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Nicoletta Pashourtidou and Christos S. Savva

Abstract

This paper studies the size of the long-run response of output to different types of shocks known as the persistence of shocks. The multi-sectoral model developed by Lee et al. (1992) was used whereby the impact of shocks to both sectoral and aggregate output growth can be estimated. The empirical analysis uses quarterly data on the gross value added of eight sectors that cover the whole of economic activity in Cyprus, to examine the long-run response of sectoral and aggregate output to macroeconomic and other shocks. The macro shocks relate to oil prices, credit, foreign exchange and the stock market. The main findings suggest that sector-specific shocks are at least as important as macroeconomic shocks in generating output fluctuations at the sectoral and aggregate level. Furthermore, the sectors of financial and insurance activities, professional services, construction and other services are found to be associated with higher persistence of shocks compared to other sectors and therefore experience larger and more protracted output fluctuations when hit by shocks. These findings suggest that more targeted economic policies and reforms might be required to address sector-specific weaknesses and to limit the persistence of sector-specific shocks. Among the macro shocks examined, credit and oil price shocks are found to have the strongest direct influence on aggregate output growth. The persistence effects of credit shocks are channelled into aggregate output via their effects on the value added of financial activities, construction, and professional and other services. The long-run response of aggregate output to oil price shocks is mainly driven by the reaction of economic activity in the sectors of construction and other services.

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ΠΕΡΙΛΗΨΗ

Το άρθρο αυτό εξετάζει το μέγεθος της μακροχρόνιας αντίδρασης της οικονομικής δραστηριότητας σε διαφόρων ειδών αναταραχές. Χρησιμοποιείται ένα σύστημα εξισώσεων για τους τομείς της οικονομίας μέσω του οποίου μπορούν να εκτιμηθούν οι επιπτώσεις αναταραχών στον ρυθμό ανάπτυξης των τομέων και της οικονομίας συνολικά. Η εμπειρική ανάλυση χρησιμοποιεί τριμηνιαία στοιχεία για την ακαθάριστη προστιθέμενη αξία (σε σταθερές τιμές) οκτώ τομέων, οι οποίοι καλύπτουν το σύνολο της οικονομικής δραστηριότητας στην Κύπρο, για να εξετάσει τη μακροχρόνια αντίδραση της παραγωγής των τομέων και της οικονομίας σε μακροοικονομικές και άλλες αναταραχές. Οι μακροοικονομικές αναταραχές σχετίζονται με τις διεθνείς τιμές του πετρελαίου, τον δανεισμό, τις συναλλαγματικές ισοτιμίες και το χρηματιστήριο. Τα αποτελέσματα δείχνουν ότι αναταραχές που προκύπτουν μεμονωμένα σε τομείς είναι τουλάχιστον το ίδιο σημαντικές με μακροοικονομικές αναταραχές στη δημιουργία διακυμάνσεων στην παραγωγή τόσο των τομέων όσο και της οικονομίας συνολικά. Επιπρόσθετα, στους τομείς των χρηματοοικονομικών και ασφαλιστικών δραστηριοτήτων, επαγγελματικών υπηρεσιών, κατασκευών και άλλων υπηρεσιών, οι επιπτώσεις των αναταραχών είναι μεγαλύτερες και πιο παρατεταμένες. Τα αποτελέσματα υποδηλώνουν την ανάγκη για πιο στοχευμένες οικονομικές πολιτικές και μεταρρυθμίσεις για να αντιμετωπιστούν αδυναμίες συγκεκριμένων τομέων και να περιοριστούν οι επιπτώσεις των μεμονωμένων αναταραχών σε τομείς. Ανάμεσα στις μακροοικονομικές αναταραχές που εξετάστηκαν, τις ισχυρότερες άμεσες επιπτώσεις στην ανάπτυξη της οικονομίας ως σύνολο εκτιμάται ότι έχουν αυτές που σχετίζονται με τον δανεισμό και τις τιμές πετρελαίου. Οι επιπτώσεις των αναταραχών που σχετίζονται με τον δανεισμό διοχετεύονται στη συνολική παραγωγή μέσω των επιδράσεων στην προστιθέμενη αξία των χρηματοπιστωτικών, ασφαλιστικών, επαγγελματικών και άλλων υπηρεσιών καθώς και των κατασκευών. Η μακροπρόθεσμη αντίδραση της συνολικής οικονομικής δραστηριότητας σε αναταραχές στις διεθνείς τιμές πετρελαίου προκαλείται κυρίως από τις διακυμάνσεις στην παραγωγή στους τομείς των κατασκευών και των άλλων υπηρεσιών.

1. INTRODUCTION

The response of aggregate output to different shocks as well as the duration of their effects has been extensively studied in the literature. The size of the response of output in the long run to a shock is known as the persistence of that shock (e.g. Lee et al. 1992; Pesaran et al. 1993). With regard to the Cypriot economy, there are estimates of the effects of some recent shocks i.e. deposit haircut and fiscal consolidation, on real economic activity as well as on other macroeconomic variables (Pashourtidou and Savva 2013; Pashourtidou, Savva and Syrichas 2014). However, it is of major importance to the conduct of economic policy to uncover the extent to which the various sectors of the economy are affected by various types of shocks, for example macroeconomic or sector-specific shocks.

