown that these two methods for testing cointegration are complementary, and that the power and size characteristics of the tests depend on how well the case at hand fits to the assumptions behind the tests. The power of the residual-based test is the higher, the closer the γ of the region in question is to the respective α's (in equation (7)). If these long- and short- run coefficients differ markedly, the power of the test collapses yielding a wrong inference. On the other hand, the crucial assumption in the 'structural' test is that vk should be exogenous or weakly endogenous. In the present case the assumption of weak endogeneity is plausible. Since vk may not be endogenous, uk (unemployment) should not affect GDP in this period, but it may affect it in the subsequent period. It seems plausible that unemployment does not affect GDP immediately, since recently laid-off workers are usually well employable. However, over a longer period of time decreasing human capital and skill levels may reduce employability resulting in lower GDP growth. In a phase of an economic upturn, unemployment may affect GDP growth immediately only if there is a shortage of labour (i.e. very low unemployment). However, there have been only two very brief cases in the Finnish economic history where the average unemployment rate was very low (the mid 1970s and late 1980s). In other periods, there has always been ample unemployment somewhere in Finland, which has acted as a pool of potential labour for other regions. In conclusion, it seems that the 'structural' test has some appealing indulging assumptions for our case.

If there are long-run relationships between components, the aggregate series may also be cointegrated. However, this is only the case in one particular situation, as can be seen by distinguishing and comparing four possible cointegration cases:

1. None of the two components is cointegrated. Then, GDP and UN are not cointegrated; they may experience positive and negative shocks, but will exhibit their own independent trends.
2. Only one of the two components is cointegrated, but not both. In that case, GDP an dUN may have common opposite shocks, but they are still not cointegrated, although they share a more common structure than in case 1.

3. Both components have different cointegration vectors. Yet, GDP and UN are not coitegrated, even though they have common shocks.
4. Both components have the same cointegration vector. In this case, GDP and UN are cointegrated and there is only one common shock.

In conclusion, for GDP and UN to be fully cointegrated, their components should be mutually cointegrated with the same cointegrating vectors.[1]

4. Empirical Results

4.1 Base-line model

Relating the aggregate time-series for economic indicators by region to the country average removes the trend from the variables. Therefore, there is no point using cointegration methods to the aggregate series UNk and lnGDPk. Instead, a simple regression model can be run, which leads to the following result:

$$UNk_{i,t} = 0.12 - 0.0126 * lnGDPk_{i,t} + \text{TTWA fixed effects} \quad (8)$$
$$(^{***}) \quad (^{***}),$$

where *** indicates statistical significance at the 1 percent level.

In other words, we find that the β coefficient in an empirical equation is one tenth of the typical value found in the literature (Moosa 1997a; Knotek 2007). Next, we will proceed by analyzing the component of both series by the above described cointegration methods (8).

4.2 Residual-based tests

Empirical results obtained with the Pedroni-testing procedure are presented in Table 1 while the Westerlund methodology leads to the results shown in Table 2.

For the linear case (aggregate variables) with or without a correction for cross-sectional dependence, the panel ρ-test statistics indicates that unemployment and GDP are not related in a

---

[1] Since virtually always unemployment and GDP are negatively correlated, neither (uk_t^+ and vk_t^+) nor (uk_t^- and vk_t^-) can be cointegrated. Thus, we concentrate here on the long-run relationship between component (uk_t^+ and vk_t^-) and component (uk_t^- and vk_t^+).

statistical sense (ρ > -2.0). This is as expected due to the stationarity of the series (there is actually no point in running this test for stationary series, but it is done here, however, for the case of comparison). Also, the long-run β-coefficient is very similar to the one found above in an OLS regression with fixed effects and thus small relative to the value found in the literature. In contrast, when the Pedroni test is computed for the decomposed variables (that have been de-meaned from the average growth rates) the test statistics is well beyond the limit of -2.0. Furthermore, the long-term coefficients are now of the same order of magnitude as those found elsewhere. They are also close to each other, as is implied by the figures above and the use of the national average growth rates as the threshold, which makes such series symmetric by construction.

