On The Predictive Content Of Production Surveys: A Pan-European Study

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ON THE PREDICTIVE CONTENT OF PRODUCTION SURVEYS: A PAN-EUROPEAN STUDY

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Abstract

For over forty years, Business Tendency Surveys have been collected in multiple member states of the European Union. Previous research has studied the predictive accuracy of the expectation variables included in those surveys through bivariate, within-country, Granger-causality tests, which has resulted in mixed conclusions. We extend previous research in various ways, as we (i) explicitly allow for cross-country influences, and (ii) do so using both bivariate and multivariate Granger-causality tests. Specifically, the multivariate El-Himdi and Roy test is adapted to jointly test the forecasting value of multiple production expectation series, to assess whether part of this joint effect is indeed due to cross-country influences, and to determine which countries' expectation series have most "clout" in predicting the production levels in the other member countries, or have higher "receptivity", in that their production levels are Granger-caused by the other countries' expectations.

KEYWORDS: Business surveys, Cross-correlations, Production Expectations, Granger causality.

1 INTRODUCTION

For over forty years, Business Tendency Surveys have been collected by the European Union in the framework of the Joint Harmonised EU Programme of Business and Consumer Surveys. The Programme was initially set up in 1961 by the European Commission, and currently includes the fifteen member states of the European Union.[1] Business Surveys are carried out on a monthly basis by various public and private institutions in the respective member countries. The presentation, methods and questions of the Business Tendency Surveys are harmonised across countries according to EU guidelines.[2] Two kinds of attitudinal data are collected: (i) "Judgments" (JUD), an assessment of the *current* or *past* status of a given variable, and (ii) "Expectations" (EXP), an estimation of the likely *future* status of that variable. These two types of attitudinal information are collected for five key components of the economy: Industry, Construction, Consumers, Retail Trade and Services. In this study, we focus on an *industry*-related indicator, the Production Expectations (*PEXP)*.

The sample size for each survey varies across countries according to their population size. Each month, almost 68,000 companies and 27,000 consumers across the European Union are currently surveyed. Not surprisingly, Business Surveys are both expensive and time-consuming. For example, the annual cost in 2003 for the European Commission of the Harmonised Joint EU Programme of Business and Consumer Surveys amounted to slightly over 4.5 million euros. This figure does not yet incorporate the costs incurred by the respective national institutions that carry out the actual surveys. The latter are estimated to be another 6 to 7 million euros.[3] These costs are often justified on the basis that they represent an early source of information for politicians, economists, researchers, senior executives and/or media. Indeed, the survey data become publicly available on the last day of each month, whereas Account data (ACC) - i.e. the actual, objectively measured, levels of a variable - are generally published only two to four months later (Buffeteau and Mora, 2000). However, *timeliness* is not a sufficient justification for the continued use of such expensive surveys. They should also prove to be *accurate* in predicting actual ACC data: if Business Tendency Surveys cannot be used as relevant predictors for the future state of the economy, there is no point using them for economic surveillance.

The *accuracy* of the $PEXP$ series will be measured by studying whether these can improve forecasts of future $PACC$[4] that are exclusively based on the past of the $PACC$ series. More precisely, we will investigate whether the variance of the error in forecasting future values of the $PACC$, using an (optimal) forecast based on the observed values of both $PACC$ and $PEXP$ series is *strictly smaller* than the variance of the prediction error, using an (optimal) forecast *only* based on the observed values of the $PACC$ series. If this is the case, we may conclude that $PEXP$ series Granger causes the $PACC$ series (Granger, 1969). In this paper, the "predictive content" always refers to this notion of Granger causality.

The predictive content of Business Surveys has already been investigated by a substantive number of researchers. Bergström (1995), Lindström (2000), Öller and Tallbom (1996), and Teräsvirta (1986), for example, found evidence that Business Tendency Surveys variables have a significant predictive content in Finland and Sweden. Hanssens and Vanden Abeele (1987), on the other hand, studied the predictive content of $PEXP$ for Belgium, France, Germany, The Netherlands and Italy, and found that the inclusion of $PEXP$ did not systematically improve the forecasting performance of simple univariate time-series extrapolations of the $PACC$ series. Hence, previous research ended in mixed results, and the question on the predictive value of Business Tendency Surveys remains open. We will contribute to this ongoing debate in a number of ways.

First, the existing literature focused on a limited subset of countries, ranging from one (e.g. Bergström, 1995 and Lindström, 2000) to five (Hanssens and Vanden Abeele,

1987) states. Our analysis, in contrast, uses data of more than ten countries.[5] Moreover, by using information that has just become publicly available, we are able to extend the end date of the analysis from, respectively, 1983 (Teräsvirta, 1986; Hanssens and Vanden Abeele, 1987) and 1998 (Lindström, 2000) to December 2002.

Second, unlike previous studies, we will take potential *cross-country* relationships into account. Previous studies only allowed for a within-country relationship, checking, for example, whether the French *PEXP* proved useful in predicting France's own future *PACC* series. We extend the scope of this investigation by testing whether also the *PEXP* in *other* countries (e.g. Germany, Italy, ...) have information value in predicting the future evolution of the French *PACC* series. Such cross-country influences may well exist among the various EU countries, as the free transfer of ideas, products and technologies among them is increasingly facilitated (Mahajan and Muller, 1994), resulting in both cross-country word-of-mouth effects (Tellis et al, 2003) and considerable trade among the various member states, as reflected in an intra-EU15 trade/GDP ratio of over 16% (Eurostat, 1999). Because of this economic interdependence, industrial optimism/pessimism in one country (e.g. Germany), as reflected in the evolution of its *PEXP*, may well affect the *PACC* in another country (e.g. France). Indeed, a positive evolution in the German *PEXP* series may not only stimulate its own *PACC*, but also its imports from other member states. As pointed out by *The Financial Times Europe* (2003, October 29), the improvement of "the business confidence in Germany, the eurozone's biggest economy" can be seen as a prelude to Europe's recovery from the recent economic crisis.

The aforementioned cross-country effects could be investigated through a sequence of *bivariate* tests. For example, bivariate Granger-causality tests could be implemented to assess whether *PEXP* in country X affects future *PACC* levels in country Y. This would constitute a straightforward extension of the abovementioned within-country studies. However, as the number of EU countries increases, the number of tests required to cover all possible combinations would rapidly become excessive, causing the individual *p*-values to suffer from the well-known multiple-testing problem (Bauer, Hommel and Sonnemann, 1988). As a third contribution, we will therefore apply the *multivariate* test procedure introduced by El Himdi and Roy (1996). Through this multivariate procedure, we will first investigate the general predictive content of the twelve *PEXP* series vis-à-vis the twelve *PACC* series. This joint Granger-causality test will offer a more powerful test on the predictive value of the ambitious European Union's Business Survey plan than a sequence of bivariate tests.