Although the literature dealing with sectoral behaviour is rather limited a few papers highlight its importance. For instance, Lee et al. (1992) and Pesaran et al. (1993) develop a multi-sectoral model of output growth rates to estimate the persistence of shocks to total output.[1] They suggest that the information contained in sectoral growth rates as well as the interrelations between sectors help to obtain a more reliable estimate of the persistence measure for aggregate output compared to that computed from a univariate model. Lee et al. (1992) extend the multi-sectoral framework proposed in their previous work accounting for the sectoral contribution to the overall output persistence using four types of macro shocks. They utilise data from the UK to stress the usefulness of the sectoral analysis in the estimation of shock persistence at the sectoral and aggregate level. Their results also revealed that the type, magnitude and significance of a shock differ between sectors and that the impact of sector-specific shocks on sectoral and aggregate output is more protracted than that of macroeconomic shocks. The importance of these findings is also confirmed by Lee and Pesaran (1993) where they extend their multi-sectoral framework to estimate persistence measures at different horizons thereby providing persistence profiles of shocks that resemble impulse response functions.

[1] In a univariate framework i.e. individual series, the measurement of persistence is equivalent to unit root testing.

More recently, Antonini et al. (2013) apply a similar methodology to uncover the persistence and the sources of shocks to public sector debt-to-GDP ratios in 10 European Countries. They find evidence of important interactions between the countries examined, prolonged responses of debt ratios to shocks as well as asymmetric effects of fiscal consolidation (reductions in government spending vs. increases in government revenues).

In this paper we apply the multi-sectoral framework developed by Lee et al. (1992) to model explicitly the effects of macroeconomic and other type of shocks (under various scenarios) on sectoral and aggregate growth rates in Cyprus and to estimate the persistence of shocks for sectoral and aggregate output. The main findings suggest that sector-specific shocks are at least as important as macroeconomic shocks in generating output fluctuations at the sectoral and aggregate level. Furthermore, the sectors of financial and insurance activities, construction, and professional and other services are found to be associated with higher persistence of shocks and therefore experience larger and more protracted output fluctuations when hit by shocks. These findings suggest that more targeted economic policies and reforms might be required to address sector-specific weaknesses and to limit the persistence of shock-specific shocks.

The remainder of the paper is organised as follows. Section 2 outlines the multi-sectoral framework used to derive various persistence measures, section 3 describes the data, section 4 presents the empirical results and section 5 provides some conclusions.

2. METHODOLOGY

An outline of the multi-sectoral model of Lee et al. (1992) for the measurement of the persistence effects of shocks is given. The $m \times 1$ vector y_t represents the logarithm of output (measured by the Gross Value Added) in the m sectors of the economy and its first difference denoted by Δy_t (i.e. the sectoral rates of growth) is assumed to be stationary. A model for the growth rates of output in the m sectors is given by

$$\Delta y_t = a + \sum_{i=0}^{\infty} \Phi_i \, v_{t-i} + \sum_{i=0}^{\infty} \Theta_i \, \varepsilon_{t-i} \qquad (1a)$$

and

$$x_t = \Gamma z_t + v_t \quad (1b)$$

where a is the $m \times 1$ vector of sector-specific mean growth rates, x_t is a $p \times 1$ vector of macroeconomic variables, z_t is a $k \times 1$ vector of predetermined variables, v_t is a $p \times 1$ vector of innovations in macroeconomic variables and ε_t is an $m \times 1$ vector of sector-specific innovations, or in other words, the variation in sector growth rates that is not accounted for by macro shocks. The innovation matrices ε_t and v_t have mean zero and covariance matrices Σ and Ψ respectively.[2] The innovations v_t correspond to macroeconomic shocks, such as shocks to oil prices, monetary policy, exchange rates, stock prices, etc. Thus, the system in (1a) and (1b) describes the dynamic behaviour of output growth in the m sectors of the economy and allows for p macroeconomic shocks (common to all sectors) and a sector-specific shock to hit each sector. By defining aggregate output Y_t as a linear function of (log) sectoral output, i.e. $Y_t = w' y_t$, where w is an $m \times 1$ vector of fixed weights, a model for total output can be obtained using (1a)[3]

$$\Delta Y_t = w'a + \sum_{i=0}^{\infty} w'\Phi_i \, v_{t-i} + \sum_{i=0}^{\infty} w'\Theta_i \, \varepsilon_{t-i} \; . \quad (2)$$

Consequently the size of the long-run response of both sectoral and aggregate output to a shock can be computed using the parameters of models in (1a), (1b) and (2). More specifically, the above setup allows one to estimate the following:

(i) a persistence measure for aggregate output, P_Y;
(ii) a persistence measure for aggregate output due solely to macro shocks, P_M;
(iii) a persistence measure for aggregate output due to other shocks that are not macro-related, P_O ;
(iv) a persistence measure due to the direct effects of each one of the p macro shocks with all the other shocks set to zero, $P_{Mj}, j = 1, \dots, p$;
(v) a persistence measure reflecting the presence of correlation between a macro shock j with the remaining macro shocks, $P_{MXj}, j = 1, \dots, p$;
(vi) an overall persistence measure of a macro shock j to aggregate output is given by the sum of the measure in (iv) and (v) i.e., $P_{Mj} + P_{MXj} \; j =$

[2] The innovations v_t and ε_t are assumed to be uncorrelated.

[3] For simplicity all the elements of w are set to unity so that total output is represented by the sum of the logarithms of sectoral Gross Value Added.

$1, \ldots, p,$. Thus, the overall persistence of a macro shock j depends on the degree and direction of correlation of the particular shock with the rest of the macro shocks hitting the economy.