Table 1. Residual-based tests and long-run coefficient

	Panel ρ	β, Panel FM[(a)]	β, Panel DOLS[(a)]
Linear (aggregate), no correction for cs dependence : UN = $\alpha + \beta$.lnGDP	-0.71	-1.539***	-2.221***
correction for cs dependence : UNk = $\alpha + \beta$.lnGDPk	-1.90	-0.016***	-0.015***
Contractions : $uk^{+} = \alpha + \beta.vk^{-}$	-5.18***	-0.134***	-0.136***
Expansions : : $uk^{-} = \alpha + \beta.vk^{+}$	-3.44***	-0.118***	-0.121***

(a) The full sample estimates of β-coefficients are computed by taking a weighted average of the individual estimates. Each individual β is weighted by the diagonal matrix formed by taking the square root of the precision matrix of the estimates for that individual. With such a weighting procedure, the coefficients and covariance matrix reproduce the average *t*-statistic so that the averaging done in calculating the *t*-statistics and the average β-coefficients match.

The conditional error correction model produces similar results. The linear model without correction for cross-sectional dependence is not cointegrated. While the linear model with correction for cross-sectional dependence is cointegrated, its long-run estimate does not have a transparent economic interpretation. In contrast, when the data series is split in positive and negative components, both equations are cointegrated and the long-run β-coefficient is very close to those obtained elsewhere in the literature.

Table 2. Results of conditional error correction model.

	Cointegration. relationship			Error Correction Model	
	γ_1	constant	β_1	Sum of coeff. On lags of Δu	Sum of coeff. On lags of Δv
Linear, no correction for cs dependence: UN = $\alpha + \beta$.lnGDP	-0.12	-0.30***	+1.80	+0.54***	-0.09**
correction for cs dependence: UNk = $\alpha + \beta$.lnGDPk	-0.30***	.000	+0.08*	+0.16**	-0.03***
Contractions: $uk^+ = \alpha + \beta.vk^-$	-0.21***	0.17	-0.194***	+0.00	+0.01
Expansions: $uk^- = \alpha + \beta.vk^+$	-0.19***	0.20	-0.165***	+0.07**	+0.07***

Both the Pedroni and the Westerlund testing strategies tell us that the hidden cointegration relationships between uk^+ and vk^- on the one hand between uk^- and vk^+ on the other hand are significant at a 5% significance level. This means that regions having different GDP growth rates from the average across regions, also have persistently different unemployment rates relative to the average unemployment.

5. Conclusion

This paper aimed to test the existence of the Okun's Law in the case of small open regional economies. Using alternative statistical methods, viz. the residual-based test and the conditional error correction model, the main finding is that the Okun's coefficient in the present case is -0.2, which is very similar to that found elsewhere. A novelty of the paper is to combine a method of hidden cointegrations with a method of removing cross-sectional dependence. Statistical tests reject the long run relationship between the regional aggregate unemployment and output series. However, after correcting for hidden cointegrations and cross-sectional dependence, both statistical methods used yield almost similar results and confirm cointegration for the relevant data on Finnish regions.

The presence of hidden cointegration may be considered as a clue for the presence of a long-run link between regional to national ratios of GDP and unemployment. More precisely, while the traditional Okun's Law relationship concerns the short-run correlation between unemployment and GDP transitory movements, our result clearly shows that this correlation also holds in the long-run at the decentralized level of regions. Various potential explanations such as insider/outsider models, human capital or regional mobility may be found in the literature for this long-run response of regional unemployment to regional GDP shocks.

Moreover, empirical estimates of the β-coefficients obtained with the Panel FM and the Panel DOLS estimators (Table 1) or with the Westerlund ECM estimation (Table 2) reveal that the impact of GDP expansions on unemployment is smaller in absolute value than the impact of GDP contractions. While the Panel FM and Panel DOLS estimators are smaller in absolute terms that those obtained with the Westerlund estimator, they all point to the presence of an asymmetric effect of GDP movements on unemployment with a larger responsiveness of unemployment in case of negative output variations. These results are fully consistent with those already observed in earlier studies by Crespo (2003) or Silvapulle et al. (2004) for specific countries. Taken as a whole, our results indicate that when regional GDP growth is larger (respectively smaller) than the national GDP growth by 1 percentage point, the gap between regional and national unemployment rate decreases (respectively increases) by an amount falling in between 0.12 and 0.17 percentage points (respectively 0.13 and 0.19 percentage points).

