Has the crisis affected the CLI's performance? A rolling cross-correlation analysis

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TABLE OF CONTENTS

1 INTRODUCTION 5
2 METHODOLOGY 6
3 DATA 8
4 RESULTS 9
5 GLOBAL VALUE CHAINS AND THE CLI 13
6 CONCLUSIONS 17

Figures

Figure 1 Cross-correlation between Reference series and CLI 7
Figure 2 CLI performance for the OECD area as a whole, 1971M7-2016M3 10
Figure 3 CUSUM test on the stability of the peak lag across the Great Recession: CLI for the OECD area 10
Figure 5 Gain and loss of the CLI peak lead before and after the Great Recession (GR), ... 11
Figure 4 CLI performance for the G7, 1980M1-2016M2 12
Figure 6 Loss of CLI predictive power in the 90s by country 13
Figure 7 Final assembly of Boeing Commercial Aircrafts 15
Figure 8 Evolution of import content of exports, %, by country, 1991-2011 16

Abstract

This paper investigates whether the OECD Composite Leading Indicators (CLIs) ability to anticipate business cycle fluctuation has been significantly affected by the Great Recession. Using a rolling cross correlation function, the results suggest that although performance at the height of the crisis was marginally affected, the effect was only temporary and the predictive ability (lead-time) for the OECD area as a whole quickly returned to pre-crisis levels. However, the analysis also indicates that structural changes that occurred in OECD and major emerging economies in the mid to late 1990s, such as international fragmentation of production and the increased up-take of Just In Time production processes, may have worked to permanently reduce the lead-time for the CLI by around 1 to 2 months, compared to the early 1990s.

JEL code: C12, C14, C43, E32.
Keywords: business cycles, composite indicators, CLIs components, turning points.

Résumé

Ce document cherche à déterminer si la capacité d'anticiper les fluctuations du cycle conjoncturel de l'OCDE a été considérablement affectée par la Grande Récession. En utilisant une fonction de corrélation croisée continue, les résultats suggèrent que, bien que la performance à la hauteur de la crise ait été marginalement affectée, l'effet n'était que temporaire et la capacité prédictive (délai) pour l'ensemble de la zone de l'OCDE est revenue rapidement à la pré-crise les niveaux. Cependant, l'analyse indique également que les changements structurels survenus dans l'OCDE et dans les principales économies émergentes vers le milieu et la fin des années 90, tels que la fragmentation internationale de la production et l'augmentation de la production Just In Time, Délai d'exécution de l'ICA d'environ 1 à 2 mois par rapport au début des années 90.

Classification: JEL: C12, C14, C43, E32
Mots clés: Cycles économiques, indicateurs composites, composantes CLI, points tournants.

Has the Crisis affected the OECD-CLI's performance? A rolling cross-correlation analysis

By Roberto ASTOLFI and Nadim AHMAD

1 INTRODUCTION

By comparing the performance of the OECD Composite Leading Indicators (CLIs) pre and post the Great Recession, this paper investigates whether the ability of CLIs to anticipate business cycle fluctuation was significantly affected by the recent crisis.

The paper differs from earlier analyses that assess the ability of CLIs to predict peaks and troughs in the economic cycle, and in particular at the time of the recent crisis (Gyomai and Guidetti, 2012; and Astolfi et al., 2016), by investigating the performance of the CLIs during expansions and contractions.

The empirical analysis performed here uses a rolling cross correlation function. More commonly used in other disciplines such as engineering (Holford et al, 2013) or hydrology (Andrews F., 2011), the approach, in effect, marries simple cross-correlation techniques with rolling-windows analyses of time series. Although both techniques have previously been used to evaluate CLI performance, up to now they have only been conducted separately: the simple cross-correlation, for instance, is routinely used by the OECD to monitor CLI performance across the full sample (Gyomai et al., 2016), while the rolling-window analysis is typically employed in unrestricted VAR models (see, for example, Fichtner et al., (2009) who used the approach to estimate the evolution of the OECD CLI performance prior to the 2008 crisis).

The results of the new analysis that we perform here suggest that the CLI's post-crisis predictive ability remains at levels seen prior to the crisis for the OECD area as a whole, although there was a marginal (and temporary) deterioration in performance at the height of the crisis. This result generally holds for most major economies too. In many there has been a marginal improvement, but a mild deterioration (one month) and a more significant loss (2-3 months) have appeared in the CLIs for the United States and Japan respectively.

However, the analysis also indicates that structural changes that occurred in OECD and major emerging economies in the mid to late 1990s, such as international fragmentation of production and the

increased up-take of Just In Time production processes, may have worked to permanently reduce the lead-time for the CLI by around 1 to 2 months, compared to the early 1990s. The remainder of the paper is organised as follows. Section 2 illustrates the methodology. Section 3 describes the data sources. Results of the empirical analysis are presented and discussed in sections 4, while section 5 investigates the relationship between global value chains and the CLI. In Section 6, we draw some conclusions.

2 METHODOLOGY

The leading properties of CLIs and their components are regularly monitored by jointly assessing mean and median leads. Combining the two measures is essential as the mean lead, used on its own, can be strongly affected by outliers. Longitudinal consistency of leads is evaluated through the standard deviation of the mean lead. Simple cross-correlation complements the analysis providing scope to assess the conformity of CLIs to the (growth) cycle fluctuations of the reference series in periods between turning points (i.e. expansions and contractions). One limitation of such an approach, however, is that it is, by design, static (as it is applied to the full sample) and, so, hinders an assessment of CLI performance over time. The rolling cross correlation function (RCCF), which extends the simple cross correlation technique with rolling-windows analysis methods, assessing parameter constancies in time-series analysis (Zivot and Wang, 2006), has the potential to overcome that limitation.