Next, we will adjust the El Himdi and Roy test statistic to answer three key questions of interest:

- Can we attribute part of this "general causality" to *cross*-country influences?
- Are there some countries whose *PEXP* are more informative for the future evolution of the *PACC* in other countries? For example, the abovementioned *Financial Times Europe* article (2003, October 29) attributes such "clout"[6] to the German economy, stating that European "recovery shows signs of strength as German business confidence grows".
- Are there countries whose *PACC* series is more predictable by other countries' *PEXP* series, and whose economy therefore seems to be more "receptive"[7] to changes in other countries' economic climate (as reflected in their respective *PEXP* series)?

Answering these questions should provide new insights into the economic interdependencies among the various member states in general, and more specifically, on the relative forecasting value of the Business Tendency Surveys undertaken in the different member states. Indeed, not all *PEXP* series may have the same predictive ability, neither for their own future *PACC*, nor for the *PACC* evolution in other member states of the European Union.

In sum, this paper differs from previously cited studies in several important aspects. It explores evidence of Granger causality at both the *country* and the *European* level, allowing for both *within-* and *cross-country* influences, in an extensive study based on a *more recent* time span and a *larger* sample of EU countries, using more powerful multivariate testing procedures.

2 LITERATURE REVIEW

The predictive content of Business Surveys was already investigated in a number of previous studies. However, most of these studies were based on Scandinavian countries. Bergström (1995) and Teräsvirta (1986) explored the relationship between the *PACC* series and a number of barometer (Business Survey) series using regression models. They compared the predictive performance of a model including Business Survey data with a simple autoprojective model for the volume of output in, respectively, Sweden and Finland. They both found substantial evidence for the predictive content of Business Survey data. Lindström (2000) extended these analyses by examining the short-term forecasting value of Business Surveys for predicting the volume of manufacturing output growth in Sweden up to 1998. Christoffersson, Roberts and Eriksson (1992) used a frequency domain analysis to investigate the relationship between *PACC* and Business Survey series of total manufacturing in Sweden. They found a high coherence between both at low frequencies. Öller and Tallbom (1996) applied an extended Kalman filter on the Business Survey series, and found - using the Granger and Newbold (1986, p.279) criterion - that incorporating survey data in the filter improved the predictive performance obtained from a univariate AR model. The general picture obtained from these earlier studies is that Business Survey variables have predictive content in explaining future *PACC* series, at least in the considered Scandinavian countries.

A different picture, however, emerges from the study of Hanssens and Vanden Abeele (1987), who investigated the predictive value of the *PEXP* series in five other European countries (Belgium, France, Germany, Italy and The Netherlands). Using bivariate Granger-causality tests, they found that current *PEXP* did *not* systematically predict next periods' *PACC* better than simple univariate time-series extrapolations.

While a variety of reasons could explain these conflicting findings (e.g. different countries, time frame and/or testing approach), it seems justified to state that the verdict is still out as to the predictive value of the *PEXP*. As these *PEXP* series are (i) *costly* to collect (cfr. supra), and (ii) *regularly used* - because of their timely character - by policy makers and managers alike, we feel that a *large-scale* (covering more EU countries with longer, more recent, time series) study using a more powerful multivariate test procedure is called for.

3 DATA

For ease of notation, we denote the Production Accounts *PACC* in country i at time t by Y_{it}, and use X_{it} to denote the surveyed Production Expectations *PEXP* made at t about the future production level in country i.

PEXP series are provided by the Directorate General Economy and Finance of the European Union.[8] They are by definition subjective, reflecting the respondents' optimism/pessimism w.r.t. the evolution of the production. They are expressed in Balance ($Bal = Pos - Neg$). Specifically, one asks the responding firms whether they expect certain variables to increase, decrease or remain stable over time, and subsequently subtracts all *decrease* (Neg) answers - in percentage points of total answers - from the percentage of *increase* (Pos) ones. A directional questionnaire is used as directions of change have been found to be easier to predict than point values (Jonung, 1986). Balance data were also used in Bergström (1995) and Lindström (2000), among others.[9]

PACC series are part of the National Accounts Statistics published by the OECD,[10] and are expressed as an index with 1995 scaled as base index 1 (at constant prices). Similar types of data were adopted, for example, in Hanssens and Vanden Abeele (1987), Christoffersson, Roberts and Eriksson (1992), and Bergström (1995), among others.

All countries in the sample belong to the European Union. The high degree of harmonisation of the EU surveys makes them a very well-suited instrument to conduct cross-country analyses. Moreover, the policy implications that could be drawn from a multivariate analysis at the European level make the choice of EU countries particularly attractive. In order to end up with a sufficiently large date range, we selected twelve EU countries out of the fifteen member states: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands and the United Kingdom. Three countries (Portugal, Spain and Sweden) were not withheld, as this would have resulted in the loss of multiple data points due to missing observations, since surveys in these countries began later. However, the twelve retained EU countries represent over 85% of the Gross Domestic Product of the EU15 in 2002 (at current prices and exchange rates).[11] All time series are collected on a monthly basis, and are already seasonally adjusted[12] by the data providers. The data range from January 1985 to December 2002, resulting in 216 observations.

A visual inspection (see Figure 1) reveals some apparent similarities in the *PACC* series among various member countries. Several of the series show a pronounced upward trend, but suffered from a temporary slowdown in the early 1990s (see e.g. the graphs for Belgium, France, Germany and the United Kingdom, among others). Still, this slowdown was much less pronounced in countries like Denmark and The Netherlands, and even less so in Ireland.

[Figure 1]

Also in the *PEXP* series (see Figure 2), some similarities seem to be present (see in this respect the graphs for Belgium, France and Germany), while countries like Ireland and Denmark seem to follow a more idiosyncratic evolution.

[Figure 2]

In sum, this preliminary visual inspection suggests that (i) some cross-country commonalities and influences could well be present, but that (ii) this will probably not be homogeneous across all member states.