These effects are all quantitatively smaller than the traditional Okun's Law coefficients obtained in the literature for the case of countries; to interpret these differences, we have to keep in mind two main points. First, the traditional version of the Okun's Law concerns a short run temporal horizon when the labor market and the nominal wages are predominantly rigid so that there is no major regulation of unemployment and GDP movements through labor market adjustments. In this case, the labor market cannot adjust. The presence of hidden cointegration relationships indicates that our results typically concern a long-run time horizon. As a consequence, they tend to indicate that regional labor market adjustment mechanisms are not able to fully incorporate the variations of unemployment rates induced by large regional GDP shocks. However, the initial impacts of GDP shocks on unemployment are partly dampened by labor market and real wages adjustments in the medium term, while only a fraction of the initial impact can remain in the long run.

The second point concerns the fact that our sample includes regional data. As mobility is much more important across regions than across countries, regional unemployment rates movements are also partly influenced by regional mobility. This mobility may thus also contribute to explain why our β-coefficients are smaller than those obtained with national data.

References

Adanu, K. (2005). A cross-province comparison of Okun's coefficient for Canada. *Applied Economics* 37: 561-570.

Altig D., Fitzgerald T. and Rupert P. (1997). Okus's Law Revisited: Should We Worry about Low Unemployment? Research commentary, Federal Reserve Bank of Cleveland.

Attfield C. and Silverstone B. (1998). Okun's law. cointegration and gap variables. *Journal of Macroeconomics* 20: 626-637

Attfield C.L.F. and Silverstone B. (1997). Okun's coefficient: a comment. *Review of Economics and Statistics* 79: 326-329.

Christopoulos D. (2004). The relationship between output and unemployment: Evidence from Greek regions. *Papers in Regional Science* 83: 611-620.

Crespo-Cuaresma J. (2003). Revisiting Okun's law: a piecewise-linear approach. *Oxford Bulletin of Economics and Statistics* 65: 439_451.

Daly, M. and Hobijn B. (2010). Okun's Law and the unemployment surprise of 2009. FRBSF Economic Letter, March 2010.

Freeman D. (2000). A regional test of Okun's Law. *International Advances in Economic Research* 6: 557-570.

Freeman D.G. (2001). Panel tests of Okun's law for ten industrial countries. *Economic Inquiry* 39: 511–523.

Gordon R.J. (1984). Unemployment and potential output in the 1980s. *Brookings Papers on Economic Activity* 2: 537-586.

Gordon R. (2010). Okun's law, productivity innovations, and conundrums in business cycle dating. Paper presented at the ASSA meeting, Atlanta, January 4, 2010.

Granger C.W. and Yoon G. (2002). Hidden cointegration . Working Paper, Department of Economics. University of California. San Diego.

Harris R. and Silverstone B. (2001). Testing for asymmetry in Okun's law: A cross-country comparison. *Economic Bulletin* 5: 1-13

IMF (2010). Unemployment dynamics during recessions and recoveries: Okun's law and beyond. Report April 2010.

Knoester A. (1986). Okun's law revisited. *Weltwirtschaftliches Archiv* 122: 657-666.

Knotek E. (2007). How usesul is Okun's law? C*ity economic review (Federal reserve bank of Kansas)* 4: 73-103.

Lee J. (2000). The robustness of Okun's law: Evidence from OECD countries. *Journal of Macroeconomics* 22: 331-356

Machin S. and Van Reenen J. (1998). Technology and changes in skill structure: evidence from seven OECD countries. *Quarterly Journal of Economics* 113: 1215-1244.

Mayes. D. and Viren M. (2002). Asymmetry and the problem of aggregation in the euro area. *Empirica* 29: 47-73.