In this section we first present the simple cross-correlation function and its use in assessing the CLIs' ability to anticipate turning points. We then describe its extension to the rolling-windows analysis.

Cross-correlation function

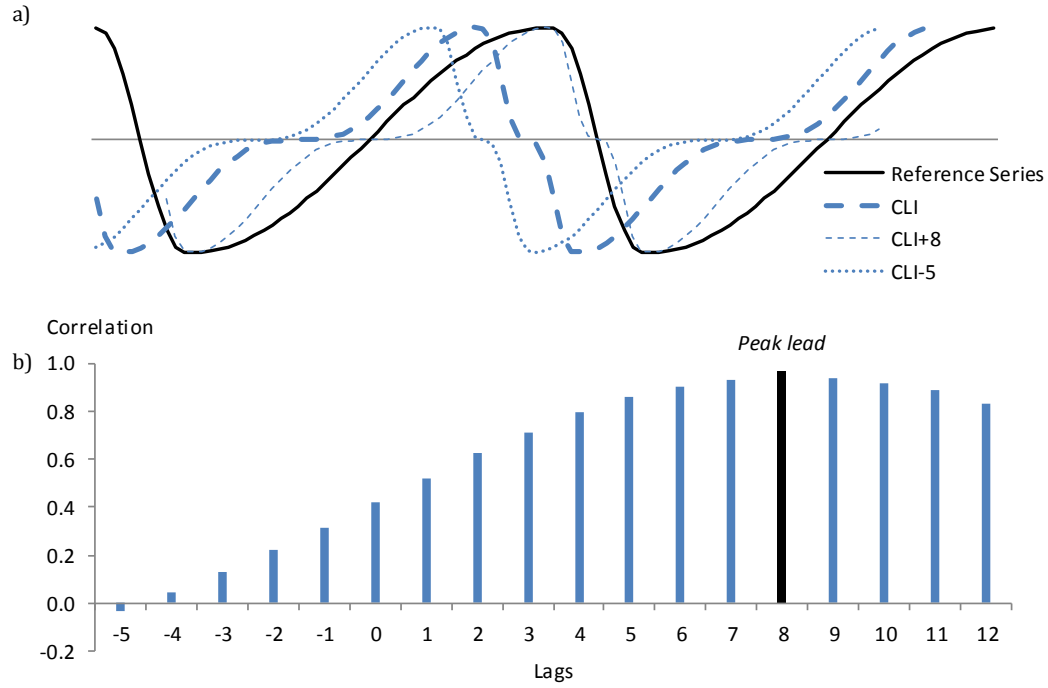
The cross correlation function (CCF) is a standard measure of the association between one time series and the past, present and future values of another time series. In the context of the present analysis, we compare each CLI against its reference series[1]. The CCF is computed by shifting the CLI a certain number of periods ahead or behind the reference series and calculating the correlation between paired observations. The lag at which the correlation between the two series peaks, indicates whether, and to what extent, the CLI leads, lags or coincides with the reference series. If the correlation is maximised with a positive lag, the CLI leads the cyclical evolution of GDP. Conversely, if the correlation is maximised with a negative lag, the CLI lags. Where the lag is zero, the CLI is a coincident indicator. Of note is that the size of the lag or lead acts as a good proxy of average lead time.

Figure 1 below illustrates this by way of a simple example. Correlations are calculated between the reference series (black solid line in panel a) and the CLI, for a range (between 5 months behind and 12

[1] In the current system of CLIs, Gross Domestic Product (GDP) is the reference series. The sole exception is China for which the value added of industry ,at 1995 constant prices, is used instead.

months ahead) of time-shifted CLIs. The correlation between the paired time series (reported in panel b) peaks at lag 8 (black solid bar), suggesting that the CLI leads the reference series by eight months.

Figure 1 Cross-correlation between Reference series and CLI



Source: simulated data

The concept of cross-correlation can be formalised as follows: given two time series $Y_t = \{y_1, \cdots, y_T\}$ and $X_t = \{x_1, \cdots, x_T\}$, the cross-correlation coefficient $\rho_{xy}(k)$is calculated as follows:

$$\rho_{xy}(k) = \begin{cases} \frac{1}{T}\sum_{t=1}^{T-k}(X_t - \mu_X)(Y_{t+k} - \mu_Y) \Big/ (\sigma_X \sigma_Y) \; for \; k = +1, +2, \cdots \\ \frac{1}{T}\sum_{t=1}^{T-k}(Y_t - \mu_Y)(X_{t-k} - \mu_X) \Big/ (\sigma_X \sigma_Y) \; for \; k = -1, -2, \cdots \end{cases}$$

where k is time shift, μ_X and μ_Y are the mean and σ_X and σ_X the standard deviation of the processes X_t and Y_t $r$espectively[2] (Box et al., 2016).