4 METHODOLOGY AND RESULTS

In line with existing literature (see e.g. Hanssens and Vanden Abeele, 1987), we adopt the notion of Granger causality between *PEXP* (X_{it}) on future *PACC* (Y_{it}) to assess the predictive value of the Business Tendency Surveys' *PEXP* series. Unlike previous studies however, we will conduct the analysis at various levels. First, in Section 4.1, we describe the bivariate Haugh (1976) test (i) to determine whether the *PEXP* series in country i ($i = 1, ..., 12$) Granger causes the *PACC* series in that same country (Section 4.1.2), and (ii) we apply this same testing procedure to assess whether *PEXP* in i Granger causes *PACC* in j (Section 4.1.3). Next, we introduce the multivariate El Himdi and Roy (1997) test to quantify the *combined* predictive content of all *PEXP* series, considering all countries together (Section 4.2.1). We subsequently modify the El Himdi and Roy statistic to determine whether part of this combined predictive value can be attributed to *cross*-country influences (Section 4.2.2). Finally, we propose two further modifications to quantify (i) which countries' *PEXP* series are more informative as to the future *PACC* levels in other countries, i.e. have most "clout", and (ii) which countries' *PACC* series are most predictable through other countries' *PEXP*, i.e. have a higher "receptivity" to the production sentiment in other countries (Section 4.2.3).

Each one of these tests requires stationarity of the series under investigation. In line with prior studies (see e.g. Hanssens and Vanden Abeele, 1987; Öller and Tallbom, 1996), it was found, in various (unreported) stationarity tests, that all *PEXP* series (X_{it}) were already stationary, while the *PACC* series (Y_{it}) required seasonal differencing of order 12 ($\nabla^{12}Y_{it} = Y_{it} - Y_{it-12}$) to achieve stationarity.

4.1 Causality tests based on bivariate cross-correlations

4.1.1 Methodology

For the bivariate test in country i, both time series, X_{it} and $\nabla^{12}Y_{it}$, are first modelled as a univariate ARMA process, i.e.

$$\begin{aligned} \Phi^x(L)X_{it} &= C^x + \Theta^x(L)u_{it} \\ \Phi^y(L)\nabla^{12}Y_{it} &= C^y + \Theta^y(L)v_{it} \end{aligned} \tag{1}$$

where $\Phi^x(L)$ and $\Phi^y(L)$ are autoregressive polynomials, $\Theta^x(L)$ and $\Theta^y(L)$ moving-average polynomials, and C^x and C^y the deterministic components (here, constant terms). After filtering the series with the above ARMA models, we obtain estimated innovation series u_{it} and v_{it}, which are white-noise processes with zero mean, possibly correlated with each other at different leads and lags.

If we consider both series of innovations, u_{it} and v_{it}, it is well known (see e.g. Gouriéroux and Monfort, 1990, p.368) that X_{it} is not Granger causing Y_{it} if and only if all cross-correlations at positive lags between u_{it} and v_{it} are equal to zero. So, with $\rho_{v_iu_i}(k) = corr(u_{it}, v_{it+k})$:

$$H_0 : X_{it} \nRightarrow Y_{it} \Leftrightarrow \rho_{v_iu_i}(k) = 0 \text{ for } k = 1, 2, 3, ..., \tag{2}$$

where $\nRightarrow$ means "does not Granger cause".

The bivariate cross-correlations are estimated as

$$\hat{\rho}_{v_i u_i}(k) = \frac{\sum_{t=1}^{T-k} \hat{u}_{it}\hat{v}_{it+k}}{\left(\sum_{t=1}^{T} \hat{u}_{it}^2\right)^{\frac{1}{2}} \left(\sum_{t=1}^{T} \hat{v}_{it}^2\right)^{\frac{1}{2}}}. \tag{3}$$

If the null hypothesis of no Granger causality holds, $\hat{\rho}_{v_i u_i}(k)$ should be close to zero for all positive lags. A natural test statistic for the hypothesis of no Granger causality is then provided by Haugh (1976):

$$Q_M = T \sum_{k=1}^{M} \left(\hat{\rho}_{v_i u_i}(k)\right)^2 \backsim \chi_M^2 \ , \tag{4}$$

where χ_M^2 is a Chi-square distribution with M degrees of freedom (under the null hypothesis (2)). For a pre-specified value of M,[13] Q_M is computed and the hypothesis of no Granger causality is rejected if $Q_M > \chi^2_{M,1-\alpha}$, where $\chi^2_{M,1-\alpha}$ is the $(1-\alpha)$ quantile of the Chi-square distribution with M degrees of freedom.

4.1.2 Results of the bivariate within-country predictive content

Traditionally (see e.g. Section 2 for a review), the *within*-country forecasting value of the *PEXP* series was assessed. This results, in our setting, in twelve tests, whose p-values are reported in Table 1.

[Table 1]

The findings confirm our earlier observation that the evidence is mixed concerning the *within*-country predictive content of *PEXP*, even if some strong Granger causalities clearly appear in the table. Indeed, the null hypothesis of no Granger causality is rejected for 7 of the 12 countries at the 5% level. In line with Teräsvirta (1986), we find a significant predictive content for the Finnish *PEXP* series ($p = 0.000$). Note, however, that this result cannot be generalized to all Scandinavian countries, as the null hypothesis could not be rejected for Denmark ($p = 0.193$). This was also the case for Ireland ($p = 0.189$) and the United Kingdom ($p = 0.132$).

4.1.3 Results of the bivariate cross-country predictive content

As indicated before, *PEXP* may influence not only the own *PACC* series (see Section 4.1.2), but also (some) other countries of the European Union, for example, through a word-of-mouth effect across various countries or because of intensive import/export activity among the member states.

This possibility can be formally investigated by running an additional 132 bivariate Haugh tests, as summarized in the off-diagonal elements of Table 2.[14] A value situated in the i^{th} row and j^{th} column of Table 2 represents the p-value for the test that the *PEXP* in country i Granger causes *PACC* in country j.

[Table 2]

In line with our earlier discussion on the dominant role of the German economy, more than predicting its own *PACC*, German *PEXP* also Granger causes *PACC* changes in several other countries, i.e. in Belgium, Finland, France, Greece, Luxembourg and The Netherlands (at the 5% level). A similar "clout" can be attributed to France and Belgium. The former result is not surprising, as France and Germany are often seen as two of the key forces (both economically and politically) of the European unification (see e.g. The Economist 2003, October 23). The latter finding, in turn, may be linked to Belgium's central role in the location of the European Union's administration.

The British *PEXP*, in contrast, does not Granger cause any other country's *PACC* at the 5% probability level. This result may reflect the distinct position of the United

Kingdom in terms of geography, economy and culture (see Northcott, 1995 for a more elaborate discussion).