Moosa I.A. (1997a). On the costs of inflation and unemployment. *Journal of Post Keynesian Economics* 19: 651-66

Moosa I.A. (1997b). A cross-country comparison of Okun's coefficient. *Journal of Comparative Economics* 24: 335-–356.

Okun A. (1962). Potential GNP: its measurement and significance. American Statistical Association. Proceedings of the Business and Economic Statistics Section, pp. 98-104.

Paldam M. (1987). How much does one percent of growth change the unemployment rate? *European Economic Review* 31: 306-313.

Palley T.I. (1993). Okun's law and the asymmetric and changing cyclical behaviour of the USA economy. *International Review of Applied Economics* 7: 144-62.

Pedroni P. (2000). Fully modified OLS for heterogeneous cointegrated panels. Non-Stationary Panels. *Panel Cointegration and Dynamic Panels* 15: 93-130.

Pedroni P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory*, 20: 597-625.

Silvapulle P., Moosa I.A. and Silvapulle M.J. (2004). Asymmetry in Okun's law. *Canadian Journal of Economics* 37: 353-374.

Villaverde J. and Maza A. (2007). Okun's law in the Spanish regions. *Economics Bulletin* 18 (5): 1-11

Westerlund J. (2006). Testing for error correction in panel data. METEOR working papers, RM/06/056.

2007-1	M. Francesca Cracolici Miranda Cuffaro Peter Nijkamp	Geographical distribution of enemployment: An analysis of provincial differences in Italy, 21 p.
2007-2	Daniel Leliefeld Evgenia Motchenkova	To protec in order to serve, adverse effects of leniency programs in view of industry asymmetry, 29 p.
2007-3	M.C. Wassenaar E. Dijkgraaf R.H.J.M. Gradus	Contracting out: Dutch municipalities reject the solution for the VAT-distortion, 24 p.
2007-4	R.S. Halbersma M.C. Mikkers E. Motchenkova I. Seinen	Market structure and hospital-insurer bargaining in the Netherlands, 20 p.
2007-5	Bas P. Singer Bart A.G. Bossink Herman J.M. Vande Putte	Corporate Real estate and competitive strategy, 27 p.
2007-6	Dorien Kooij Annet de Lange Paul Jansen Josje Dikkers	Older workers' motivation to continue to work: Five meanings of age. A conceptual review, 46 p.
2007-7	Stella Flytzani Peter Nijkamp	Locus of control and cross-cultural adjustment of expatriate managers, 16 p.
2007-8	Tibert Verhagen Willemijn van Dolen	Explaining online purchase intentions: A multi-channel store image perspective, 28 p.
2007-9	Patrizia Riganti Peter Nijkamp	Congestion in popular tourist areas: A multi-attribute experimental choice analysis of willingness-to-wait in Amsterdam, 21 p.
2007-10	Tüzin Baycan-Levent Peter Nijkamp	Critical success factors in planning and management of urban green spaces in Europe, 14 p.
2007-11	Tüzin Baycan-Levent Peter Nijkamp	Migrant entrepreneurship in a diverse Europe: In search of sustainable development, 18 p.
2007-12	Tüzin Baycan-Levent Peter Nijkamp Mediha Sahin	New orientations in ethnic entrepreneurship: Motivation, goals and strategies in new generation ethnic entrepreneurs, 22 p.
2007-13	Miranda Cuffaro Maria Francesca Cracolici Peter Nijkamp	Measuring the performance of Italian regions on social and economic dimensions, 20 p.

2007-14	Tüzin Baycan-Levent Peter Nijkamp	Characteristics of migrant entrepreneurship in Europe, 14 p.
2007-15	Maria Teresa Borzacchiello Peter Nijkamp Eric Koomen	Accessibility and urban development: A grid-based comparative statistical analysis of Dutch cities, 22 p.
2007-16	Tibert Verhagen Selmar Meents	A framework for developing semantic differentials in IS research: Assessing the meaning of electronic marketplace quality (EMQ), 64 p.
2007-17	Aliye Ahu Gülümser Tüzin Baycan Levent Peter Nijkamp	Changing trends in rural self-employment in Europe, 34 p.
2007-18	Laura de Dominicis Raymond J.G.M. Florax Henri L.F. de Groot	De ruimtelijke verdeling van economische activiteit: Agglomeratie- en locatiepatronen in Nederland, 35 p.
2007-19	E. Dijkgraaf R.H.J.M. Gradus	How to get increasing competition in the Dutch refuse collection market? 15 p.