Moreover, the above measures are related as follows:

$$P_Y^2 = \lambda P_M^2 + (1 - \lambda) P_O^2 \quad (3)$$

and

$$P_M^2 = \sum_{j=1}^{p} \mu_j^2 (P_{Mj}^2 + P_{MXj}). \quad (4)$$

In equation (3) the (squared of) overall persistence in aggregate output is decomposed into an element caused by macro shocks and an element driven by other shocks; the parameter λ is the weight assigned to the persistence of macro shocks. In equation (4) the (squared of) persistence measure due to macro shocks is given by the weighted average of the persistence from the direct effects of these shocks and the persistence caused by the correlation between the macro shocks (with weights given by μ_j^2).

The effects of shocks on the output of each sector can also be computed. The persistence measures for total economy in (i) can be estimated from the multi-sectoral model (1a)-(1b) as a matrix P with elements the cross-sectoral persistence effects of shocks on sectoral output. The off-diagonal element (i, j) measures the long-run response of output level in sector i to shocks in sector j. The k–th diagonal element of P corresponds to the measure of persistence for sector k due to shocks (macro or sector-specific) hitting the particular sector. The sector-specific persistence measures given by the diagonal elements can be decomposed for any given sector as in equation (3) and (4) presented above.

3. DATA

We use seasonally adjusted quarterly data over the period 1995Q1-2014Q4 on the Gross Value Added (in constant 2005 prices) covering all sectors of the Cypriot economy. In total we use eight broad sectors, namely[4]:

- **Agriculture**: agriculture, forestry and fishing (A).

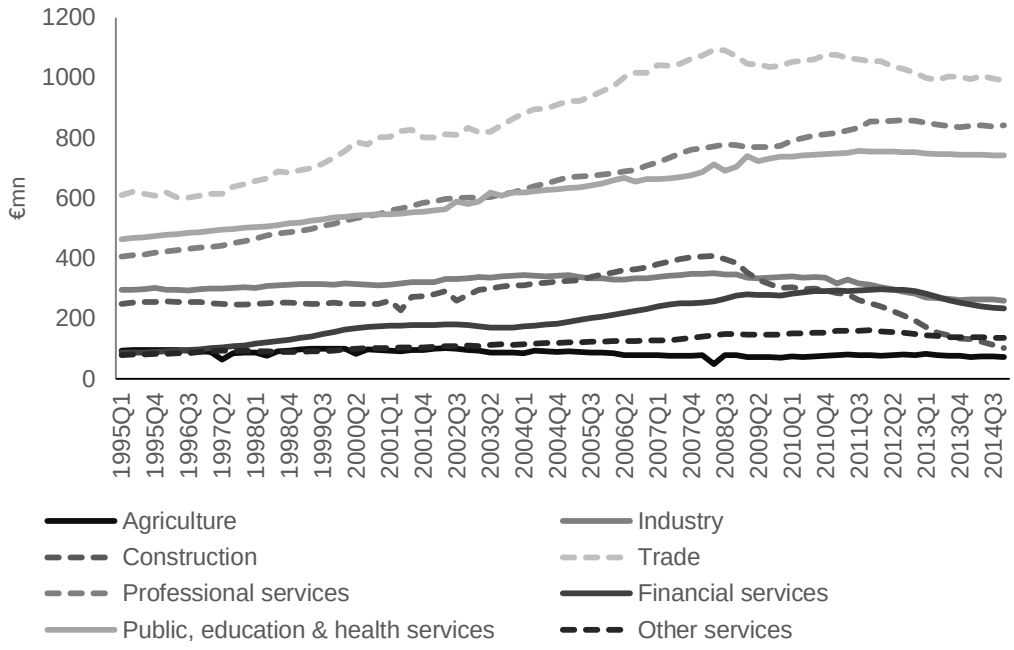
[4] The NACE Rev. 2 classification is shown in brackets

- **Industry**: mining and quarrying (B); manufacturing (C); electricity, gas, steam and air conditioning supply (D); water supply, sewerage, waste management and remediation activities (E).
- **Construction** (F).
- **Trade**: wholesale and retail trade; repair of motor vehicles and motorcycles (G); transportation and storage (H); accommodation and food service activities (I).
- **Professional services**: information and communication (J); real estate activities (L); professional, scientific and technical activities (M); administrative and support service activities (N).
- **Financial and insurance activities** (K).
- **Public, health and education services**: public administration and defence; compulsory social security (O); education (P); human health and social work activities (Q).
- **Other services**: arts, entertainment and recreation (R); other service activities (S); activities of households as employers; undifferentiated goods and services producing activities of households for own use (T).

Macroeconomic variables are also employed as a proxy for various shocks that hit the economy. In particular, the shocks are assumed to operate via unanticipated changes in oil prices, credit, exchange rates (under two scenarios, namely the British pound one and the Russian rouble) and stock prices.

Figure 1 plots the Gross Value Added (GVA) in real terms for each sector over the period 1995 - 2014. The sectors' experiences are distinct mainly in terms of levels GVA but also in terms of evolution of the series over time. However, for most of the cases, the upward trend is interrupted in 2009 as a result of the global financial crisis. Historically, the trade sector, which also includes tourism services, has been making the largest contribution to aggregate output. The sector of professional services was growing steadily until 2009 with a GVA between 2005-2006 similar to that of public, education and health services. After 2009 professional services have been gaining importance over the sector of public, education and health services. The construction sector experienced the largest losses in terms of GVA over the period 2008-2014; its GVA currently stands slightly above that of the smallest sector of the economy, i.e. the agriculture sector.