Note further that Table 2 is not symmetric. Consider, for example, Luxembourg. Its *PEXP* series is not informative for the future evolution of the *PACC* series of its neighbouring Belgium and Germany, while those countries' *PEXP* series Granger cause the *PACC* series of Luxembourg.

Even though the aforementioned examples provide some face validity to the figures of Table 2, it is obvious that the interpretation of that many test results is quite cumbersome, and may, not surprisingly, lead to some apparent "anomalies". For example, it is not immediately clear why *PEXP* in Luxembourg would Granger cause *PACC* in Greece, but not in its neighbouring, and culturally and economically more similar, Belgium. Moreover, even though 44 of the 132 off-diagonal p-values turned out to be smaller than 0.05, one should keep in mind that the p-values in Table 2 may suffer from the multiple-testing problem, and be biased downwards (Bauer, Hommel, and Sonnemann, 1988). Therefore, *the predictive power of the PEXP surveys is likely to be lower that what might be inferred from Table 2.*[15] To address these concerns, we introduce in Section 4.2 a multivariate extension of the bivariate Granger-causality tests used thus far.

4.2 Multivariate Granger-Causality tests

Since the multivariate approach allows to consider a *group* of *PEXP* and/or *PACC* together, it can be used to address our three remaining research questions. First, we introduce the general multivariate approach developed by El Himdi and Roy (1997) to assess the *general* predictive content of all *PEXP* time series, considering all countries together. Then, we detail the modified El Himdi and Roy test that allows us to identify whether part of the Granger causality obtained in Section 4.2.1 can be attributed to cross-country influences. Finally, we specify the necessary modifications for testing which countries have more "clout" and/or are more "receptive".

4.2.1 What is the predictive content of the combined *PEXP* series?

Let X_t and Y_t be two multivariate time series, $X_t \in \mathbb{R}^{d_1}$ and $Y_t \in \mathbb{R}^{d_2}$. In our case, $d_1 = d_2 = 12$, the number of EU countries considered. In a first step, the multivariate time series X_t (the twelve *PEXP* series) and $\nabla^{12} Y_t$ (the twelve seasonally differenced *PACC* series) are modelled separately, using Vector Autoregressive (VAR) models, where the order of each VAR model is determined by the SBIC (Schwartz Bayesian Information) Criterion, i.e.

$$\begin{aligned} X_t &= C^x + \Phi_1^x X_{t-1} + \Phi_2^x X_{t-2} + \ldots + \Phi_{\rho_x}^x X_{t-\rho_x} + U_t \\ \nabla^{12} Y_t &= C^y + \Phi_1^y \nabla^{12} Y_{t-1} + \Phi_2^y \nabla^{12} Y_{t-2} + \ldots + \Phi_{\rho_y}^y \nabla^{12} Y_{t-\rho_y} + V_t, \end{aligned} \tag{5}$$

with U_t and V_t two, possibly correlated, multivariate white-noise series, $U_t \in \mathbb{R}^{d_1}$ and $V_t \in \mathbb{R}^{d_2}$. Furthermore, C^x and C^y are deterministic components; Φ_i^x and Φ_j^y are autoregressive polynomials, $\Phi_i^x \in \mathbb{R}^{d_1 \times d_1}$ for $i = 1, \ldots, \rho_x$ and $\Phi_j^y \in \mathbb{R}^{d_2 \times d_2}$ for $j = 1, \ldots, \rho_y$. We denote:

$$U_t = \begin{pmatrix} u_{1,t} \\ \vdots \\ u_{d_1,t} \end{pmatrix} \text{ and } V_t = \begin{pmatrix} v_{1,t} \\ \vdots \\ v_{d_2,t} \end{pmatrix}. \tag{6}$$

Note that the series U_t obtained after filtering with a VAR model are likely to differ from the series obtained by filtering each individual component of X_t through univariate models. Indeed, the innovations U_t obtained from (5) are independent of the past of every single component of X_t. With a univariate filtering procedure, in contrast, the innovation series from the first series may still carry information related to the past of the other series of X_t. Such indirect effects among the components of the X_t (or $\nabla^{12} Y_t$) vector are filtered out in the VAR-based approach of (5).

The estimated innovations U_t and V_t are cross-correlated at various leads and lags:

$$\hat{R}^{VU}(k) = \mathrm{CORR}(\hat{U}_t, \hat{V}_{t+k}) = \begin{pmatrix} \hat{\rho}_{v_1u_1}(k) & \hat{\rho}_{v_1u_2}(k) & \ldots & \hat{\rho}_{v_1u_{d_1}}(k) \\ \vdots & & & \vdots \\ \hat{\rho}_{v_{d_2}u_1}(k) & \ldots & \ldots & \hat{\rho}_{v_{d_2}u_{d_1}}(k) \end{pmatrix} \in \mathbb{R}^{d_2 \times d_1} \quad (7)$$

with $k = \ldots, -2, -1, 0, 1, 2, \ldots$

The corresponding auto-correlations are defined as

$$\hat{R}^{UU}(k) = \mathrm{CORR}(\hat{U}_t, \hat{U}_{t+k}) \in \mathbb{R}^{d_1 \times d_1},\ \hat{R}^{VV}(k) = \mathrm{CORR}(\hat{V}_t, \hat{V}_{t+k}) \in \mathbb{R}^{d_2 \times d_2}. \quad (8)$$

Since the two series of innovations U_t and V_t are multivariate white noise, we know that $R^{UU}(k) = 0 = R^{VV}(k)$ for any $k \neq 0$.

Similar to (2), one can prove (see Gouriéroux and Monfort, 1990, pp.369-370) that

$$H_0 : X_t \not\Rightarrow Y_t \Leftrightarrow R^{VU}(k) = 0, \text{ for all } k > 0. \quad (9)$$

A natural test-statistic for the hypothesis of no Granger causality is proposed by El Himdi and Roy (1997). This test looks, for every $k = 1, \ldots, M$,[16] at the vector:

$$\mathrm{vec}\, \hat{R}^{VU}(k) = \begin{pmatrix} \hat{\rho}_{v_1u_1}(k) & \hat{\rho}_{v_2u_1}(k) & \ldots & \hat{\rho}_{v_1u_2}(k) & \ldots & \hat{\rho}_{v_{d_2}u_{d_1}} \end{pmatrix}^t, \text{ i.e.} \quad (10)$$

the correlation matrix $\hat{R}^{VU}(k)$ is vectorised into a vector of length d_1d_2. Under the null hypothesis, all components of this vector should be small. Note though, that not all components are independent of each other. Indeed, one can show that, under the null hypothesis and for $k > 0$,

$$\mathrm{cov}(\hat{\rho}^{(k)}_{v_iu_j}, \hat{\rho}^{(k)}_{v_{i'}u_{j'}}) \approx \frac{R^{vv}(0)_{ii'} R^{uu}(0)_{jj'}}{T}, \quad (11)$$

with $1 \leq i, i' \leq d_2$ and $1 \leq j, j' \leq d_1$ and $\approx$ standing for asymptotical equivalence.