2008-1	Maria T. Borzacchiello Irene Casas Biagio Ciuffo Peter Nijkamp	Geo-ICT in Transportation Science, 25 p.
2008-2	Maura Soekijad Jeroen Walschots Marleen Huysman	Congestion at the floating road? Negotiation in networked innovation, 38 p.
2008-3	Marlous Agterberg Bart van den Hooff Marleen Huysman Maura Soekijad	Keeping the wheels turning: Multi-level dynamics in organizing networks of practice, 47 p.
2008-4	Marlous Agterberg Marleen Huysman Bart van den Hooff	Leadership in online knowledge networks: Challenges and coping strategies in a network of practice, 36 p.
2008-5	Bernd Heidergott Haralambie Leahu	Differentiability of product measures, 35 p.
2008-6	Tibert Verhagen Frans Feldberg Bart van den Hooff Selmar Meents	Explaining user adoption of virtual worlds: towards a multipurpose motivational model, 37 p.
2008-7	Masagus M. Ridhwan Peter Nijkamp Piet Rietveld Henri L.F. de Groot	Regional development and monetary policy. A review of the role of monetary unions, capital mobility and locational effects, 27 p.
2008-8	Selmar Meents Tibert Verhagen	Investigating the impact of C2C electronic marketplace quality on trust, 69 p.
2008-9	Junbo Yu Peter Nijkamp	China's prospects as an innovative country: An industrial economics perspective, 27 p
2008-10	Junbo Yu Peter Nijkamp	Ownership, r&d and productivity change: Assessing the catch-up in China's high-tech industries, 31 p
2008-11	Elbert Dijkgraaf Raymond Gradus	Environmental activism and dynamics of unit-based pricing systems, 18 p.
2008-12	Mark J. Koetse Jan Rouwendal	Transport and welfare consequences of infrastructure investment: A case study for the Betuweroute, 24 p
2008-13	Marc D. Bahlmann Marleen H. Huysman Tom Elfring Peter Groenewegen	Clusters as vehicles for entrepreneurial innovation and new idea generation – a critical assessment
2008-14	Soushi Suzuki Peter Nijkamp	A generalized goals-achievement model in data envelopment analysis: An application to efficiency improvement in local government finance in Japan, 24 p.
2008-15	Tüzin Baycan-Levent	External orientation of second generation migrant entrepreneurs. A sectoral

	Peter Nijkamp Mediha Sahin	study on Amsterdam, 33 p.
2008-16	Enno Masurel	Local shopkeepers’ associations and ethnic minority entrepreneurs, 21 p.
2008-17	Frank Frößler Boriana Rukanova Stefan Klein Allen Higgins Yao-Hua Tan	Inter-organisational network formation and sense-making: Initiation and management of a living lab, 25 p.
2008-18	Peter Nijkamp Frank Zwetsloot Sander van der Wal	A meta-multicriteria analysis of innovation and growth potentials of European regions, 20 p.
2008-19	Junbo Yu Roger R. Stough Peter Nijkamp	Governing technological entrepreneurship in China and the West, 21 p.
2008-20	Maria T. Borzacchiello Peter Nijkamp Henk J. Scholten	A logistic regression model for explaining urban development on the basis of accessibility: a case study of Naples, 13 p.
2008-21	Marius Ooms	Trends in applied econometrics software development 1985-2008, an analysis of Journal of Applied Econometrics research articles, software reviews, data and code, 30 p.
2008-22	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Changing trends in rural self-employment in Europe and Turkey, 20 p.
2008-23	Patricia van Hemert Peter Nijkamp	Thematic research prioritization in the EU and the Netherlands: an assessment on the basis of content analysis, 30 p.
2008-24	Jasper Dekkers Eric Koomen	Valuation of open space. Hedonic house price analysis in the Dutch Randstad region, 19 p.