Figure 1. Gross Value Added by sector (constant 2005 prices)



4. EMPIRICAL ANALYSIS

Prior to the estimation of the multi-sectoral model described above, the trend properties of the sectoral GVA time series were examined using unit root and cointegration tests. The Augmented Dickey-Fuller tests for a unit root in the log-levels of the sectoral GVA cannot be rejected. Moreover, evidence is found in favour of rejecting the unit root hypothesis in the case of the growth rates of sectoral GVA.[5] The tests therefore indicate that output in the eight sectors of the economy can be treated as difference stationary variables. The presence of common trends among sectoral output series was investigated by applying Johansen's tests for cointegration (Johansen 1988). The time series of sectoral GVA are found to be cointegrated with one or two cointegrating vectors (i.e. common trends) depending on the specification of the deterministic terms used.[6] According to Lee et al. (1992) the small number of cointegrating relationships among the output of the sectors suggests that output fluctuations stem largely

[5] The Augmented Dickey-Fuller models include a constant, a deterministic trend in cases where it is found statistically significant, and up to four lags.

[6] The detailed results of unit root and cointegration tests are available upon request.

from independent, sector-specific shocks than from shocks affecting simultaneously all the sectors of the economy.

We proceed with the estimation of various versions of model in (1a)-(1b).[7] A simple version of the model is obtained in the case where the macro shocks are not identified and are therefore part of model's innovations; thus the empirical model is given by an unrestricted Vector Autoregression (VAR) in the growth rates of the m sectors

$$\Delta y_{(i)t} = c_{(i)0} + \sum_{s=1}^{r} c_{(ii)s}\Delta y_{(i)t-s} + \sum_{j=1,j\neq i}^{m}\sum_{s=1}^{r} c_{(ij)s}\Delta y_{(j)t-s} + u_{(i)t}, \qquad (M_1)$$

and model M_1 gives the equation for the i –th sector. Furthermore, imposing restrictions on the effects of the lagged output growth of sectors on the growth rate of sector i we obtain the following model

$$\Delta y_{(i)t} = c_{(i)0} + \sum_{s=1}^{r} c_{(ii)s}\Delta y_{(i)t-s} + \sum_{s=1}^{r} b_{(i)s}\Delta y_{(-i)t-s} + e_{(i)t}, \qquad (M_2)$$

where $\Delta y_{(-i)t} = \sum_{j=1,j\neq i}^{m} \Delta y_{(j)t}$. In model M_2 output growth in sector i is modelled by the past growth rates in sector i and past aggregate output growth in the rest of the economy. A more restricted version of model M_2 is also estimated in which variables with low statistical significance are excluded; in particular all the parameters of model M_2 with t-ratio lower than one (in absolute value) are set to zero and we refer to the resulting model as M_3.

For the above specifications (M_1-M_3) we computed persistence measures to shocks which can be sector-specific and/or macro-related since none of the macroeconomic shocks is explicitly identified. All models were estimated using the Full Information Maximum Likelihood (FIML) method; two lags of sectoral and aggregate output growth were included. The estimates of sectoral and aggregate persistence measures for models M_1, M_2, and M_3 are presented in Table 1.

The restricted specifications (M_2 and M_3) deliver more precise estimates in line with the findings of Lee et al. (1992). Specifically, the aggregate persistence measure obtained from the most parsimonious model M_3 is estimated at 1.545 which is lower than that obtained using models M_1 and M_2. The size of the long-run response of aggregate output to shocks is the largest in the unrestricted

[7] The empirical analysis heavily draws on the steps followed by Lee et al. (1992).

model M_1. The sectoral persistence measures vary considerably between sectors with financial and insurance activities, and agriculture exhibiting the highest and lowest persistence to shocks respectively in all specifications considered. The effects of shocks on the output of the sectors of professional and other services, and construction are characterised by high persistence.

Table 1. Sectoral and aggregate persistence measures

	Models		
Sectors	M_1	M_2	M_3
1. Agriculture	0.650	0.501	0.671
	(0.147)	(0.004)	(0.002)
2. Industry	2.775	1.491	1.344
	(1.807)	(0.104)	(0.034)
3. Construction	4.603	2.111	1.708
	(3.218)	(0.343)	(0.083)
4. Trade	4.029	1.552	1.110
	(2.791)	(0.116)	(0.006)
5. Professional services	4.866	2.460	1.994
	(3.286)	(0.378)	(0.086)
6. Financial and insurance activities	13.150	6.822	5.584
	(9.318)	(4.114)	(1.398)
7. Public, health and education services	2.200	0.997	0.828
	(1.438)	(0.057)	(0.012)
8. Other services	4.557	2.590	2.455
	(2.937)	(0.450)	(0.378)
Aggregate output	4.411	2.175	1.545
	(3.136)	(0.628)	(0.167)

Note: Standard errors are shown in brackets.

Next the contribution of various identified macroeconomic shocks and sector-specific shocks towards the total persistence measure is analysed using an empirical version of model (1a)-(1b) based on model M_2

$$\Delta y_{(i)t} = c_{(i)0} + \sum_{s=1}^{r} c_{(ii)s}\Delta y_{(i)t-s} + \sum_{s=1}^{r} b_{(i)s}\Delta y_{(-i)t-s} + \sum_{k=1}^{p}\sum_{s=0}^{r} \gamma_{(ik)s} v_{(k)t-s} + \eta_{(i)t} \qquad (M_{2m})$$

where the index $i = 1, \dots, 8$ denotes as before the i –th sector and $v_{(k)}$ for $k = 1, \dots, 4$ represents and the k –th macro shock defined in equation (1b).

In particular we examine the effects of unanticipated changes in the following macroeconomic variables:

- Nominal international oil prices (oil price shock)
- Loans to non-financial corporations (credit shock)
- Euro exchange rate to (i) British pound (GBP) and (ii) Russian rouble (RUB) (foreign exchange shock)
- Cyprus stock exchange general index (stock market shock).