Rolling cross-correlation function

To assess the stability of the cross-correlation coefficient over time, we apply the rolling cross-correlation function. According to Banerjee et al. (1992), "rolling statistics have been historically

[2] Note that $\rho_{xy}(h) = \rho_{yx}(-h)$ but $\rho_{xy}(h) \neq \rho_{xy}(-h)$.

important tools in the econometric analysis of time series". The rolling analysis is based on the idea of running multiple estimations of the parameter of interest using sub-samples (either overlapping or non-overlapping) that are moved along the full time-series. In our case, we computed the simple cross-correlation on a sub-sample (also called window) of N observations that are subsequently shifted ahead at regular intervals. A constant location (time-shift) of the peak-leads across moving windows indicates that the CLI's performance has been maintained over time. Conversely, a reduction of the peak-lead indicates deterioration in the predictive property. In such a case, rolling cross-correlation analysis can also be used to identify the starting point of any deterioration (or indeed improvement) in performance.

The rolling cross correlation coefficient $\rho_{xy}(k)$ is calculated as follows:

$$\rho_{xy}(k) = \begin{cases} \frac{1}{T}\sum_{t=1}^{T-k}\sum_{m=t+k}^{t+N-k}(X_t-\mu_X)(Y_{t+k}-\mu_Y)\Big/(\sigma_X\sigma_Y)\ for\ k=+1,+2,\cdots \\ \frac{1}{T}\sum_{t=1}^{T-k}\sum_{m=t+k}^{t+N-k}(Y_t-\mu_Y)(X_{t-k}-\mu_X)\Big/(\sigma_X\sigma_Y)\ for\ k=-1,-2,\cdots \end{cases}$$

where N is the size of the rolling window, and *k*, *X*, *Y*, σ_X and σ_Y are defined as above.

In our analysis the length of the rolling window has been set to 120 observations (i.e. 10-years) with the windows shifting ahead and behind by one month intervals up to 12 lags. Although the selection of the size of the rolling windows is somewhat arbitrary, our choice is guided by the value of the parameters for the Hodrick–Prescott filter used by the OECD in computing the CLIs (with fluctuations longer than 10 years assigned to the trend component of the time series). The same length was also used by Crivellini et al. (2004) in studying industrial output fluctuations in developed countries. Stability of the RCCF is first evaluated through visual inspection and then through the CUSUM test [3].

3 DATA

Monthly observation of the Composite Leading Indicators (CLIs) and the cyclical components of the reference series were obtained from the OECD *Main Economic Indicators* database. While all series end in March 2016, the starting date varies from country to country[4]. In this study we used the CLI in its *amplitude-adjusted* form, while for the reference series we opted for the *deviation-from-trend* form.

[3] The CUSUM (CUmulative SUM) test allows detecting the structural instability of parameters in regression equations. The test takes the cumulative sum of recursive residuals and plots its value against upper and lower bounds of the 95% confidence interval. The null hypothesis of having stable parameters is rejected if any of the bounds is significantly crossed. In our study, parameters estimates are obtained by regressing peak lead series on a constant.

[4] Starting date ranges from February 1960 for the United States and Canada to June 1996 for Estonia.

All series are the result of the smoothing and de-trending filtering process that the OECD performs to isolate the cyclical component of the series. Rather than a single step approach (referred to as band-pass filtering), the OECD employs a two-step approach based on the double application of the Hodrick-Prescott (HP) filter. In this way the OECD procedure cuts off, first, frequencies with periods lower than 120 months and then those with periods higher than 12 months. The filtering procedure is applied to the reference series as well as to the CLI components. The latter are then normalised (by subtracting their mean and dividing by their mean absolute deviation) and aggregated into the raw CLIs. To match the amplitudes of the business cycle reference series, raw CLIs are also amplitude adjusted (see also Gyomai et al., 2016).

4 RESULTS

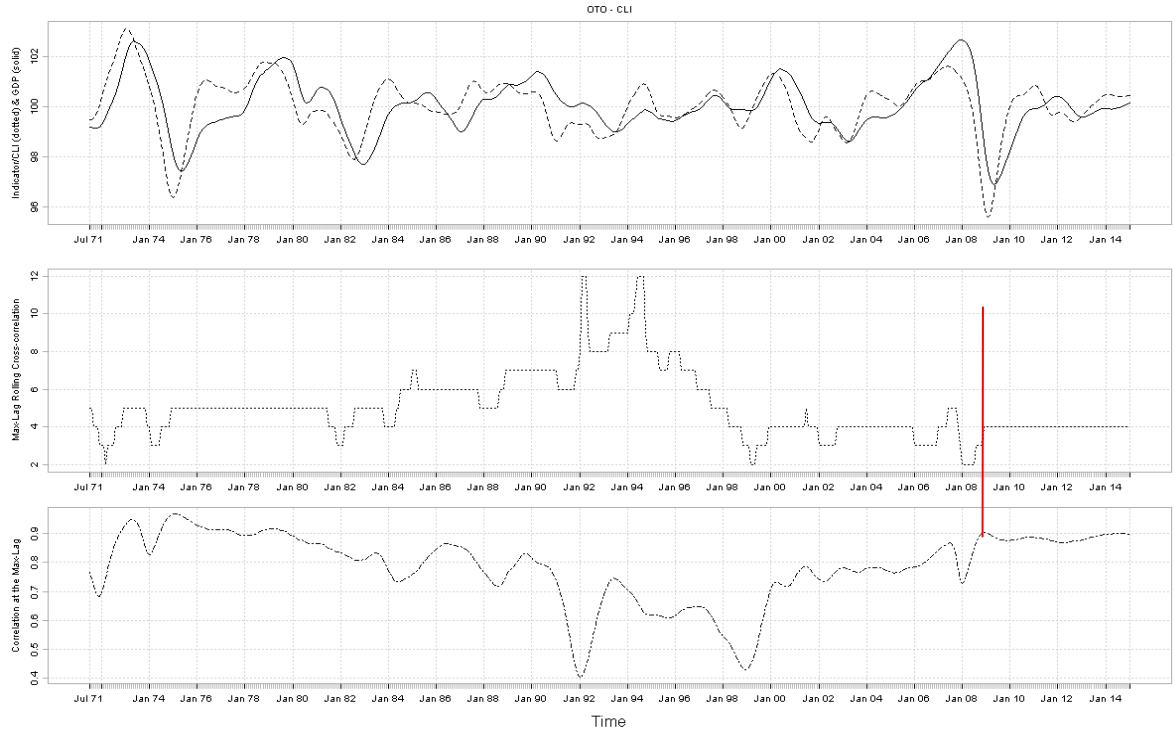
Aggregated results for the OECD area as a whole suggest that while the performance of CLIs at the height of the Great Recession dipped, the dip was temporary and predictive performance has since returned to pre-crisis levels. However, the analysis also reveals that a generalised reduction of the CLI's leading performance occurred in the 90s.