2009-1	Boriana Rukanova Rolf T. Wignand Yao-Hua Tan	From national to supranational government inter-organizational systems: An extended typology, 33 p.
2009-2	Marc D. Bahlmann Marleen H. Huysman Tom Elfring Peter Groenewegen	Global Pipelines or global buzz? A micro-level approach towards the knowledge-based view of clusters, 33 p.
2009-3	Julie E. Ferguson Marleen H. Huysman	Between ambition and approach: Towards sustainable knowledge management in development organizations, 33 p.
2009-4	Mark G. Leijsen	Why empirical cost functions get scale economies wrong, 11 p.
2009-5	Peter Nijkamp Galit Cohen-Blankshtain	The importance of ICT for cities: e-governance and cyber perceptions, 14 p.
2009-6	Eric de Noronha Vaz Mário Caetano Peter Nijkamp	Trapped between antiquity and urbanism. A multi-criteria assessment model of the greater Cairo metropolitan area, 22 p.
2009-7	Eric de Noronha Vaz Teresa de Noronha Vaz Peter Nijkamp	Spatial analysis for policy evaluation of the rural world: Portuguese agriculture in the last decade, 16 p.
2009-8	Teresa de Noronha Vaz Peter Nijkamp	Multitasking in the rural world: Technological change and sustainability, 20 p.
2009-9	Maria Teresa Borzacchiello Vincenzo Torrieri Peter Nijkamp	An operational information systems architecture for assessing sustainable transportation planning: Principles and design, 17 p.
2009-10	Vincenzo Del Giudice Pierfrancesco De Paola Francesca Torrieri Francesca Pagliari Peter Nijkamp	A decision support system for real estate investment choice, 16 p.
2009-11	Miruna Mazurencu Marinescu Peter Nijkamp	IT companies in rough seas: Predictive factors for bankruptcy risk in Romania, 13 p.
2009-12	Boriana Rukanova Helle Zinner Hendriksen Eveline van Stijn Yao-Hua Tan	Bringing is innovation in a highly-regulated environment: A collective action perspective, 33 p.
2009-13	Patricia van Hemert Peter Nijkamp Jolanda Verbraak	Evaluating social science and humanities knowledge production: an exploratory analysis of dynamics in science systems, 20 p.

2009-14	Roberto Patuelli Aura Reggiani Peter Nijkamp Norbert Schanne	Neural networks for cross-sectional employment forecasts: A comparison of model specifications for Germany, 15 p.
2009-15	André de Waal Karima Kourtit Peter Nijkamp	The relationship between the level of completeness of a strategic performance management system and perceived advantages and disadvantages, 19 p.
2009-16	Vincenzo Punzo Vincenzo Torrieri Maria Teresa Borzacchiello Biagio Ciuffo Peter Nijkamp	Modelling intermodal re-balance and integration: planning a sub-lagoon tube for Venezia, 24 p.
2009-17	Peter Nijkamp Roger Stough Mediha Sahin	Impact of social and human capital on business performance of migrant entrepreneurs – a comparative Dutch-US study, 31 p.
2009-18	Dres Creal	A survey of sequential Monte Carlo methods for economics and finance, 54 p.
2009-19	Karima Kourtit André de Waal	Strategic performance management in practice: Advantages, disadvantages and reasons for use, 15 p.
2009-20	Karima Kourtit André de Waal Peter Nijkamp	Strategic performance management and creative industry, 17 p.
2009-21	Eric de Noronha Vaz Peter Nijkamp	Historico-cultural sustainability and urban dynamics – a geo-information science approach to the Algarve area, 25 p.
2009-22	Roberta Capello Peter Nijkamp	Regional growth and development theories revisited, 19 p.
2009-23	M. Francesca Cracolici Miranda Cuffaro Peter Nijkamp	Tourism sustainability and economic efficiency – a statistical analysis of Italian provinces, 14 p.
2009-24	Caroline A. Rodenburg Peter Nijkamp Henri L.F. de Groot Erik T. Verhoef	Valuation of multifunctional land use by commercial investors: A case study on the Amsterdam Zuidas mega-project, 21 p.
2009-25	Katrin Oltmer Peter Nijkamp Raymond Florax Floor Brouwer	Sustainability and agri-environmental policy in the European Union: A meta-analytic investigation, 26 p.
2009-26	Francesca Torrieri Peter Nijkamp	Scenario analysis in spatial impact assessment: A methodological approach, 20 p.
2009-27	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Beauty is in the eyes of the beholder: A logistic regression analysis of sustainability and locality as competitive vehicles for human settlements, 14 p.