Each macro shock is determined by a model given in Table 2. The specification strategy followed involved the inclusion of lagged dependent variable terms and other relevant explanatory variables motivated by economic theory, so that the residuals from the most parsimonious specifications were serially uncorrelated. Since the residuals of the macro equations will be used to proxy unexpected changes, i.e. shocks, it is crucial that there is no evidence of dependence patterns in the residuals.

The percentage changes of oil prices are modelled by an AR(5) process augmented by seasonal dummies, while the percentage changes of euro exchange rate to GBP and to RUB are modelled by an AR(3) and an AR(1) process respectively. Credit growth depends on its own lags (up to 4th order), lagged changes in lending interest rates for non-financial corporations as well as on past changes in the unemployment rate. Stock returns are determined by their first lag, past inflation values and lagged changes in the deposit interest rate for non-financial corporations.

The specifications of the models that determine the macro shocks described above, are re-estimated jointly with the system of sectoral output growth equations given in M_{2m} using the Full Information Maximum Likelihood method (FIML). The system of the eight sectoral equations is estimated together with the four macro shocks with the foreign exchange shock simulated first by the euro to GBP and then by the euro to RUB rate. The empirical model included two lags of sectoral and aggregate growth rates along with the current and lagged values of macro innovations. Subsequently two hypotheses regarding the effects of the identified macro shocks on the growth rate of output in the eight sectors were tested. The hypotheses involve the parameters $\gamma_{(ik)s}$ of model M_{2m} as follows

$H_{01}: \gamma_{(ik)0} = \gamma_{(ik)1} = \gamma_{(ik)2} = 0,\ i = 1, \dots, 8,\ k = 1, \dots, 4$

$H_{02}: \sum_{s=0}^{2} \gamma_{(ik)s} = 0,\ i = 1, \dots, 8,\ k = 1, \dots, 4.$

Table 2. Estimates of the equations used in the derivation of macro shocks

Oil price equation

$DLP_t = -0.118 + 0.203S_1 + 0.160S_2 + 0.187S_3 + 0.137DLP_{t-1} - 0.163DLP_{t-2} + 0.135DLP_{t-3} - 0.111DLP_{t-4} - 0.211DLP_{t-5} + u_{1t}$

(-2.760) (3.128) (2.747) (3.042) (0.110) (-1.286) (1.075) (0.883) (-1.692)

Adj. $R^2 = 0.179$, SE of regression = 0.161, LLF = 34.104, SC1 = 0.052 [p-value=0.820], SC4 = 3.401 [p-value=0.493]

Credit growth equation

$C_t = 0.013 + 0.601C_{t-1} - 0.424C_{t-2} + 0.275C_{t-3} + 0.200C_{t-4} + 0.039DLRS_{t-1} + 0.007DLRS_{t-2} + 0.003DLRS_{t-3} + 0.072DLRS_{t-4} - 0.004DLRL_{t-1} + 0.002DLRL_{t-2}$

(2.452) (4.985) (-3.117) (2.086) (1.837) (1.761) (0.324) (0.138) (3.287) (-0.436) (0.252)

$-0.012DLRL_{t-3} - 0.028DLRO_{t-1} - 0.021DLRO_{t-2} + 0.019DLRO_{t-3} - 0.081DLRO_{t-4} -0.014UR_{t-1} - 0.012UR_{t-2} + u_{2t}$

(-1.436) (-1.273) (-0.905) (0.843) (-3.356) (-2.506) (-2.142)

Adj. $R^2 = 0.629$, SE of regression = 0.024, LLF = 176.75, SC1 = 1.603 [p-value=0.205], SC4 = 7.281 [p-value=0.122]

Exchange rate equation (Euro to GBP)

$DER_t = 0.001 - 0.021DER_{t-1} - 0.123DER_{t-2} + 0.222DER_{t-3} + u_{3t}$

(0.152) (-0.179) (-1.075) (1.933)

Adj. $R^2 = 0.030$, SE of regression = 0.041, LLF = 130.59, SC1 = 0.987 [p-value=0.320], SC4 = 3.896 [p-value=0.420]

Exchange rate equation (Euro to RUB)

$DER_t = 0.027 + 0.203DER_{t-1} + u_{3t}$

(1.644) (1.652)

Adj. $R^2 = 0.024$, SE of regression = 0.136, LLF = 42.41, SC1 = 0.034 [p-value=0.854], SC4 = 0.527 [p-value=0.971]

Stock Returns equation

$R_t = 0.055 + 0.369R_{t-1} - 6.892INF_{t-1} - 7.058INF_{t-2} - 0.009DDR_{t-1} + u_{4t}$

(1.390) (3.387) (-2.535) (-2.557) (-0.123)

Adj. $R^2 = 0.204$, SE of regression = 0.233, LLF = 5.469, SC1 = 1.143 [p-value=0.225], SC4 = 7.406 [p-value=0.116]

Notes: Equations were estimated using the OLS method. The variable symbols are as follows: DLP = changes in the (log) nominal oil prices, S_i = seasonal dummy variable for the i-th quarter, C = changes in the (log) stock of loans to non-financial corporations, DLRS = changes in the lending interest rate for non-financial corporations (amounts below €1mn), DLRL = changes in the lending interest rate for non-financial corporations (amounts over €1mn), DLRO = changes in the lending interest rate for non-financial corporations (overdraft facilities), UR = changes in the unemployment rate, DER = changes in the (log) Euro exchange rate, R = Cyprus stock market returns, INF = inflation measured by the Consumer Price Index, DDR = changes in the deposit (1 year) interest rate for non-financial corporations.
Figures in brackets are t-ratios. LLF is the maximised log likelihood, SC1 and SC4 are the Lagrange Multiplier statistics for testing residual serial correlation of first and fourth order respectively which are chi-squared distributed with one and four degrees of freedom.