Using this vector, one can compute (similar to (4)) the following multivariate test-statistic:

$$Q_{HR}^k = T\left[\operatorname{vec}\hat{R}^{VU}(k)\right]^t A^{-1}\left[\operatorname{vec}\hat{R}^{VU}(k)\right], \tag{12}$$

where A is the asymptotic covariance matrix of $\sqrt{T}\operatorname{vec}\hat{R}^{VU}(k)$, so $A = \hat{R}^{VV}(0)\otimes\hat{R}^{UU}(0)$, with $\otimes$ the Kronecker product. Hence, Q_{HR}^k can be plotted against k, giving an idea about the strength of the cross-correlation at various lags. The above quadratic form follows a $\chi^2_{d_1 d_2}$ distribution under the null hypothesis, leading to the El Himdi and Roy (1997) test-statistic:

$$Q_{HR} = \sum_{k=1}^{M} Q_{HR}^k \sim \chi^2_{Md_1d_2}. \tag{13}$$

This multivariate procedure provides a more powerful test than the bivariate analogues of Section 4.1. This power gain is derived from two sources. First, all twelve countries are pooled to find evidence of Granger causality. Moreover, it automatically permits to look for Granger causality across countries, meaning that we already allow for the possibility that the *PEXP* in one country Granger causes the *PACC* in another country. El Himdi and Roy (1997) applied this multivariate test to investigate the causal relations between money (M1 and M2) and income (Gross National Product) for Canada, as well as to study the causal directions between the Canadian and American economies.

The El Himdi and Roy (HR) test for the null hypothesis of no Granger causality between *PEXP* and *PACC* at the joint European level resulted in a test statistic Q_{HR} = 2687.760, with associated p-value = 0.000. The multivariate test procedure therefore established that, in combination, the twelve *PEXP* series from the European Business Surveys' program have predictive value in forecasting the actual *PACC* series, thereby offering further justification for their continued use.

In order to get insight into the distribution of the predictive content of *PEXP* over time, we consider the strength of the cross-correlation at lag k as measured by Q^k_{HR}, the k^{th} term of the test statistic Q_{HR}, defined in (12), as in El Himdi and Roy (1997). Specifically, the values of Q^k_{HR} are plotted with respect to the lag length, and compared with the marginal critical value $\chi^2_{d_1 d_2, 1-\alpha}$ (see Figure 3).

[Figure 3]

Figure 3 illustrates that the predictive content is significant for lags until approximately two years and a half. It slowly decreases over the first five years, before dropping completely under the significance cut-off.

4.2.2 Is part of the joint causality due to cross-country influences?

Knowing the predictive content of *PEXP* in the twelve EU countries together, one could wonder whether part of this causality can be attributed to cross-country influences, which is a natural extension of the bivariate cross-country analysis of Section 4.1.3. To test whether the joint cross-country causality is significant, we state the following null hypothesis:

$$H_0 : \tilde{R}^{VU}(k) = 0 \text{ for all } k > 0, \tag{14}$$

where $\tilde{R}^{VU}(k)$ is equal to $R^{VU}(k)$ without the elements on the diagonal, yielding a $d_1 \times (d_1 - 1)$ matrix.[17]

The test statistic is adjusted accordingly to:

$$Q^{cross}_{HR} = T \sum_{k=1}^{M} \left[\operatorname{vec} \widehat{\tilde{R}}^{VU}(k) \right]^t \tilde{A}^{-1} \left[\operatorname{vec} \widehat{\tilde{R}}^{VU}(k) \right], \tag{15}$$

which is $\chi^2_{Md_1(d_1-1)}$ distributed, where $\tilde{A}$ is the asymptotic covariance matrix of $\sqrt{T} \operatorname{vec} \widehat{\tilde{R}}^{VU}(k)$, $\tilde{A} = \widehat{\tilde{R}}^{VV}(0) \otimes \widehat{\tilde{R}}^{UU}(0)$.[18] An analogous reasoning can be applied to obtain a within-country test statistic Q^{within}_{HR}, which will be $\chi^2_{Md_1}$ distributed.

When testing for the joint nullity of all cross-correlations at positive lags (14), we obtain $Q_{HR}^{cross} = 2390.276$ (with $132 \times M$ degrees of freedom), with associated p-value $= 0.000$, and $Q_{HR}^{within} = 230.793$ (with $12 \times M$ degrees of freedom), with associated p-value $= 0.000$. This implies that cross-country influences clearly exist, and contribute to the high combined predictive content of *PEXP* series in Europe.

4.2.3 Which countries have more clout or are more receptive?

Finally, in order to more deeply understand the mechanisms of influence, and hence the underlying interdependences, within the European Union, one could further modify the multivariate procedure to also investigate whether the *PEXP* series in country i Granger causes the *PACC* of all other countries $j = 1, 2, ..., 12$, $i \neq j$, and therefore offer a quantification for that country's "clout". The modification consists of taking the estimated innovations u_{it} derived from that country's *PEXP* series (as derived from a univariate filter, since $d_1 = 1$), as well as the estimated innovations V_t' derived from the multivariate series containing the *PACC* of the eleven other countries (hence, $d_2 = 11$) when computing Q_{HR}.

Similarly, we may want to test whether the *PACC* series of a given country j is Granger caused by the *PEXP* of all other countries $i = 1, 2, ..., 12$, $i \neq j$, giving a measure of the "receptivity" of country j. To that extent, one takes the estimated innovations U_t' derived from the multivariate series containing the *PEXP* of the eleven other countries (i.e. excluding country j), hence $d_1 = 11$, as well as the estimated innovations v_{jt} derived from the univariate *PACC* series of country j ($d_2 = 1$). In both cases, the distribution of the test statistic is a χ^2_{11M}.

[Table 3]

Table 3 reports the results of the tests assessing the "clout" and the "receptivity" of each of the twelve EU countries. The second column provides the p-value for testing the Granger causality of the *PEXP* in the country mentioned in the first column on all other countries' *PACC* series. The smaller this value, the higher the "clout" of the country. The third column of Table 3 represents the p-value related to the test for Granger causality of the *PEXP* in all other countries on the *PACC* in that specific country. The smaller this value, the higher the "receptivity" of the country.