2009-28	Marco Percoco Peter Nijkamp	Individual time preferences and social discounting in environmental projects, 24 p.
2009-29	Peter Nijkamp Maria Abreu	Regional development theory, 12 p.
2009-30	Tüzin Baycan-Levent Peter Nijkamp	7 FAQs in urban planning, 22 p.
2009-31	Aliye Ahu Gülümser Tüzin Baycan-Levent Peter Nijkamp	Turkey’s rurality: A comparative analysis at the EU level, 22 p.
2009-32	Frank Bruinsma Karima Kourtit Peter Nijkamp	An agent-based decision support model for the development of e-services in the tourist sector, 21 p.
2009-33	Mediha Sahin Peter Nijkamp Marius Rietdijk	Cultural diversity and urban innovativeness: Personal and business characteristics of urban migrant entrepreneurs, 27 p.
2009-34	Peter Nijkamp Mediha Sahin	Performance indicators of urban migrant entrepreneurship in the Netherlands, 28 p.
2009-35	Manfred M. Fischer Peter Nijkamp	Entrepreneurship and regional development, 23 p.
2009-36	Faroek Lazrak Peter Nijkamp Piet Rietveld Jan Rouwendal	Cultural heritage and creative cities: An economic evaluation perspective, 20 p.
2009-37	Enno Masurel Peter Nijkamp	Bridging the gap between institutions of higher education and small and medium-size enterprises, 32 p.
2009-38	Francesca Medda Peter Nijkamp Piet Rietveld	Dynamic effects of external and private transport costs on urban shape: A morphogenetic perspective, 17 p.
2009-39	Roberta Capello Peter Nijkamp	Urban economics at a cross-yard: Recent theoretical and methodological directions and future challenges, 16 p.
2009-40	Enno Masurel Peter Nijkamp	The low participation of urban migrant entrepreneurs: Reasons and perceptions of weak institutional embeddedness, 23 p.
2009-41	Patricia van Hemert Peter Nijkamp	Knowledge investments, business R&D and innovativeness of countries. A qualitative meta-analytic comparison, 25 p.
2009-42	Teresa de Noronha Vaz Peter Nijkamp	Knowledge and innovation: The strings between global and local dimensions of sustainable growth, 16 p.
2009-43	Chiara M. Travisi Peter Nijkamp	Managing environmental risk in agriculture: A systematic perspective on the potential of quantitative policy-oriented risk valuation, 19 p.
2009-44	Sander de Leeuw	Logistics aspects of emergency preparedness in flood disaster prevention, 24 p.