Under the first hypothesis H_{01}, the macro shocks have no short-run or long-run effects on the growth rates of sectoral output. The second hypothesis H_{02} is less restrictive than the first, since macro shocks can impact output growth in the short run but not in the long run. The Wald statistics for the null hypothesis H_{01} and H_{02} are given in Table 3. In the first specification where the foreign exchange shock comes from the euro to British pound exchange rate, we find that more sectors are affected by macro shocks compared to the second specification in which the exchange rate shock is through the Russian rouble. In the first specification the oil price shock is found to impact output growth in the sectors of construction, trade and, to a lesser degree, other services, while in the second specification sudden changes in oil prices influence significantly output growth only in other services. The credit shock affects the most sectors in both specifications, notably construction, trade, public, health and education services as well as other services. Unanticipated changes in the euro to British pound exchange rate influence the growth rate of output in construction, public, health education and other services and, to a smaller extent, in professional services. Shocks to the Russian rouble exchange rate are not found to significantly impact sectoral output growth. Both specifications provide evidence that stock market shocks impact primarily on output growth in the sectors of trade and professional services.

Prior to moving on to the discussion of the persistence measures, we impose further parameter restrictions on model M_{2m} by excluding variables with t-values less than unity in absolute terms. The sectoral and aggregate persistence measures derived on the basis of this model are presented in Table 4 for the specifications with the British pound and the Russian rouble exchange rate shock. The measure of the total persistence of shocks to sectoral and aggregate output is given in column (1). The total persistence measure is decomposed in one element due to macro shocks and another due to other shocks shown in column (2) and (3) respectively. Using the relationship given in equation (4), the component measuring the persistence due to macro shocks can be further decomposed into the measures denoting the direct effect of each macro shock, presented in columns (4)-(7), and a term capturing the correlations between the macro shocks, given in the last column of Table 4.

Table 3. Wald test statistics (coefficients of macroeconomic shocks)

Macro shock	Oil price		Credit		Euro to GBP		Stock market	
	H_{01}	H_{02}	H_{01}	H_{02}	H_{01}	H_{02}	H_{01}	H_{02}
1. Agriculture	3.357	2.534	11.878*	2.606	1.937	0.140	6.128	2.199
2. Industry	7.547	1.709	7.932	6.826*	6.293	0.036	6.943	5.722*
3. Construction	12.224*	0.042	15.055*	1.395	15.116*	0.045	1.452	1.382
4. Trade	10.231*	0.163	11.512*	0.173	6.663	0.739	17.493*	7.339*
5. Professional services	3.866	0.179	7.234	0.438	6.380	5.693*	11.582*	1.245
6. Financial and insurance activities	4.830	0.001	3.822	0.034	4.404	0.320	3.903	2.747
7. Public, health and education services	5.188	0.050	9.075*	3.571	17.812*	14.874*	2.461	2.094
8. Other services	7.144	6.536*	15.531*	10.322*	9.083*	1.883	5.623	0.909
Macro shock	**Oil price**		**Credit**		**Euro to RUB**		**Stock market**	
	H_{01}	H_{02}	H_{01}	H_{02}	H_{01}	H_{02}	H_{01}	H_{02}
1. Agriculture	2.845	0.852	8.184	1.543	1.357	1.293	5.587	2.087
2. Industry	0.077	0.007	2.575	0.592	0.392	0.355	5.968	3.985
3. Construction	3.091	0.659	9.821*	0.029	1.085	0.036	1.799	1.513
4. Trade	6.529	0.011	11.892*	1.709	2.618	0.035	14.616*	7.728*
5. Professional services	1.182	0.656	6.234	0.782	1.315	0.456	9.456*	2.870
6. Financial and insurance activities	3.500	1.652	2.096	0.077	1.861	1.833	6.948	1.965
7. Public, health and education services	7.055	1.596	10.796*	8.009*	0.375	0.126	0.531	0.037
8. Other services	11.734*	4.260	9.829*	4.698	2.567	0.260	9.943*	0.665

Note: The Wald statistics for H_{01} and H_{02} are chi-squared distributed with 3 and 1 degrees of freedom respectively. The symbol "*" denotes rejection of the null hypothesis at 5% level and using the critical values from the chi-squared distribution H_{01} is rejected for values of the statistic larger (smaller) than 9.348 (0.216) and H_{02} is rejected for values of the statistic larger (smaller) than 5.024 (0.001).

The measures for the total persistence in Table 4 are of similar magnitude to those obtained from the restricted models in Table 1. Under both specifications in Table 4 the largest total persistence to shocks is estimated for the sector of financial and insurance activities, although these estimates are also associated with the largest standard errors; these findings are similar to those in Table 1. Moreover, as in Table 1, high total persistence is exhibited in the sectors of professional services, other services and construction.

In the first specification (GBP) the effects of macro shocks on aggregate output are smaller than the impact of other shocks albeit both components are statistically significant. For aggregate output, the estimated contribution of the two types of shocks (macro and other) to the total persistence is about the same (i.e. a weight of 0.5). At the sectoral level, the size of the persistence measure due to macro shocks is larger than the magnitude of the component due to other shocks in all sectors except agriculture and construction. However, the uncertainty surrounding the estimates of the macro shock persistence measure is higher than that in the case of other shocks; therefore the effects on sectoral output triggered by sector-specific shocks are associated with stronger statistical significance than the impact from macro shocks. Sector-specific shocks appear to be more dominant particularly in the sectors of financial and insurance activities, other services and industry as they account for over 80% of total persistence exhibited by sectoral output.