Figure 2 below shows the evolution of the CLI's predictive ability for the OECD area as a whole from the early 70s to present. The top panel of Figure 2 displays the cyclical component of GDP (solid line), as obtained through the use of the double Hodrick–Prescott filter, together with the CLI resulting from the aggregation of national CLIs (dotted line). Graphical inspection of the chart suggests that the CLI is slightly more volatile than GDP, with larger local peaks appearing at times. The middle chart reports the lag at which the cross correlation maximises for each rolling window, with the corresponding correlation presented in the bottom chart.

As can be seen from the middle chart, the post crisis period is characterised by an almost constant four month peak lead, comparable with the 3.8 average peak-lead for the 2000 to 2007 period. The fluctuations in 2008, with an initial increase followed by a decline in performance, could possibly reflect the lower ability of leading indicators to anticipate troughs as opposed to peaks[5].

[5] The application of the rolling cross-correlation function allows the CLI leading peak to be identified for each month in the usable sample. However, given the size of the rolling windows (120 months in our case), both expansion and contraction phases can be included in a single window. As a result, the selected leading peak represents an average measure of sorts, of the CLI's ability to track the different phases of economic fluctuations, namely expansions and contraction. Given that leading indicators have longer time leads at peaks than at troughs (Burns and Mitchel, 1946, and Paap et al., 2009), our results should not be interpreted as a measure of the CLI's lead at turning points, rather they should be seen as an assessment of the evolution of the average lead across various phases of the (growth) business cycle.

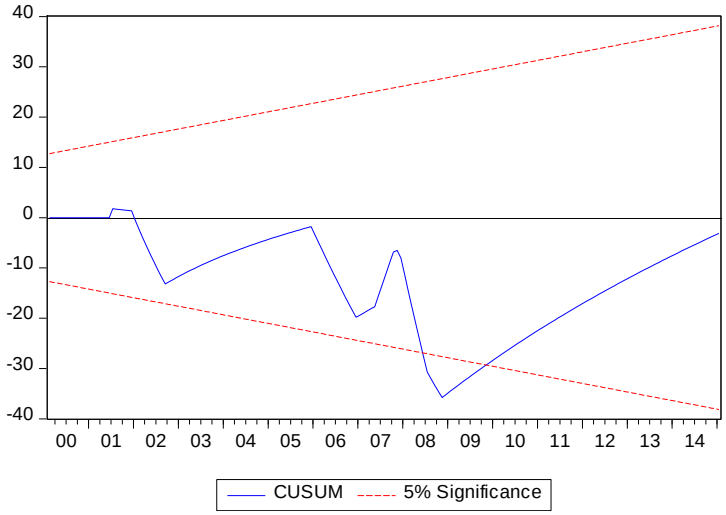
Figure 2 CLI performance for the OECD area as a whole, 1971M7-2016M3



Note: Red vertical solid line identifies the Great Recession peak
Source: OECD calculations

The relative comparability of the pre-post crisis period is also confirmed by the CUSUM test (Figure 3), which indicates that average lead remained within the 5% significance interval throughout the post 2000 period, with the sole exception around the peak of the crisis.

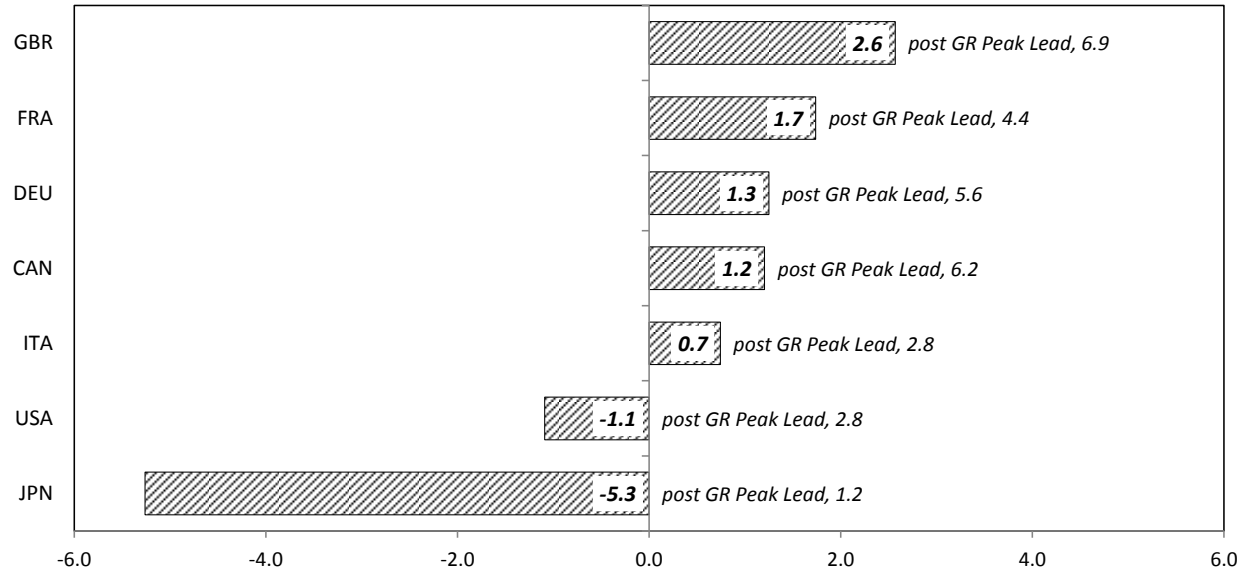
Figure 3 CUSUM test on the stability of the peak lag across the Great Recession: CLI for the OECD area