First of all, we may observe that only the *PEXP* series of Germany and France have highly significant predictive content (in the multivariate Granger sense) on future *PACC*. These findings are in line with our previous bivariate analysis, and confirm common intuition that those two economies are two key economic *drivers of the European integration*. The economic climate in those countries (as reflected in their balance scores on the *PEXP* series) is found to Granger cause the subsequent actual production in the rest of the European Union, which offers further justification for the quite large sample sizes[19] (and hence higher costs of data collection) in those countries' Business Tendency Surveys. In contrast, Germany has a low "receptivity" score: while it drives the European Union, it is less likely to be influenced by the other member countries.

Another key fact illustrated by the multivariate test is that many countries have no significant "clout", not even at very liberal significance levels; see e.g. Austria ($p = 0.889$), Denmark ($p = 0.810$), Ireland ($p = 0.345$), Italy ($p = 0.812$), and the United Kingdom ($p = 0.533$). This suggests that the highly significant findings of Section 4.2 will be mainly driven by a few key countries such as France and Germany. One could even question the usefulness of a continued use of the Business Tendency Surveys in countries like Denmark, Ireland or the United Kingdom, as they do not have a significant predictive power for the actual economic evolution in the other member countries (Table 3), nor for their own actual economic evolution (cf. Table 1). The latter conclusion is, however, conditional on the analyzed *PEXP* and *PACC* series. As indicated in Section 1, the Business Tendency Surveys also collect data on other components of the economy such as retail trade, services, construction..., and more research is necessary to assess whether this conclusion also holds in these other domains.

In terms of the "receptivity", we find a significant ($p < 0.05$) effect for three countries: Austria, Denmark and Finland. Our findings for Denmark are in line with Putsis et al. (1997), who showed that this country derives a higher percentage of its contacts from outside its borders than internal. This corroborates the fact that Denmark has low within-country predictive power ($p = 0.193$), while having high "receptivity" ($p = 0.029$; Table 3). As for Austria and Finland, more than 60% of the total trade of these former EFTA countries is directed towards the EU (Sapir, 1998), which may well explain their high receptivity scores.

Finally, it is worth noting that the United Kingdom and Ireland score low on both dimensions. This may reflect their geographically distinct position, but also - at least for the United Kingdom - the country's relative distinctiveness in terms of economic integration and culture (Northcott, 1995). The low "receptivity" and "clout" of Ireland, in turn, is in line with the pan-European study of Mahajan and Muller (1994), who found the Irish population to be much less sensitive to word-of-mouth influences, which is a key mechanism through which cross-country *PEXP* may influence future *PACC* levels.

5 CONCLUSIONS

Each month, for over forty years, the European Union, together with institutions from the fifteen member states of the European Union, carries out costly and time-consuming Business Tendency Surveys on the past, actual and future state of the European Economy. Since they are, on a regular basis, used for economic surveillance by several parties, there is a concern about their *accuracy* in predicting actually realized *ACC* data, especially since existing literature on the topic offers mixed evidence on the Surveys' predictive content.

In this paper, we tested the Granger causality between *PEXP* and *PACC* series from twelve European countries. Instead of only focusing on a sequence of bivariate within-country analyses, we also undertook a simultaneous, *multivariate* approach. Indeed, when predicting the future production level in a country, there is no reason to a priori ignore the information conveyed by Business Surveys in other countries. In this sense, the predictive content of *PEXP* series could be evaluated both at the *national* (bivariate test) and at the *European* (multivariate test) level.

While confirmation of Granger causality at the individual country level was not found for every country - seven countries out of twelve showed a significant predictive content at the 5% level - , very strong evidence of Granger causality was discovered at the multi-country level. It also turned out that the cross-country Granger causalities were jointly strongly significant, indicating that it could indeed be advantageous to exploit these correlations in multivariate forecast methods.

Moreover, it results from the multivariate analysis that some countries (i.e. France and Germany) have more “clout”, while others are more “receptive” (i.e. Austria and Finland and Denmark). Finally, the United Kingdom and Ireland seem to occupy a fairly isolated position. They both have no “clout” and no “receptivity”.

As a conclusion, we state that the harmonization of European Business Tendency Surveys allows to exploit cross-country relations between the different series and to improve forecasts of future Account data for an individual country by using a multivariate approach. More research is open to generalize these findings to other variables that are routinely collected in the EU Business Tendency Surveys.

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Notes

[1]i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden, and The United Kingdom. More recently, Business Surveys data are also collected from twelve Accession Countries, i.e. Bulgaria, Cyprus, The Czech Republic, Estonia, Hungaria, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

[2]We refer to "The Joint Harmonised EU Programme of Business and Consumer Surveys User Guide 2002" of the European Commission, Directorate General Economic and Financial Affairs, Economic Studies and Research, Business Surveys for more detailed information on how these surveys are implemented.

[3]Personal communication with the Business Surveys Unit of the European Commission, Directorate General Economic and Financial Affairs.

[4]*PACC* refers to the *Production* Accounts series.

[5]See Section 3 for more details on the choice of countries.

[6]Referring to the notion of asymmetry developed in the market-share literature (Cooper and Nakanishi, 1998, pp.56-57), "clout" is the ability of a brand or company to influence the other players (i.e. brands or firms) in a specific market, and consequently shape the demand and competition in this market. Similarly, in the context of *PEXP*, we denote by "clout" the ability of a country to Granger cause the future production level of other countries.

[7]See Cooper and Nakanishi (1998, pp.56-57) for a conceptually similar use of the term in the market-share attraction literature.

[8]The data are publicly available on http://europa.eu.int/comm/economy_finance/indicators/businessandconsumersurveys_en.htm

[9]For an in-depth discussion on the relative merits of such balance indicators, see e.g. Granger (1980, ch.7), Klein and Moore (1983) or Hanssens and Vanden Abeele (1987).

[10]See OECD publication, *Main Economics Indicators*, the Industrial Production Index (1995=1), ref. 2027K

[11]See OECD publication, *Main Economics Indicators*, Gross Domestic Product, 2002

[12]Seasonally adjusted Business Tendency Survey series were also used in Öller and Tallbom (1996) and Lindström (2000), among others.

[13]M is chosen equal to the square root of the length of the series, as often recommended (e.g. Diebold, 2001, p.136).

[14]Please note that the diagonal elements of Table 2 correspond to the abovementioned elements of Table 1.

[15]Because of this multiple testing issue, we only consider a probability level lower than or equal to 5%.