	Iris F.A. Vis Sebastiaan B. Jonkman	
2009-45	Eveline S. van Leeuwen Peter Nijkamp	Social accounting matrices. The development and application of SAMs at the local level, 26 p.
2009-46	Tibert Verhagen Willemijn van Dolen	The influence of online store characteristics on consumer impulsive decision-making: A model and empirical application, 33 p.
2009-47	Eveline van Leeuwen Peter Nijkamp	A micro-simulation model for e-services in cultural heritage tourism, 23 p.
2009-48	Andrea Caragliu Chiara Del Bo Peter Nijkamp	Smart cities in Europe, 15 p.
2009-49	Faroek Lazrak Peter Nijkamp Piet Rietveld Jan Rouwendal	Cultural heritage: Hedonic prices for non-market values, 11 p.
2009-50	Eric de Noronha Vaz João Pedro Bernardes Peter Nijkamp	Past landscapes for the reconstruction of Roman land use: Eco-history tourism in the Algarve, 23 p.
2009-51	Eveline van Leeuwen Peter Nijkamp Teresa de Noronha Vaz	The Multi-functional use of urban green space, 12 p.
2009-52	Peter Bakker Carl Koopmans Peter Nijkamp	Appraisal of integrated transport policies, 20 p.
2009-53	Luca De Angelis Leonard J. Paas	The dynamics analysis and prediction of stock markets through the latent Markov model, 29 p.
2009-54	Jan Anne Annema Carl Koopmans	Een lastige praktijk: Ervaringen met waarderen van omgevingskwaliteit in de kosten-batenanalyse, 17 p.
2009-55	Bas Straathof Gert-Jan Linders	Europe's internal market at fifty: Over the hill? 39 p.
2009-56	Joaquim A.S. Gromicho Jelke J. van Hoorn Francisco Saldanha-da-Gama Gerrit T. Timmer	Exponentially better than brute force: solving the job-shop scheduling problem optimally by dynamic programming, 14 p.
2009-57	Carmen Lee Roman Kraeussl Leo Paas	The effect of anticipated and experienced regret and pride on investors' future selling decisions, 31 p.
2009-58	René Sitters	Efficient algorithms for average completion time scheduling, 17 p.

2009-59	Masood Gheasi Peter Nijkamp Piet Rietveld	Migration and tourist flows, 20 p.

2010-1	Roberto Patuelli Norbert Schanne Daniel A. Griffith Peter Nijkamp	Persistent disparities in regional unemployment: Application of a spatial filtering approach to local labour markets in Germany, 28 p.
2010-2	Thomas de Graaff Ghebre Debrezion Piet Rietveld	Schaalsprong Almere. Het effect van bereikbaarheidsverbeteringen op de huizenprijzen in Almere, 22 p.
2010-3	John Steenbruggen Maria Teresa Borzacchiello Peter Nijkamp Henk Scholten	Real-time data from mobile phone networks for urban incidence and traffic management – a review of application and opportunities, 23 p.
2010-4	Marc D. Bahlmann Tom Elfring Peter Groenewegen Marleen H. Huysman	Does distance matter? An ego-network approach towards the knowledge-based theory of clusters, 31 p.
2010-5	Jelke J. van Hoorn	A note on the worst case complexity for the capacitated vehicle routing problem, 3 p.
2010-6	Mark G. Lijesen	Empirical applications of spatial competition; an interpretative literature review, 16 p.
2010-7	Carmen Lee Roman Kraeussl Leo Paas	Personality and investment: Personality differences affect investors’ adaptation to losses, 28 p.
2010-8	Nahom Ghebrihiwet Evgenia Motchenkova	Leniency programs in the presence of judicial errors, 21 p.
2010-9	Meindert J. Flikkema Ard-Pieter de Man Matthijs Wolters	New trademark registration as an indicator of innovation: results of an explorative study of Benelux trademark data, 53 p.
2010-10	Jani Merikivi Tibert Verhagen Frans Feldberg	Having belief(s) in social virtual worlds: A decomposed approach, 37 p.
2010-11	Umut Kilinç	Price-cost markups and productivity dynamics of entrant plants, 34 p.
2010-12	Umut Kilinç	Measuring competition in a frictional economy, 39 p.

2011-1	Yoshifumi Takahashi Peter Nijkamp	Multifunctional agricultural land use in sustainable world, 25 p.
2011-2	Paulo A.L.D. Nunes Peter Nijkamp	Biodiversity: Economic perspectives, 37 p.
2011-3	Eric de Noronha Vaz Doan Nainggolan Peter Nijkamp Marco Painho	A complex spatial systems analysis of tourism and urban sprawl in the Algarve, 23 p.
2011-4	Karima Kourtit Peter Nijkamp	Strangers on the move. Ethnic entrepreneurs as urban change actors, 34 p.
2011-5	Manie Geyer Helen C. Coetzee Danie Du Plessis Ronnie Donaldson Peter Nijkamp	Recent business transformation in intermediate-sized cities in South Africa, 30 p.
2011-6	Aki Kangasharju Christophe Tavéra Peter Nijkamp	Regional growth and unemployment. The validity of Okun’s law for the Finnish regions, 17p.