Source: OECD calculations

Looking more closely at the performance for G7 economies rather than the OECD as a whole (Figure 5 **Error! Reference source not found.**) reveals a marginal improvement in performance post-crisis, in Canada and European economies. However, there was a mild deterioration in the United States and a more significant loss in performance in Japan.

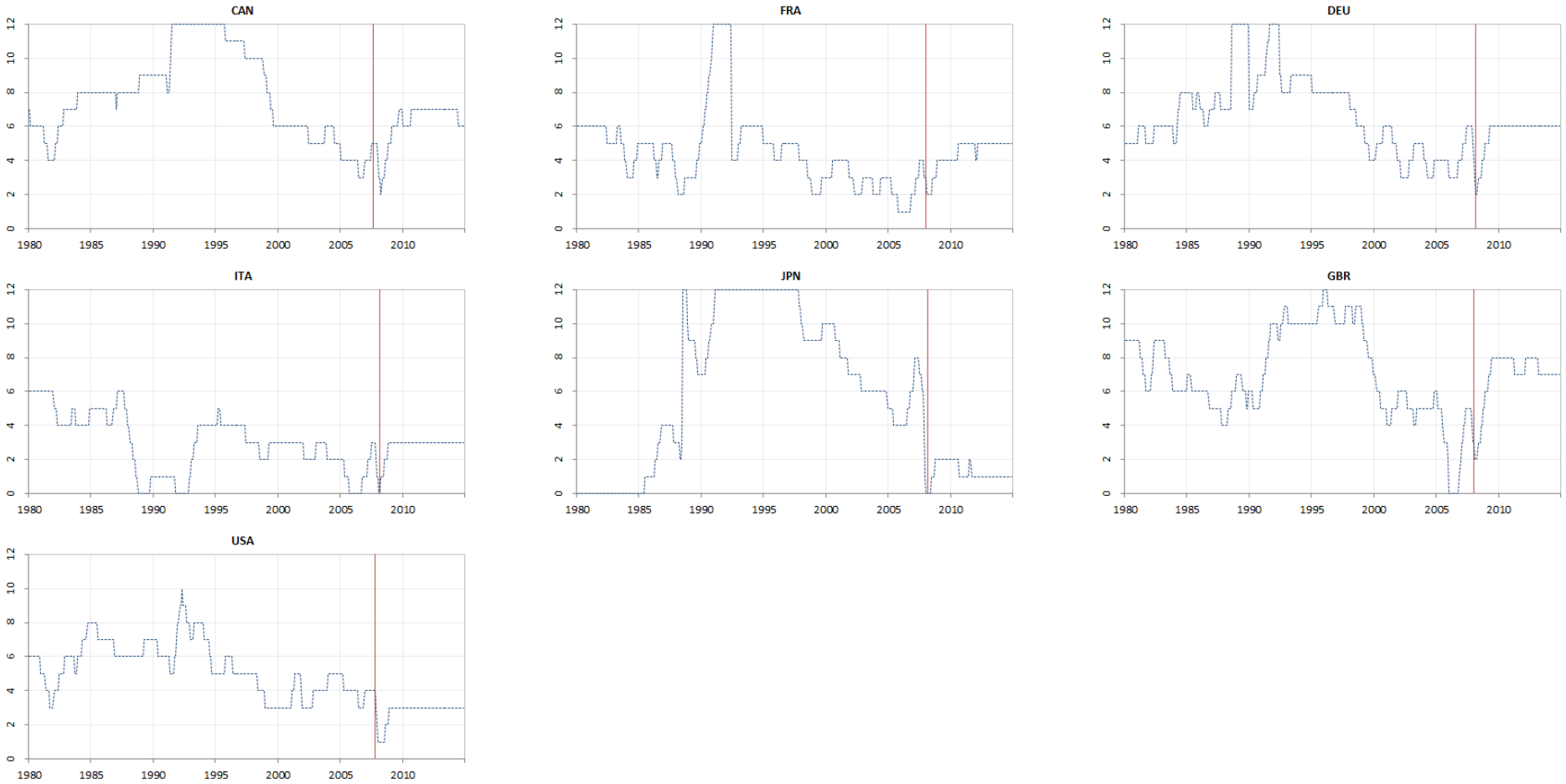
Figure 4 Gain and loss of the CLI peak lead before and after the Great Recession (GR), G7 Countries, 2000-2015



Source: OECD calculations

Among countries where the leading performance improved, the United Kingdom exhibited the largest increase (up 2.6 months) with a peak-lead time of almost seven months (**Error! Reference source not found.**). France, Germany and Canada also recorded rises, albeit more modest, while in Italy the increase was negligible (0.7 months) bringing the peak-lead to just below three months. On the other hand, in the United States there was a just over a month loss in performance, while in Japan performance fell sharply, by more than five months, resulting in an average peak-lead of just over a month.