[16]M is again chosen to be equal to the square root of the number of observations.

[17]Recall that $d_1 = d_2$ in this application.

[18]In fact, $\tilde{A}$ is simply equal to A, from which the rows and columns corresponding to the diagonal elements of $R^{VU}(k)$ are deleted.

[19]According to "The Joint Harmonised EU Programme of Business and Consumer Surveys User Guide 2002", France and Germany together represent more than 25% of the industry-related surveyed units across the European Union.

Tables and Figures

Table 1: p-values of the Haugh test for assessing whether $PEXP$ of a selected country Granger causes $PACC$ in the same country.

Country	p-value
Austria	0.008*
Belgium	0.003*
Denmark	0.193
Finland	0.000*
France	0.000*
Germany	0.001*
Greece	0.080
Ireland	0.189
Italy	0.001*
Luxembourg	0.013*
The Netherlands	0.057
The United Kingdom	0.132

* significant at the 5% probability level.

Table 2: Bivariate cross-country analysis: p-values for the Haugh test for testing whether $PEXP$ in country i (i^{th} row) Granger causes $PACC$ in country j (j^{th} column)

		Production Accounts $PACC$											
	p-value*	*Austria*	*Belgium*	*Denmark*	*Finland*	*France*	*Germany*	*Greece*	*Ireland*	*Italy*	*Luxembourg*	*The Netherlands*	*The United Kingdom*
Production Expectations $PEXP$	*Austria*	0.008*	0.246	0.019*	0.234	0.002*	0.072	0.983	0.797	0.046*	0.721	0.227	0.302
	Belgium	0.013*	0.003*	0.003*	0.102	0.000*	0.137	0.068	0.052	0.006*	0.010*	0.019*	0.015*
	Denmark	0.004*	0.134	0.193	0.003*	0.185	0.780	0.927	0.247	0.139	0.530	0.311	0.191
	Finland	0.086	0.138	0.014*	0.000*	0.048*	0.293	0.694	0.012*	0.268	0.103	0.510	0.125
	France	0.000*	0.002*	0.001*	0.013*	0.000*	0.001*	0.008*	0.013*	0.001*	0.051	0.002*	0.134
	Germany	0.125	0.000*	0.152	0.010*	0.003*	0.001*	0.036*	0.552	0.162	0.039*	0.006*	0.441
	Greece	0.395	0.016*	0.152	0.023*	0.393	0.107	0.080	0.448	0.183	0.297	0.272	0.056
	Ireland	0.032*	0.053	0.039*	0.290	0.395	0.105	0.961	0.189	0.460	0.019*	0.042*	0.486
	Italy	0.022*	0.076	0.090	0.524	0.013*	0.463	0.196	0.444	0.001*	0.009*	0.024*	0.252
	Luxembourg	0.252	0.140	0.285	0.062	0.084	0.377	0.009*	0.709	0.200	0.013*	0.347	0.931
	The Netherlands	0.131	0.020*	0.138	0.021*	0.293	0.071	0.145	0.674	0.027*	0.444	0.057	0.311
	The United Kingdom	0.347	0.063	0.620	0.328	0.756	0.520	0.757	0.144	0.143	0.138	0.592	0.132

* significant at the 5% probability level

Table 3: p-values of the El Himdi and Roy test for assessing the "clout" and the "receptivity" of a selected country.

Country	Clout	Receptivity
Austria	0.889	0.005*
Belgium	0.058	0.159
Denmark	0.810	0.029*
Finland	0.122	0.028*
France	0.000*	0.052
Germany	0.004*	0.427
Greece	0.096	0.253
Ireland	0.345	0.476
Italy	0.812	0.250
Luxembourg	0.098	0.148
The Netherlands	0.156	0.357
The United Kingdom	0.533	0.796

* significant at the 5% probability level.

Figure 1: *PACC* (raw) time series of the twelve EU countries.