In the second specification (RUB) the persistence measures due to macro and other shocks are of about the same size but the significance of the macro shock is weaker. The estimated weight of the macro shocks in the computation of total persistence is much smaller (about 0.2) compared to the contribution of other shocks. The picture is somewhat different from the first specification also at the sectoral level. The macro persistence measure is larger than that of other shocks in the sectors of construction, trade, professional and other services. However, as in the first specification the macro persistence measures are associated with larger standard errors than the persistence estimates for other shocks and therefore weaker significance. In industry and financial activities, changes in macro variables were not found to be statistically significant and therefore persistence is determined only by the effects of other shocks. Also, we find a dominant contribution of other shocks to the total persistence in public, health and education services as well as in construction.

Table 4. Decomposition of persistence measures for shocks

Sectors	(1) Total P_Y	(2) Other P_O	(3) Macro P_M	(4) Oil $\mu_1 P_{M1}$	(5) Credit $\mu_2 P_{M2}$	(6) Euro to GBP $\mu_3 P_{M3}$	(7) Stock market $\mu_4 P_{M4}$	(8) Interaction $\Sigma \mu_j^2 P_{MXj}$
1. Agriculture	0.544	0.577	0.474	0.101	0.084	0.234	0.301	0.062
	(0.084)	(0.090)	(0.163)	(0.177)	(0.210)	(0.171)	(0.153)	–
2. Industry	1.081	0.872	1.698	0.033	1.500	0.060	0.774	0.032
	(0.128)	(0.091)	(0.515)	(0.491)	(0.426)	(0.484)	(0.470)	–
3. Construction	1.822	1.865	1.733	1.096	1.231	0.340	0.000	0.173
	(0.410)	(0.354)	(0.750)	(0.745)	(0.473)	(0.871)	–	–
4. Trade	1.450	1.222	1.940	0.167	0.323	0.493	1.857	-0.061
	(0.230)	(0.140)	(0.695)	(0.552)	(0.501)	(0.644)	(0.729)	–
5. Professional services	2.137	1.885	2.724	0.628	1.868	1.250	0.903	1.158
	(0.350)	(0.297)	(0.708)	(0.817)	(0.370)	(0.709)	(0.608)	–
6. Financial and insurance activities	6.545	6.274	9.055	3.039	6.189	1.269	5.085	6.999
	(1.929)	(1.995)	(7.623)	(6.256)	(6.239)	(5.509)	(4.912)	–
7. Public, health and education services	1.028	0.892	1.370	0.370	0.018	1.424	0.498	-0.537
	(0.175)	(0.148)	(0.556)	(0.398)	(0.317)	(0.606)	(0.302)	–
8. Other services	2.222	1.467	5.485	3.593	3.884	2.180	1.341	-4.464
	(0.312)	(0.190)	(2.518)	(2.116)	(1.613)	(1.629)	(1.090)	–
Aggregate output	1.546	1.804	1.183	0.582	0.969	0.194	0.300	-0.006
	(0.290)	(0.317)	(0.463)	(0.512)	(0.421)	(0.548)	(0.301)	–

Note: Standard errors are shown in brackets.

Table 4. Continued

Sectors	(1) Total P_Y	(2) Other P_O	(3) Macro P_M	(4) Oil $\mu_1 P_{M1}$	(5) Credit $\mu_2 P_{M2}$	(6) Euro to RUB $\mu_3 P_{M3}$	(7) Stock market $\mu_4 P_{M4}$	(8) Interaction $\Sigma \mu_j^2 P_{MXj}$
1. Agriculture	0.557	0.558	0.555	0.159	0.236	0.011	0.516	-0.039
	(0.097)	(0.085)	(0.292)	(0.138)	(0.390)	(0.015)	(0.226)	–
2. Industry	0.968	0.968	0.000	0.000	0.000	0.000	0.000	0.000
	(0.110)	(0.110)	–	–	–	–	–	–
3. Construction	1.996	1.915	3.498	3.055	1.725	0.040	0.388	-0.228
	(0.417)	(0.412)	(3.012)	(3.329)	(2.293)	(0.066)	(1.701)	–
4. Trade	1.608	1.199	2.274	0.526	0.378	0.601	2.018	0.316
	(0.257)	(0.137)	(0.666)	(0.391)	(0.554)	(0.246)	(0.707)	–
5. Professional services	2.147	2.067	2.481	0.828	1.384	0.855	1.287	1.166
	(0.370)	(0.330)	(0.973)	(0.735)	(0.673)	(0.582)	(0.826)	–
6. Financial and insurance activities	5.392	5.392	0.000	0.000	0.000	0.000	0.000	0.000
	(1.496)	(1.496)	–	–	–	–	–	–
7. Public, health and education services	1.075	1.075	1.073	0.066	1.048	0.043	0.419	-0.130
	(0.205)	(0.195)	(0.539)	(0.468)	(0.552)	(0.055)	(0.399)	–
8. Other services	2.273	1.646	6.173	4.362	4.210	0.000	1.068	0.211
	(0.365)	(0.241)	(3.545)	(2.909)	(2.056)	–	(1.208)	–
Aggregate output	1.710	1.707	1.724	1.210	0.457	0.081	0.793	0.664
	(0.325)	(0.324)	(0.926)	(0.746)	(0.836)	(0.101)	(0.773)	–

Note: Standard errors are shown in brackets.