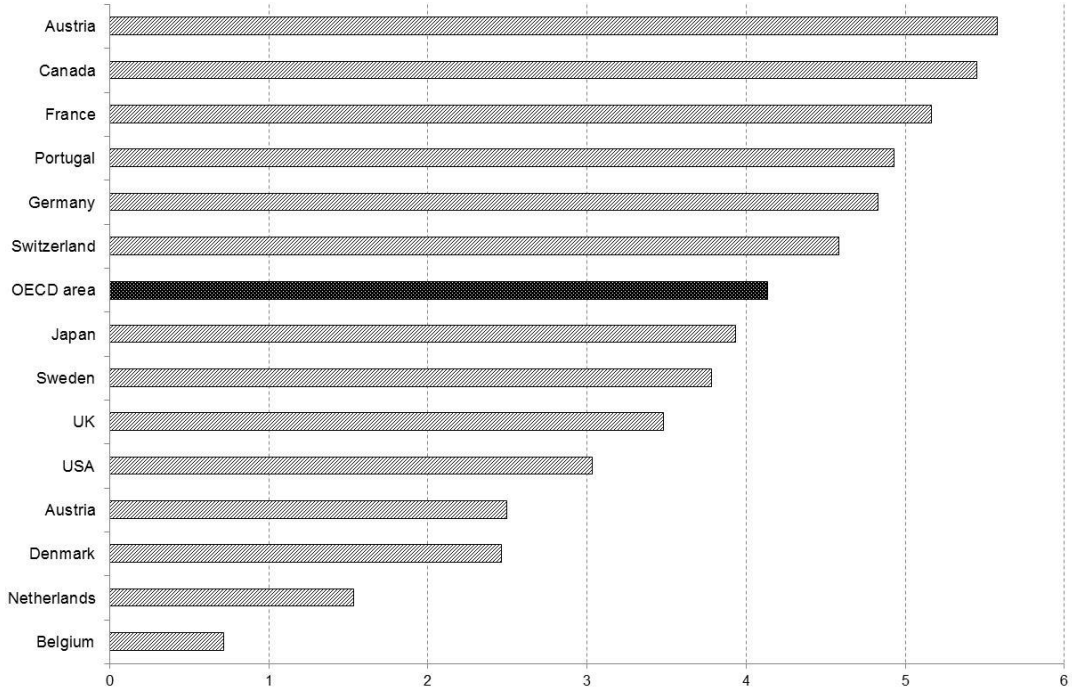
Figure 5 CLI performance for the G7, 1980M1-2016M2



Note: Red Vertical lines identify the Great Recession peaks
Source: OECD calculations

A striking feature of the analysis is the loss of predictive performance that the CLIs recorded in the second half of the 90s. Overall, the average peak-lead increased significantly during the second half of the 80s right through to the early 90s, when the CLI peak-lead reached eight months on average (Figure 2, central panel)[6]. From that moment on however, the peak-lead time started decreasing, stabilising only in the early 2000s. Figure 6 ranks countries that recorded major losses in leading performance in the mid-90s, of which Austria, Canada and France saw the largest declines. Of particular note, given its fall in performance in the post-crisis period is Japan, with a deterioration of close to four months[7].

Figure 6 Loss of CLI predictive power in the 90s by country



Source: OECD calculations

5 GLOBAL VALUE CHAINS AND THE CLI

Although the higher performance in the early 90s, and indeed the lower performance in the 70s, might possibly reflect CLI model specifications which maximised the then in-sample performance, the widespread decline in performance during the 1990s appears to reflect structural changes in the nature of production across OECD and many other economies that have resulted in shorter production times and as a

[6] The two peaks of longer leads, up to 12 months, observable in the early 90s can be considered as outliers and are therefore discarded, as they are associated to a much lower correlation coefficient hinting a somewhat spurious signal (bottom chart). This is particularly the case of the first leading peak recorded between 1992 and 1994.

[7] Italy, Mexico and Spain are not included in Figure 6 as no significant loss in their CLI performance could be identified.

result a permanent downward shift in the CLI's predictive ability. Of particular note in this regard are the following factors (Radlo, 2006):