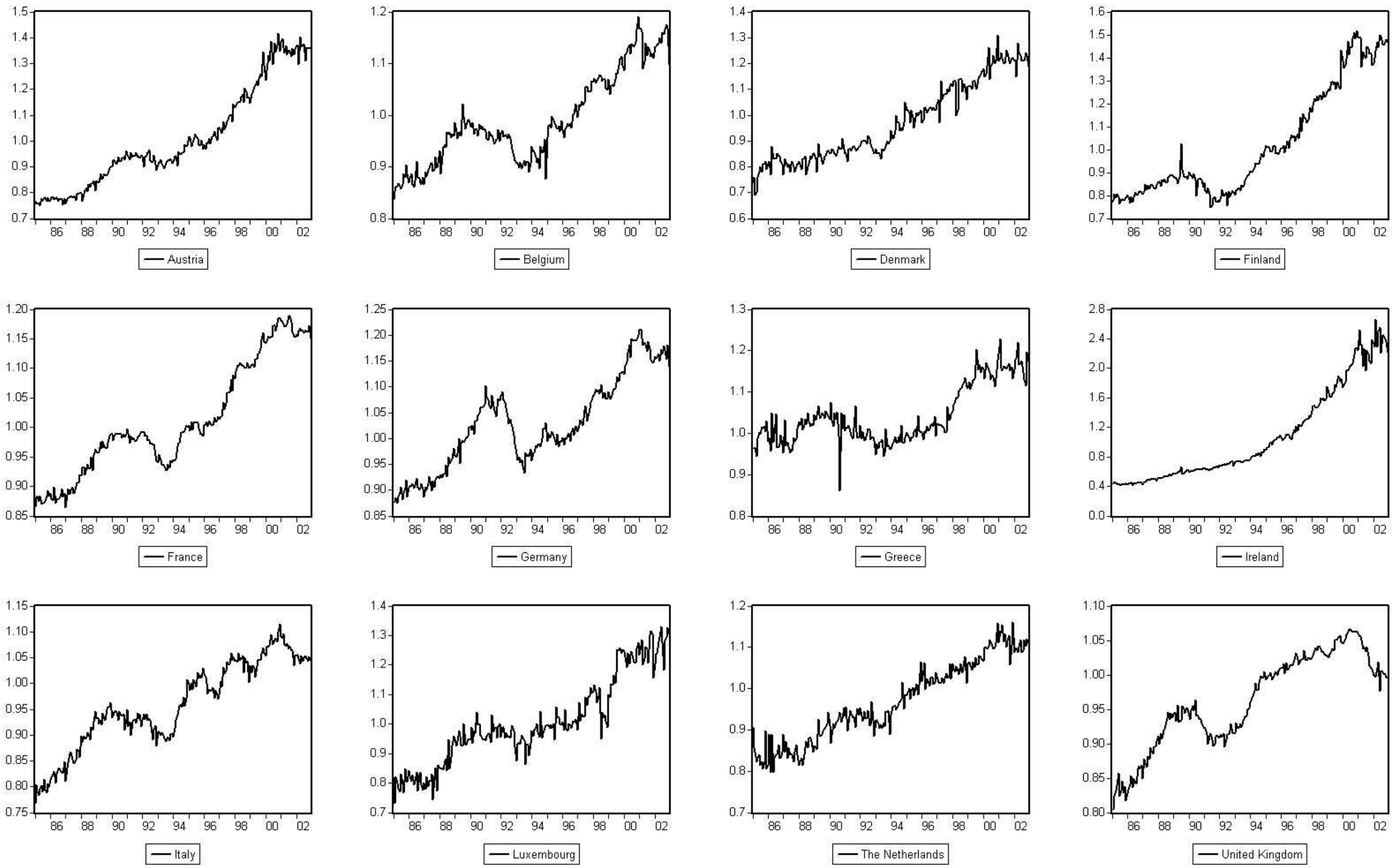


Figure 2: *PEXP* (raw) time series of the twelve EU countries.

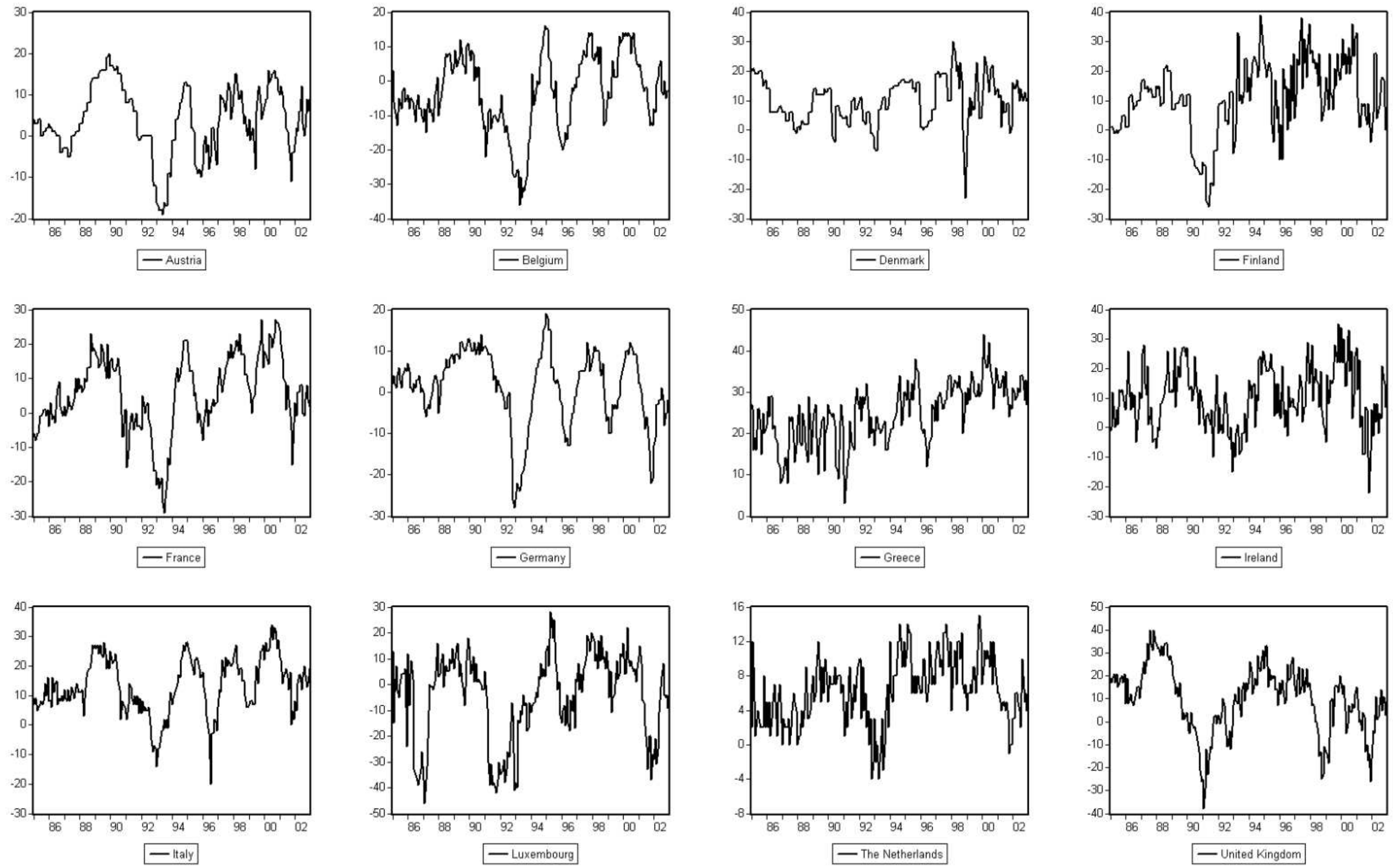
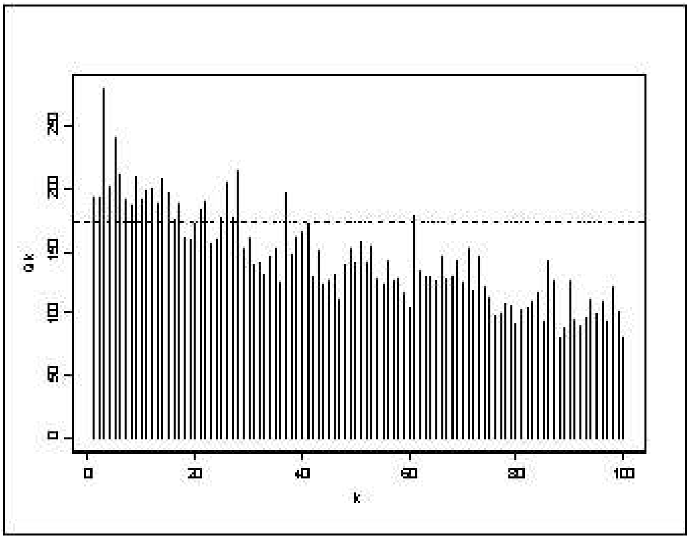


Figure 3: Measure Q_{HR}^k of multivariate Granger causality of $PEXP$ on $PACC$, for lags up to $k = 100$ months.



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