The contribution of the macro persistence measures can be further decomposed into the direct effect of each macro shock (column 4-7) on sectoral and aggregate output, and the persistence resulting from the correlations between the different macro shocks (column 8). In the first specification, credit shocks are found to have the strongest direct influence on aggregate output among the four macro shocks examined. The effects of credit shocks are channelled into total activity through their impact on the value added of financial activities and other services, and to a smaller degree through their influence on the output of professional services and construction. Nevertheless, the contribution of credit shocks is statistically significant in five out of the eight sectors, most importantly the sectors of professional services, industry and construction. Sudden oil price changes, shocks to the domestic stock market and unanticipated changes in the euro to British pound exchange rate induce much smaller direct effects on aggregate output that are not found to be statically significant; the least important impact on the economy is due to the exchange rate shock. Some of these shocks, however, influence significantly the output of some sectors (e.g. the exchange rate and stock market shocks generate statistically significant effects on the output in public, health and education services, and in trade respectively). The persistence effect on aggregate output due to the interactions of between the macro shocks is negative, indicating that an unexpected change in one macro variable is related to shocks to the other macro variables that have offsetting effects as the latter lower the overall persistence. However, the magnitude of the interaction between shocks is very small, having minimal impact in reducing total persistence for aggregate output. The negative contribution is a result of offsetting persistence effects of shocks in trade, public, health and education services as well as in other services.

Looking at the impact of macro shocks in the second specification, we find that oil price shocks contribute the most to the macro persistence measure although their impact is not highly significant; the direct persistence effects associated with the rest of the macro shocks are even smaller and less significant. The size of direct oil shock effects is larger in the sectors of construction and other services, thereby driving the persistence effects on aggregate output. The interaction term due to the correlation between the macro shocks is large and positive in the second specification, thus adding to the total persistence. Consequently, the persistence effects of an unanticipated change in one macro variable in the

second specification is intensified by other macro shocks in the system. In particular a compounding impact of shocks is found in trade, professional and other services, while weak offsetting effects of shocks on total persistence are estimated for agriculture, construction, public, education and health services.

5. CONCLUSION

This paper studied the size of the long-run response of output to different types of shocks known as the persistence of shocks. The multi-sectoral model developed by Lee et al. (1992) was used, whereby the impact of shocks to both sectoral and aggregate output growth can be estimated. In the multi-sectoral framework the persistence of macroeconomic and sector-specific (other) shocks can be analysed; the contribution of each type of shock to the overall persistence of sectoral and aggregate output can also be estimated.

The analysis used quarterly data on the gross value added (constant prices) on eight sectors, which cover the whole of economic activity in Cyprus, to examine the long-run response of sectoral and aggregate output to macroeconomic and other shocks. The macro shocks studied relate to oil prices, credit, foreign exchange and stock prices. Two alternative foreign exchange shocks were considered: (i) euro to British pound and (ii) euro to Russian rouble. The findings depend on the specification used in relation to the exchange rate shock.

The results show that shocks have particularly persistent effects on the output of financial and insurance activities, professional services, construction and other services. Macroeconomic shocks contribute about the same or less than sector-specific shocks to the overall persistence of aggregate output, depending on the exchange rate specification. In general, sectoral output persistence is mostly driven by sector-specific shocks. Nevertheless, in the first specification (pound) macro shocks play a larger role in determining the total persistence of sectoral output than in the second specification (rouble). Comparing across sectors, macro shock effects are more prominent in shaping total persistence in agriculture and trade, in both specifications, and in construction and professional services in the first and second specification respectively. Among the macro shocks examined, credit and oil price shocks are found to have the strongest direct influence on aggregate output growth in the first and second specification respectively. The persistence of credit shocks is channelled into aggregate

output via their effects on the value added of financial activities, other services, professional services and construction. The long-run response of aggregate output to oil price shocks is mainly driven by the reaction of economic activity in the sectors of construction and other services. Furthermore, the interactions between macro shocks are not found to generate offsetting effects on the persistence for aggregate output.

The empirical analysis revealed that sector-specific shocks are at least as important as macroeconomic shocks in generating output fluctuations at the sectoral and aggregate level. Moreover, the sectors of financial and insurance activities, construction as well as professional and other services are found to be associated with higher persistence of shocks and therefore experience larger and more protracted output fluctuations in the event of shocks. These findings suggest that a more in-depth study is needed at the sectoral level to investigate the sources of sector-specific shocks, which play a larger role in determining persistence, and to examine whether these sources are related to sectoral rigidities or are intrinsic to the activities of particular sectors. Sector-specific policies or reforms might also be needed to mitigate the effects of shocks on growth at the sectoral and consequently at the aggregate level.

The framework used for the analysis allows us to study different sources of output fluctuations and to assess their importance in determining the long-run response of economic activity. The advantage of the persistence measures computed using this framework over the estimation of impulse response functions from VAR models is the invariance of the measures to the parameterisations of the moving average representation of sectoral output growth rates. The computation of impulse response functions is not invariant to the orthogonalisation chosen for the system innovations (i.e. shocks); furthermore impulse response analysis does not allow for correlations between shocks.

A limitation of the persistence measures computed here is that they pertain only to long-term responses of output to shocks, but short-term and medium-term effects are also of interest in policy analysis and policy-making. The current analysis can therefore be extended to compute “persistence profiles” i.e. persistence measures for different horizons as in Lee and Pesaran (1993). Moreover, this framework can be applied to the study of other macroeconomic

shocks, for example, fiscal, monetary (e.g. interest rates) or external activity (e.g. shocks to output of Cyprus's trading partners) shocks.

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