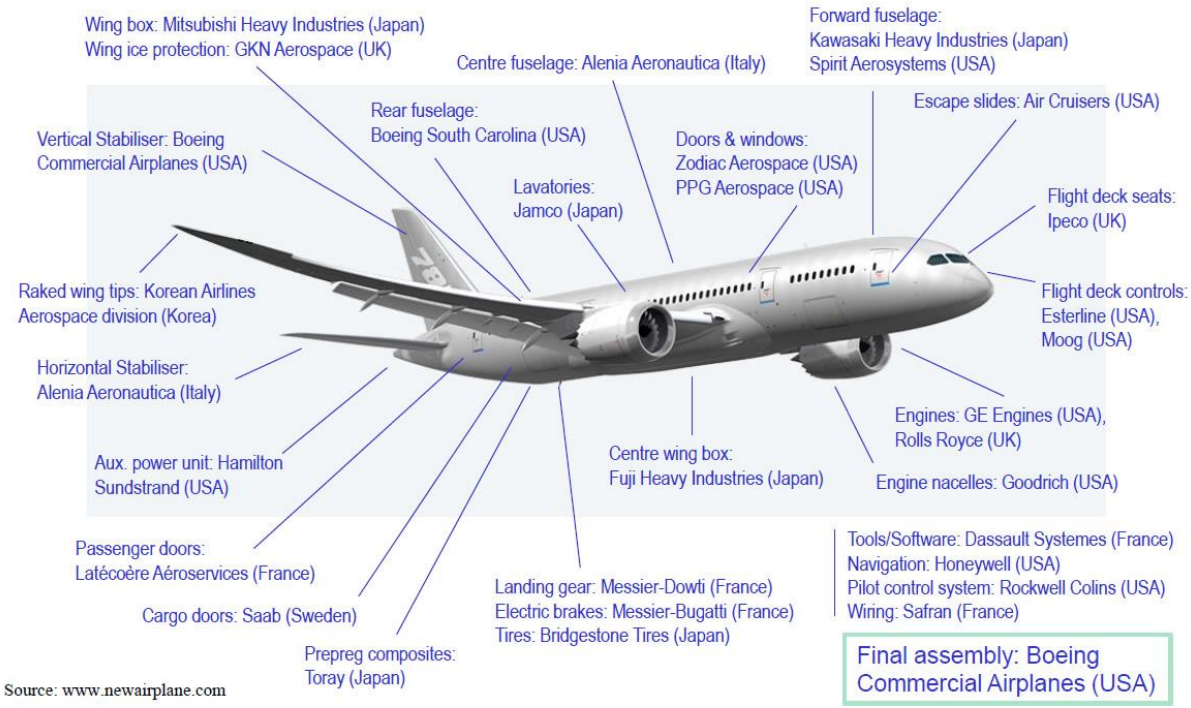
- International fragmentation of production
- Geopolitical changes (Trade liberalisation, emerging new independent states)
- Adoption of "just-in-time" inventory practices
- Spread of information and communication technology
- Implementation of a novel distribution strategy
- Decreasing transportation and communication costs.

Global value chains (GVCs) characterised by international fragmentation of production, have become a dominant feature of today's global economy. This process of international fragmentation, driven by technological progress, cost reductions, access to resources and markets, and trade policy reforms has seen previously integrated production activities, located in one country, and often in one firm, fragmented and de-localised across a number of countries in a global value chain, where each country (and firm) specialises in particular parts of the chain for which they have comparative advantages.

Perhaps the best known example of this process is the out-sourcing of processing and assembly activities to low-wage economies, but this is certainly not the only manifestation. Increasingly, higher value-added parts of the production chain are being fragmented, especially in sectors such as transportation equipment and ICT. In some OECD economies, this has led to an acceleration of the 'servisification' process as manufacturing activities shift abroad; building on the earlier phases of servisification that occurred in the 80s in many economies, as in-house services performed by manufacturers were outsourced to specialised service suppliers.

Boeing for example assembles its 787 aircraft in the United States using components built by suppliers in Japan, Italy, Korea and the United Kingdom as well as Boeing subsidiaries in Australia, Canada and Russia (Figure 7). In turn many of these components also integrate other imported sub-components. For instance, Alenia of Italy builds fuselage sections, to which it adds the aft cargo door produced by Saab of Sweden (Gates, 2006; and Gunter, 2006). In the past many of these activities would have been performed by Boeing or by other US based suppliers.

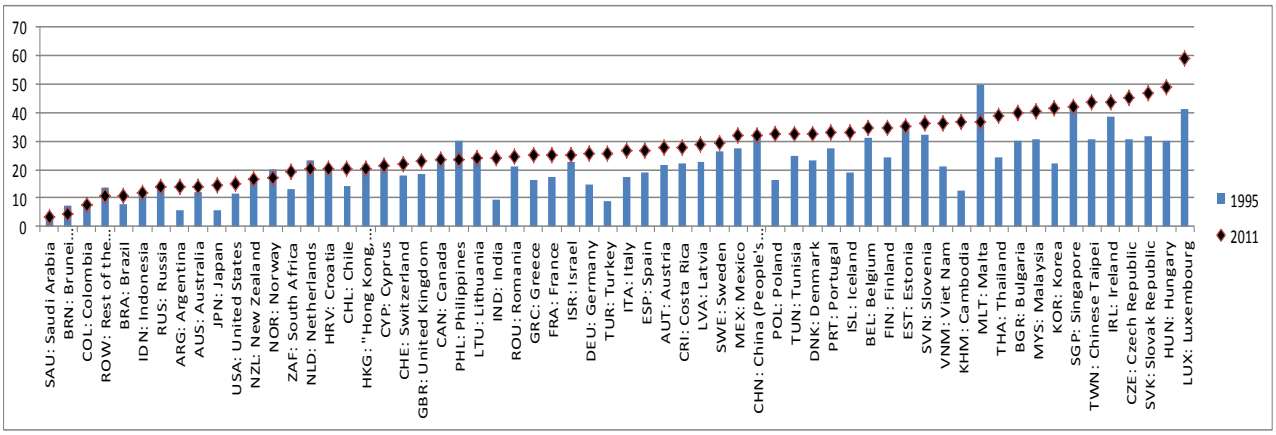
Figure 7 Final assembly of Boeing Commercial Aircrafts



Source: www.newairplane.com

Of course international fragmentation of production is not a new phenomenon. However its increasing scale and scope is new (OECD, 2013). Feenstra (1998) calls such a process the "integration of trade and disintegration of production in the global economy". The OECD provides a broad range of work that sheds light on this process through the OECD-WTO Trade in Value Added (TiVA) database. Figure 8 below, which shows the import content of exports across countries, well illustrates the scale of this change in global production, showing an increasing (and significant) contribution of imports in most economies. In Japan for example the import content of exports rose nearly threefold between 1995 and 2011 as Japanese firms increasingly outsourced stages of production to other countries in Factory Asia, notably China.

Figure 8 Evolution of import content of exports, %, by country, 1991-2011



Source: OECD-WTO TiVA database

Because fragmentation of production across borders means, almost by definition, shorter production processes within each country as firms specialise in particular tasks, thus contributing to shorter times between order and supply, the advent of significant GVCs is likely to have negatively affected the CLIs leading performance, especially when the CLIs target the dynamic of the early stages of domestic production to anticipate fluctuations in final output.

Coupled with, and perhaps in part bolstered by, international fragmentation of production, the adoption of inventory management techniques (Davis and Kahn, 2008) may also have contributed to further reduce the CLI's leading performance. In particular, the adoption of so called "Just-in-time (JIT)" inventory strategies may have worked to reduce the predictive performance of the CLIs. To contain costs, increase efficiency and decrease waste, companies adopting JIT approaches tend to acquire intermediate inputs only when required in the production process. Such a strategy shifts away from the older just-in-case strategy, in which producers carried large inventories in case higher demand had to be met.

In addition, developments in ICT have increased the tradability of many goods and services and revolutionised distribution activities that, in turn, may have further reduced the gap between early stages of production and the final use of a good (OECD, 2011 and 2013). Advancements in ICT have significantly decreased the co-ordinating costs between (as well as within) companies, which have helped to facilitate the growth in GVCs. But ICT has also provided improved access for final consumers. For instance, in the late 80s and early 90s, Dell was among one of the first companies to implement a direct selling strategy using a mail-order system, which took a significant evolutionary step with the development of an online sales platform, cutting out the retail middleman and decreasing the time between production and final consumption. Indeed the internet, and e-commerce more generally, has led to a shrinking space between the time a good leaves the factory gate and arrives with a final consumer (household).

The relative stability in the performance of the CLI since around the early to mid 2000s chimes well with the evidence that suggests that the wave of GVCs, propelled by technological progress, cost reductions, access to resources and markets, trade policy reforms and geopolitical factors - notably the fall of the Berlin Wall, NAFTA and the opening up of China, including its accession to the WTO in 2001, may have subsided. Certainly the pace of GVC expansion has slowed in recent years compared to its heyday in the late 90s and early 2000s. This partly reflects a combination of factors such as an inevitable point of saturation (as production processes cannot be fragmented infinitely) and the one-off shift effects caused by technological progress and trade policy reforms, but it may also partly reflect signs that re-shoring is occurring as comparative advantages shift, calls for protectionism rise, and firms look to exploit new technologies such as 3-D printing and automation.

6 CONCLUSIONS

Notwithstanding the dip in performance that occurred around the height of the crisis, the performance of the CLIs, certainly for the OECD as a whole, has remained broadly stable over the last decade, suggesting that there has been no permanent impairment in performance because of the crisis. Indeed, in most major European economies and Canada there has been a marginal improvement in performance since the crisis, although this is partially offset by a mild deterioration in the United States and a more significant loss in performance in Japan.

Of particular interest however, has been the change in performance of the CLIs over the last few decades, where results point to a significant (1 to 2 month) decline in the mid to late 90s, at the height of significant changes in the global economy and global production process, which, combined, appear to have shortened production processes within economies. These include the up-take of improved management processes such as JIT models of production, but the real game changer has been the advent of significant GVCs that have capitalised on geopolitical changes such as the fall of the Berlin Wall, the accession of China to the WTO and subsequent trade liberalisation, including regional trade agreements such as NAFTA, and the spread of information and communication technology (see also Fitchtner et al., 2009).

Whereas earlier structural changes, such as the outsourcing of in-house services to specialised, typically domestic, service providers, introduced efficiencies that reduced the costs of production, the changes related to GVCs have also worked to reduce the time engaged in production; in other words the time between the purchase of intermediate parts and subsequent sales of output by firms that specialise in particular tasks, or stages, of a GVC. This has inevitably led to an impairment of the CLIs predictive performance, which, in part, looks at these inputs as leading indicators of output.

However, the pace of change in GVCs and their impact on the time firms engage in production does appear to have slowed in recent years, particularly in those economies where GVC integration is relatively mature, such as Germany (where integration with former transition economies began in the early 1990s) and North America (where NAFTA came into effect in 1994). In Japan the deterioration in performance has continued post-crisis but this may also reflect the nature of value-chains within Factory Asia, which now also appear to be showing signs of slowing (noting that China's accession to the WTO, which acted as a significant catalyst to Asian GVCs, only occurred in 2001).

Although the slowing pace of GVCs does appear to have led to a stabilisation in the performance of CLIs, the findings do reveal the importance of ensuring that the leading component variables used in constructing the CLI for any given country are kept under constant review (see also Marcellino, 2006). Indeed, although GVCs may have slowed, there are many other challenges appearing on the horizon, such as the data revolution and more broadly Industry 4.0, that require keeping a close eye on the components used to construct the CLI.

In this regard, the rolling cross correlation function used in this analysis should, and indeed will, be added to the set of tools regularly used to evaluate the evolution of the CLIs leading performance.

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